Ministry of Environment, Waters and Forests

National Environmental Protection Agency

Romania's Greenhouse Gas Inventory

1989–2023

National Inventory Document

April 2025

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AD	Activity Data
AFOLU	Agriculture, Forestry, and Other Land Use
Ag	Arable
AGB	Above Ground Biomass
ANCPI/NACREP	National Agency of Cadastre and Real Estate Publicity
ANMDM	National Agency for Medicines and Medical Devices
ANRE	Romanian Energy Regulatory Authority
APMCR	Romanian Association of Construction Materials Producers
APIA	Agency for Payments and Intervention in Agriculture
A/R	Afforestation/Reforestation
AR 4	Fourth Assessment Report
AR 5	Fifth Assessment Report
AT	Other Land
Ata	Shrub crops
AtVf	Other Land with Forest Vegetation
AU	Construction + Roads
ASH	ASH content of the manure
AWMS	Animal Waste Management Systems
B_0	Maximum methane (CH_4) producing capacity for manure produced by animal within defined population
BEF	Biomass Expansion Factor
BGB	Below Ground Biomass
BOD	Biochemical Oxygen Demand
BOF	Basic Oxygen Furnace
C	Carbon
C^{nat}	National Oxidation Factor expressed in Carbon content
C_2F_6	Hexafluoroethane
$CaCO_3$	Calcium Carbonate (limestone)
CaO	Calcium Oxide (lime)
CaO*MgO	Dolomitic lime
CAP	Agricultural Production Cooperatives

Cel B	Gross Pulp
CF_4	Tetrafluoromethane
CH_4	Methane
CHP	Co-generation Heat Plants
CIV	Identity Card Vehicle
CKD	Cement Kiln Dust
CLRTAP	Convention on Long-range Transboundary Air Pollution
CL	Cropland
CL-FL	Cropland converted to Forest land
CLC	Corine Land Cover
CLa	Cropland annual
CLp	Cropland perennial
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CN	Combined Nomenclature
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
Coll	Collaboratores
COP	Conference of the Parties
CORINAIR	Coordination of Information on the Environment, sub-project: Air
CRF	Common Reporting Format
CRT	Common Reporting Tables
CS	Country Specific
CSC	Carbon Stock Change
CS EF_s	Country Specific Emission Factors
CWPB	Centre Worked Pre-baked
D	Default
D	Deforestation
DE	Digestible Energy
DOC	Degradable Organic Carbon

DOC_F	Fraction of DOC Dissimilated
DOM	Dead Organic Matter
DTM	Military Topographic Direction
DS_{dom}	Fraction of Degradable Organic Component
dm	decimeter
DW	Dead Wood
E	Emissions
EAF	Electric Arc Furnace
EB	Energy Balance
EC	European Commission
EEA	European Environment Agency
EEA-UG	Environment Agency of Austria- University of Graz
EF	Emission Factor
EF^{nat}	National Emission Factor without Factor Oxidation
$EF\text{-}Ox^{nat}$	National Emission Factor with Factor Oxidation
EF_S	Emission Factors
EGM	Explicit geospatial map
EMEP/EEA	Air Pollutant Emission Inventory Guidebook 2019 – Update Dec. 2021
ERT	Expert Review Team
ETF	Enhanced Transparency Framework
EU	European Union
EUROSTAT	Statistical Office of the European Communities
EU-ETS	European Union-Emission Trading Scheme
Eq	equivalent
FAO	Food and Agriculture Organization
FI	Input Factor
FOD	First Order Decay
FFN	National Forest Fund
FLRFL	Forest Land Remaining Forest Land
FL	Forest Land
FLU	Land Use Factor
FM	Forest Management
FMG	Management Factor

FORLUC	Forest Land Use
FTY	Forest Type (Copernicus dataset)
GB	Gross Fat
GD	Governmental Decision
GE	Gross Energy Intake
G	Grams
Gg	Giga gram
GDDLR	General Directorate for Driving Licenses and Registrations
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GPG	Good Practice Guidance
GL	Grassland
GLg	Grassland Grassy
GLw	Grassland Woody
GWP	Global Warming Potential
Ha	Hectares
HCFC	Fluorinated Gases
HFC_s	Hydro-fluorocarbons
IACS	Administration and Control System
ICAS/INCDS	National Research and Development Institute in Forestry ”Marin Drăcea”
ICIM	National Research and Development Institute for Environmental Protection
ICPA	National Institute of Research and Development in Soil Science, Agro-chemistry and Environment
ICSI	National Research and Development Institute for Cryogenic and Isotopic Technologies Rm. Vâlcea
ICPIL	Research and Design Institute of Wood Industry
IGSU	Romanian General Inspectorate for Emergency Situations
IEA	International Energy Agency
INCAS	National Institute for Aerospace Research “Elie Carafoli”
INSEMEX Petroșani	National Institute for Research and Development in Mine Safety and Protection to Explosion
IPCC 1996	Revised IPCC Guidelines for National Greenhouse Gas Inventories - 1996

IPCC GPG 2000	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories - 2000
IPCC GPG 2003	IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry - 2003
IPCC 2006	2006 IPCC Guidelines for National Greenhouse Gas Inventories
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrating Pollution Prevention and Control
ISPB	Public Health Institute of Bucharest
ISPE	Institute for Studies and Power Engineering
IT	Information Technologies
ITRSV	Territorial Inspectorates on Forestry and Hunting Regime
JI	Joint Implementation
Jn	Pinus Mugo Shrubs
KP	Kyoto Protocol
KP Supplement	2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol
KCA	Key Category Analysis
Kcal	Kilocalorie
Kg	Kilograms
Kj	Kilojoule
L	Level
L	liquid
L-FL	Other land categories converted to Forest land
LB	Loss in Biomass
LIDAR	Light Detection and Ranging
LPIS	Land Parcel Identification System
LT	Litter
LTO	Landing/Taking Off
LULUCF	Land Use, Land Use Change and Forestry
Lv	Orchards
M	meter
M^3	meter cubic
mm	milimeter

MARD	Ministry of Agriculture and Rural Development
MAI	Ministry of Administration and Interior
MCF	Methane Conversion Factor
MEF	Ministry of Environment and Forests
MEWF	Ministry of Environment, Water and Forests
$MgCO_3$	Magnesium Carbonate
MgO	Magnesium Oxide
MJ	Megajoule
MoEO	Ministry of Environment Order
MPGs	Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement
MS	Fraction of minimal species/category manure handled using manure system
MSW	Municipal Solid Waste
N	Nitrogen
N.A. ”Romanian Waters”	National Administration ”Romanian Waters”
N_2O	Nitrous Oxide
NACE	National Classification of Economic Activities
NCV_s	Net Calorific Values
NEPA	National Environmental Protection Agency
N_{ex}	Annual average N excretion per head of species/ category
NFFI	National Forest Fund Inventory
NFF	National Forest Fund
NFI	National Forest Inventory
NGHGI	National Greenhouse Gas Inventory
NH_3	Ammonia
NIA	National Inventory Arrangements
NID	National Inventory Document
NIM	National Institute of Meteorology
NIR	National inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases
NIS	National Institute for Statistics
NMVOC	Non-methane Volatile Organic Compound
NOx	Nitrogen Oxides

N_2O	Nitrous Oxide
NS	National System for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol
NSCR	Non Selective Catalytic Reduction
NTPA - 011	Romanian Standard regarding wastewater treatment
OL	Other land
OSM	Organic soil map
Pa	Hayfields
PA	Paris Agreement
PB	Gross Protein
PFC_s	Per-fluorocarbons
Pf	Pasture with spare trees
Pp	Pastures
PRODCOM Codes	Codes of PRODucts of the European COMmunity
PTR	Pedotransfer
QA/QC	Quality Assurance/Quality Control
R	Removals
RAR	Romanian Automobile Register
Rev	Re-vegetation
ROSA	Romanian Space Agency
RSD	Relative Standard Deviation
R&D	Research & Development
RNP ” ROMSILVA”	National Forest Administration” ROMSILVA”
S	Solid
Saturday Paper	Problems and Further Questions from the ERT formulated in the course of the review of the submitted greenhouse gas inventories
SEF	Standard Electronic Files
SEN	Extractable Non-nitrogenous Substances
SF_6	Sulfur Hexafluoride
SILV 4-Statistical Report	Forest regeneration works performed in the forestry fund, degraded lands and other lands outside the forest fund, Statistical Report
SL	Settlements

SL-FL	Settlements converted to Forest Land
SNAP	Selected Nomenclature for Air Pollution
SNFI 1984	Synthesis of National Forest Inventory, 1988
SO_2	Sulfur Dioxide
SOC	Soil Organic Carbon
SOCref	Soil Organic Carbon reference
SRC	Selective Catalytic Reduction
SWDS	Solid Waste Disposal Sites
SWPB	Side Worked Pre-baked
SOCref	Soil Organic Carbon reference
SY	Statistical Yearbook
T	Trend
Tf	Shrubs
T1/T2/T3	Tier
t	tones
TACCC	transparency, accuracy, completeness, consistency, comparability
TOS	Total Organic Sludge
TOW	Total Organic Wastewater
UN	Nutritive Units
UNFCCC	United Nations Framework Convention on Climate Change
VFAFF	Forest Vegetation outside of the National Forest Fund
VS	Volatile Solid excretion per day on a dry-matter weight basis
Vv	Vineyards
WA	Weighted arithmetic average
WL	Wetland
Wetlands Supplement	2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands
WS_x	Fraction of wastewater treated anaerobically
Y_m	Methane conversion rate as the fraction of gross energy in feed converted to methane
YR	Year
ZuA	Water/Ponds
%	Percent

ZuV		Wet areas with vegetation
Notation Keys	IE	Included elsewhere
	NA	Not Applicable
	NE	Not Estimated
	NO	Not occurring
	C	Confidential

Executive Summary (ES)

ES.1. Background information on GHG inventories and climate change

Background information on climate change

Romania signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, and ratified it in 1994 by Law 24. Romania signed the Kyoto Protocol in 1999 and ratified it in January 2001, being the first Annex 1 Party that ratified it. Romania committed itself to reduce the greenhouse gas (GHG) emissions by 8% comparing to 1989 (base year) levels in the first commitment period 2008–2012. In the context of Decision no. 1/CMP. 8, for the second commitment period, 2013–2020, Romania committed to a GHG emissions reduction of 20% compared to the reference year, 1990, as part of a joint fulfillment with the other member States of European Union, based on the provisions in Article 4 of the Kyoto Protocol. Romania signed the Paris Agreement in 2016 and ratified it in 2017 by Law 57. The estimation of climate change impact in Romania has been realized through the elaboration of a study, by the Romanian Academy; in this sense, different atmosphere General Circulation Models were selected, models which reflect the best Romanian conditions. In accordance with the results generated by these models, presuming that the CO_2 atmospheric concentration would double, it is expected for the coming decades that the average global temperature will increase by 2.4–7.4^{0}C.

Background information on greenhouse gas inventories

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and to the Paris Agreement (PA), Romania is required to elaborate, regularly update and submit the National GHG Inventory Report. In compliance with the reporting requirements, this is the 34th version of the national inventory submitted by Romania, covering the national inventories of GHG emissions/ removals for the period 1989–2023. This inventory (comprising the current National Inventory Document and the associated CRTs) represents the 2025 National Greenhouse Gas Inventory Report of Romania under the UNFCCC and under the PA. This report documents Romania's National Inventory Report of anthropogenic emissions/ removals of direct GHGs: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3 and indirect GHGs: NO_x, CO, NMVOC and SO_2. This report includes descriptions of methods, data sources, key categories, quality assurance and quality control (QA/QC) activities carried out and a trend analysis. The NID also comprises a full quantitative assessment of the uncertainty; the uncertainty analysis is presented both on the sub–sectorial level and in the Annex II.

The reporting considers the elements that are available in accordance with the current functioning status of the ETF GHG Inventory Reporting Tool.

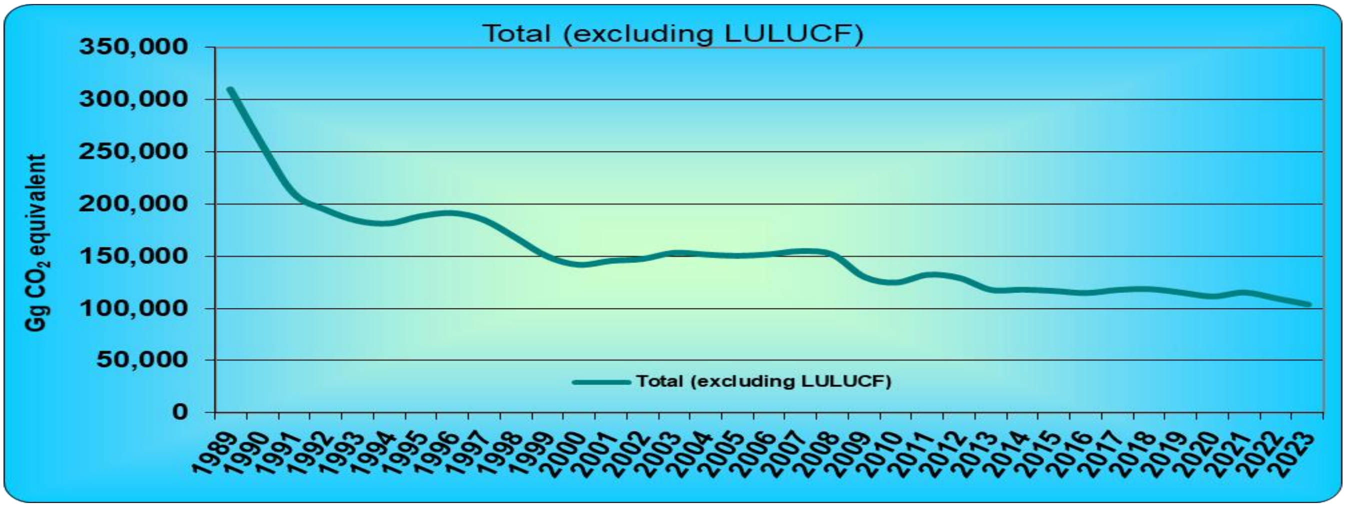
ES.2 Summary of trends related to national emissions and removals

For the trends analysis, the GHG emissions resulted from each sector were converted into CO_2 equivalent using the Global Warming Potential values provided by IPCC in the Fifth Assessment Report (the GWP values are presented in the Annex V.8 of the NID). The evolution of the total GHG emissions is presented in the next chart. The GHG emissions trend reflects the main trends in the economic development of the country. The period is characterized by a process of transition to a market economy, restructuring of the economy, bringing into operation of the first reactor at the Cernavoda nuclear power plant (1996). The emissions have started to increase after 2000 as a consequence of the economy revitalization; in 2009, the emissions decreased significantly comparing to the level in 2008 while in 2010 they continued to decrease, due to the economic crisis. In 2011, the emissions started to increase again while in 2012-2016 they decreased; in 2017–2018 they increased and in 2019-2020 they decreased, following the economic activities level. In 2021, the emissions increased, while in the period 2022-2023 they decreased. The largest contributor to the total national GHG emissions is CO_2, followed by CH_4 and N_2O. The share of each direct GHG in total emissions in 1989 and, respectively 2023, and the average share of each direct GHG in total emissions for 1989–2023 period are presented in the Table ES.1. The total GHG emissions excluding LULUCF, in CO_2 equivalent, during 1989–2023 period, are presented in the Figure ES.1.

Table ES.1 Share of each direct GHG in total emissions in 1989, 2023, and, respectively, 1989–2023 period

GHG	1989 (%)	2023 (%)	Average share for 1989–2023 period (%)
CO_2	67.51%	65.34%	67.06%
CH_4	23.93%	23.79%	24.23%
N_2O	7.27%	8.90%	7.66%
HFCs	0.00%	0.0191%	0.60%
PFCs	1.29%	0.00%	0.43%
SF_6	0.00%	0.00054%	0.02%
NF_3	0.00%	0.00%	0.00%

Figure ES.1 The total GHG emissions in CO_2 equivalent during 1989–2023 period



ES.3 Overview of source and sink category emission estimates and trends

The present National Inventory Report for 1989–2023 was compiled according to the specific provisions for GHG inventories set out in Decision 18/CMA 1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement and in Decision 5/CMA 3 Guidance for operationalizing the modalities, procedures and guidelines for the enhanced transparency framework referred to in Article 13 of the Paris Agreement, using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as well as the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement) and 2013 Supplement to the 2006 Guideliness for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement). The inventories cover all sectors and the majority of the IPCC categories. The direct GHGs (including groups of gases) included in the national inventory are:

- ❖ carbon dioxide (CO_2);
- ❖ methane (CH_4);
- ❖ nitrous oxide (N_2O);
- ❖ hydrofluorocarbons (HFCs);
- ❖ perfluorocarbons (PFCs);
- ❖ sulphur hexafluoride (SF_6);
- ❖ nitrogen trifluoride (NF_3).

The report also contains data on calculations of emissions of the indirect GHGs: NO_x, NMVOC, CO and SO_2, which should be included according to the reporting guidelines. GHG emissions inventories have been reported since the 2005 submission using the inventory dedicated software, delivered by the UNFCCC Secretariat.

This version of NID refers to figures in CRT generated using ETF GHG Inventory Reporting Tool.

ES.4 Other information

The emissions of the indirect GHGs (NO_x, NMVOC, CO and SO_2) are included in the report, as requested by the UNFCCC reporting guidelines. A detailed description of the calculation methodologies for these gases is not included in this report.

Fuel combustion activities in the Energy sector are the major sources of SO_2, NO_x and CO emissions.

Additional to the Energy sector, the NMVOC emissions are generated mainly through activities within the Industrial Processes and Product Use sector.

ES.5 Key category analysis (flexibility provided to those developing country Parties that need it in the light of their capacities as per para. 25 of the MPGs)

The key category analysis has been performed according to the provisions in Chapter 4 in Volume 1 of IPCC 2006, following the Approach 1. Separate key category analysis were conducted taking into account both the exclusion and inclusion of the LULUCF sector and also both level and trend criteria; all IPCC sectors and categories, sources and sinks (as suggested in Table 4.1 of Volume 1 of IPCC 2006), and gases were analyzed. KCA has been performed in the context of the ETF GHG Inventory Reporting Tool. KCA was conducted for every year of the characterized period.

Additional information is provided in Section 1.5.

ES.6 Improvements introduced (related to a non-mandatory provision as per para. 7 of the MPGs, with flexibility provided to those developing country Parties that need it in the light of their capacities as per para. 7(c) of the MPGs)

The elements associated to the areas of improvements are presented in the sectoral chapters, at subsectoral level, in the category–specific planned improvements sections, and in Chapter 10, in the planned improvements related section.

1 National circumstances, institutional arrangements and cross-cutting information

1.1 Background information on GHG inventories and climate change

1.1.1 Background information on climate change

In Romania, the climate variability will have direct effects on certain sectors such as agriculture, forestry, water management, residential and infrastructure will lead to changes in the vegetation cycle and to movement of the demarcation lines between forests and meadows, will determine the increase of the frequency and of the intensity of the extreme meteorological events (storms, floods, droughts). The changes in the Romanian climate regime are framed within the global context, considering the regional conditions: the temperature increase will be more pronounced during the summer, while in north–western Europe the most pronounced temperature increase is expected in winter. In Romania it is expected an increase of the average annual temperature compared to the 1980–1990 similar to that specific to the whole Europe, with small differences between the models results in respect to the first decades of the XXI century, and with larger differences in respect to the end of the same century:

- ❖ between 0.5°C and 1.5°C, for 2020–2029;
- ❖ between 2.0°C and 5.0°C, for 2090–2099, depending on the scenario (e.g. between 2.0°C and 2.5°C for the scenario foreseeing the lowest increase of the average global temperature and between 4.0°C and 5.0°C in case of the scenario with the most pronounced temperature increase).

Considering the pluviometrical view, over than 90% of the climate models forecasts for 2090–2099 pronounced droughts during the summer in Romania, especially in south and south–east (with negative deviations compared to 1980–1990 larger than 20%). Taking into account the winter precipitations, the deviations are smaller while the uncertainty is larger.

Effects on agriculture: The agriculture represents the most vulnerable sector, the elaborated studies highlighting the following aspects:

- ❖ wheat crop – a production increase with approximately 0.4–0.7 t/ha and the decrease of the vegetation season by 16–27 days;
- ❖ non-irrigated maize crop – the grains production increase with approximately 1.4–5.6 t/ha, a decrease of the vegetation season ranging between 2–32 days, a decrease of the vegetation cycle ranging between 2–19%; the estimated values depend on the model used;
- ❖ irrigated maize crop – the results depend on the models used and on the conditions of the locations chosen for data sampling;

- for analyzing the effects on the main crops agricultural productivity, several agro–meteorological models were used.

Effects on silviculture: Out of the national area, approximately 29% represent the area covered by forests; the forests are unevenly spread on the country's territory (approximately 51.9% in the mountain area, 37.2% in the hilly area and 10.9% in the plain area). In 2023 year, the forest land area accounted for approximately 6,993 thousand ha; associated to that, an additional area was destined to forest crop, production and management. In the lower and hilly forested areas, a considerable drop of the forests productivity is foreseen after 2040, due to the increase of the temperatures and to the decrease of the precipitations volume.

Effects on the water management: The hydrological consequences of the increase of the CO_2 atmospheric concentration are significant. The modeling of the effects produced by this phenomenon was realized focusing on the main hydrographic basins. The modeling results show the probable effects of the changes in the precipitations volume and in the evapo–transpiration.

Effects on the human establishments: The industrial, commercial, residential and infrastructure sectors (including the supplying with energy and water, the transport and the waste disposal) are vulnerable to the climate change. The main impact of the climate change on urban areas, on infrastructure and on constructions is mainly linked to the effects of extreme meteorological events such as heat waves, pronounced snowfalls, storms, and floods, increase of the slopes instability and the modification of some geophysical properties. Thus, urban planning and designing of an appropriate infrastructure plays an important role in minimizing the impact of climate change and in reducing the risk on the anthropic environment.

1.1.2 Background information on greenhouse gas inventories

As a Party to the UNFCCC and to the PA, Romania is required to produce and regularly update the national GHG inventory. According to the Decision 18/CMA. 1 on Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement, each Party shall provide a national inventory report of anthropogenic emissions by sources and removals by sinks of GHGs; the national inventory report consists of a national inventory document and the common reporting tables. This is the 34th complete submission of the national GHG inventory of Romania. The structure of the National Inventory Document is in line with the provisions in Annex V in Decision 5/CMA. 3 Outline of the national inventory document, pursuant to the modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement; the CRTs follow the format established through Annex I in Decision 5/CMA. 3 Common reporting tables for the electronic reporting of the information in the national inventory reports of anthropogenic emissions by sources and removals by sinks of greenhouse gases. This inventory (comprising the current National Inventory Document and the associated CRTs) represents the 2025 National Greenhouse Gas Inventory Report of Romania under the UNFCCC and under the PA. For this submission, Romania prepared the CRTs and the database containing emissions/removals estimates and background data for 1989–2023 period and the National Inventory Document. The greatest attention during the preparation was payed to the direct GHGs – CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3. In addition, the indirect GHGs (NO_X, CO, NMVOCs, and SO_2) were also taken into account. The GHG inventories submitted annually by Parties are subject to reviews by Expert Review Teams coordinated by the UNFCCC Secretariat. Up to now, the GHG inventories of Romania were reviewed under UNFCCC/Article 8 of the KP as presented in Table 1.1.

Table 1.1 Overview of the Romanian GHG Inventories review under UNFCCC/Article 8 of the KP

Year	Submission	Review process
2002	CRT and draft NID submitted (late submission)	No Review
2003	CRT and NID submitted	In–Country Review
2004	CRT and NID submitted	Desk Review
2005	CRT Reporter database, CRTs for LULUCF and NID submitted	Centralized Review
2007	2nd version of the 2006 submission: CRT Reporter database, CRT and NID + Initial Report of Romania under the Kyoto Protocol	In–Country Review
2008	2007 and 2008 submissions: CRT Reporter database, CRT and NID	Centralized Review
2009	2009 submission: CRT Reporter database, CRT and NID	Centralized Review
2010	2010 submission: CRT Reporter database, CRT and NID	Centralized Review
2011	3rd version of the 2011 submission	In–Country Review
2012	2nd version of the 2012 submission	Centralized Review
2013	1st version of the 2013 submission	Centralized Review
2014	1st version of the 2014 submission	Centralized Review
2016	2nd version of the 2015 and 2016 submission	Centralized Review
2018	2018 submission	In–Country Review
2020	2020 submission	Centralized Review
2022	2022 submission	Centralized Review

The reports on these reviews can be found on the UNFCCC website.

1.2 A description of national circumstances and institutional arrangements

1.2.1 National entity or national focal point

1.2.1.1 Institutional, legal and procedural arrangements

The elements on the implementation of the National Inventory Arrangements under the UNFCCC and under the Paris Agreement are presented below.

The Governmental Decisions (GD) no. 1022/2016, 120/2014 and 668/2012 for modifying and completing the GD no. 1570 for establishing the National System for the estimation of anthropogenic greenhouse gas emissions levels from sources and removals by sinks, adopted in 2007, and the subsequent relevant procedures, the GD no. 1000/2012 on the reorganization and functioning of the National Environmental Protection Agency and of the subordinated public institutions, the GD no. 38/2015 on the organization and functioning of the Ministry of Environment, Waters and Forests and the Governmental Decision no. 600/2022 on the establishment of measures on implementing the provisions in Art. 26.2 in Regulation (EU) 2018/1999 of the European Parliament and of the Concil of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council are regulating all the institutional, legal and procedural aspects for supporting the Romanian authorities to estimate the greenhouse gas emissions/removals levels, to report and to archive the National Inventory Report (NIR) information. The National Inventory Arrangements (NIA) are based on the provisions in the Decision 24/CP. 19 on the Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention, and complies with the provisions of the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, with the provisions of the Commission Implementing Regulation (EU) no. 1208/2020 of 7 August 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014 and of other subsequent legislation.

The main objective of the Governmental Decision no. 1570/2007, as ulteriorly modified and completed, is to ensure the fulfillment of the relevant provisions and the obligations of Romania under the United Nations Framework Convention on Climate Change (UNFCCC) and under the European Union legislation.

Starting with 1 April 2013, the competent authority, which was responsible for administrating the National Inventory Arrangements and National System under the Kyoto Protocol, was the Ministry of Environment and Climate Change (MECC), and, ulteriorly, following the reorganization of the institution, the Ministry of Environment, Waters and Forests (MEWF). Anteriorly, the competent authority was the National Environmental Protection Agency (NEPA), under the subordination of the MECC. Based on the GD no. 48/2013, all NEPA climate change related structure, personnel, attributions and responsibilities were took over by MECC, in order to improve the institutional arrangements and capacity within the climate change domain, thus increasing the efficiency in activities implementation also in respect to the NIA/NS/NGHGI administration. Starting with 4 July 2016, the competent authority, which is responsible for administrating the National Inventory Arrangements, is the National Environmental Protection Agency, based on the relevant provisions in the Government Urgency Ordinance no. 9/2016 and in the Governmental Decision no. 284/2016.

Starting with November 2024, the implementation of the technical activities related to the Land Use, Land-Use Change and Forestry (LULUCF) Sector is subject to the Governmental Decision no. 1415/2024 for defining the obligations on the administration of the Agriculture subdomain and of the LULUCF subdomain, part of the Climate change domain; based on the mentioned decision, responsibilities of administrating the Agriculture and LULUCF Sector of the inventory were allocated as follows:

- ❖ the National Research and Development Institute for Cryogenic and Isotopic Technologies Rm. Valcea:
  - in respect to the Agriculture Sector: administrates directly and/or through collaboration with other organizations a series of technical parameters;
  - in respect to the LULUCF Sector: is monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/removals in soils; the institute is also the technical coordinator of the LULUCF Sector activities.
- ❖ National Institute for Research and Development in Forestry "Marin Dracea" is monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;

- ❖ National Research and Development Institute for Soil Science, Agrochemistry and Environment Bucharest is monitoring and estimating/reporting the GHG emissions/removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- ❖ the National Environmental Protection Agency is implementing a series of technical activities following the receipt of the deliverables from the institutes and administrative activities to allow for a continuous implementation of specific activities;
- ❖ the Ministry of Environment is analyzing and approving the consolidated version of the LULUCF inventory and is ensuring, depending on needs, the Romania's representation in the associated inventory review, together with NEPA and institutes.

The implementation of activities by the three institutes previously mentioned, is based also on the allocation of adequate financial resources through the Environment Fund Administration and on individual contracts with the Environment Fund Administration.

Based on the Governmental Decision no. 590/2019 for defining the obligations on the administration of the LULUCF subdomain, part of the Climate change domain, and the subsequent ministerial order, during August 2019–December 2023, the responsibilities of administrating the LULUCF Sector of the inventory were allocated as follows:

- ❖ the National Research and Development Institute for Cryogenic and Isotopic Technologies Rm. Valcea was monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/ removals in soils; the institute was also the technical coordinator of the LULUCF Sector activities;
- ❖ National Institute for Research and Development in Forestry "Marin Dracea" was monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;
- ❖ National Research and Development Institute for Soil Science, Agrochemistry and Environment Bucharest was monitoring and estimating/reporting the GHG emissions/ removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- ❖ the National Institute for Aerospace Research "Elie Carafoli" was monitoring the land use and land-use change in a spatial–explicit system, using aero photogrammetry and aerial surveillance technologies, at national level;
- ❖ the National Environmental Protection Agency was implementing a series of technical activities following the receipt of the deliverables from the institutes and administrative activities to allow for a continuous implementation of specific activities;
- ❖ the Ministry of Environment was analyzing and approving the consolidated version of the LULUCF

inventory and was ensuring, depending on needs, the Romania's representation in the associated inventory review, together with NEPA and institutes.

The implementation of activities by the four institutes previously mentioned, was based also on the allocation of adequate financial resources through the Environment Fund Administration and on individual contracts with the Environment Fund Administration.

National Inventory Arrangements are designed and operated:

- to ensure the transparency, consistency, comparability, completeness and accuracy of inventories;
- to ensure the quality of inventories through the planning , preparation and management of inventory activities.

The definition and characteristics of the Romanian National Inventory Arrangements for the estimation of anthropogenic GHG emissions by sources and removals by sinks (NIA) comprise:

- includes all institutional, legal and procedural arrangements made as a Party included in Annex I for estimating anthropogenic GHG emissions by sources and removals by sinks, and for reporting and archiving inventory information;
- represents a system for the collection, processing and adequate presentation of data and information for the elaboration of the NIR;
- are designed and operated to ensure the transparency, consistency, comparability, completeness and accuracy of inventories as defined in the guidelines for the preparation of inventories by Parties included in Annex I, in accordance with relevant decisions of the COP;
- are designed and operated to ensure the quality of the NIR through planning, preparation and management of inventory activities;
- are designed and operated to support compliance with the UNFCCC and with the European Union legislation commitments related to the estimation of anthropogenic GHG emissions by sources and removals by sink;
- are designed and operated to consistently estimate anthropogenic emissions by all sources and removals by all sinks of all GHGs, as covered by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol and by the 2013 Supplement to the 2006 Guideliness for National Greenhouse Gas Inventories: Wetlands, in accordance with relevant decisions of the COP and/or CMA.

The elements on the implementation of the NIA general functions are described below:

A. *Establish and maintain the institutional, legal and procedural arrangements necessary to perform the functions for NIA, as appropriate, between the government agencies and other entities responsible for* *the performance of all functions defined in these guidelines*

Institutional arrangements

The elements characterizing the institutional arrangements comprise:

- ❖ according to legal provisions in place, the single national entity with overall responsibility for the national inventory, including with the responsibilities of administrating the NIA and of preparation and management of the NGHGI, is the National Environmental Protection Agency.

Before 1 April 2013, the competent authority was the National Environmental Protection Agency (NEPA), under the subordination of the MECC. Based on the GD no. 48/2013, all NEPA climate change related structure, personnel, attributions and responsibilities were took over by MECC, in order to improve the institutional arrangements and capacity within the climate change domain, thus increasing the efficiency in activities implementation also in respect to the NS/NGHGI administration; before 4 July 2016, the competent authority was the Ministry of Environment, Waters and Forests.

- ❖ central and territorial public authorities, research and development institutes and other public organizations under the authority, in the subordination or in the coordination of central public authorities, owners and professional associations, economic operators and other relevant organizations have the obligation of providing to NEPA the necessary activity data, emission factors and associated uncertainty data;
- ❖ the main activity data supplier is the National Institute for Statistics through the yearly–published documents as the National Statistical Yearbook and the Energy Balance and other documents;
- ❖ the characteristics of the institutional arrangements include:
  - ➢ centralized approach – NEPA maintain a large degree of control and decision making authority over the inventory preparation process;
  - ➢ in-sourced approach, in majority – the major part of the inventory is prepared by NEPA (governmental agency);
  - ➢ single agency – the single national entity is housed within a single governmental organization;
  - ➢ separate approach – the inventory related work is not integrated with other air pollutant inventories work; however, cross checking activities are periodically implemented.
- ❖ the institutional arrangements currently used in Romania are presented in the Figure 1.1;
- ❖ in 2011, the NGHGI Land Use, Land–Use Change and Forestry (LULUCF) Sector, both under the UNFCCC and KP, was administrated by the Forest Research and Management Planning Institute (ICAS), based on a contract with Ministry of Environment and Forests, in the context of the study “NGHGI LULUCF both under the UNFCCC and KP obligations”;
- ❖ in 2012–2014 period, the NGHGI LULUCF Sector, both under the UNFCCC and KP, was administrated

by ICAS, based on the Protocol of collaboration no. 3029/MMP-RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS; ICAS also contributed by developing:

- in 2012, the studies mentioned in Annex V.15 Table 3–rows 3 and 4;
- in 2013, the studies mentioned in Annex V.15 Table 2 rows 3 and 4;
- in 2014, the study mentioned in Annex V.15 Table 1–row 4.

❖ on an undetermined period, the preparation of Road transport category estimates based on COPERT 4 model is administered also based on the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior;

❖ development of country-specific values associated to several NGHGI sectors has been also supported by the Institute for Studies and Power Engineering (ISPE) through the development:

- in 2011, of the study mentioned in Annex V.15 Table 4–row 1;
- in 2013, of the study mentioned in Annex V.15 Table 2–row 2;
- in 2014, of the studies mentioned in Annex V.15 Table 1–rows 1, 2 and 3.

❖ based on the study mentioned in Annex V.15 Table 2–row 1, Denkstat improved the system of administrating the HFCs, PFCs and SF_6 data and information;

❖ in 2017, the LULUCF Sector both under the UNFCCC and KP has been further supported through the development of the study "Report on the technical specifications necessary for the Terms of Reference for acquiring the study Administration of the Land Use, Land-Use Change and Forestry Sector of NGHGI (CRT Sector 4) according with the obligations under the United Nations Framework Convention on Climate Change and with the obligations under the Kyoto Protocol", by GEOSTUD;

❖ based on the Governmental Decision no. 590/2019, during August 2019-December 2023, the responsibilities of administrating the LULUCF Sector of the inventory were allocated as follows:

- ICSI was monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/removals in soils; the institute was also the technical coordinator of the LULUCF Sector activities;
- INCDS was monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;
- ICPA was monitoring and estimating/reporting the GHG emissions/removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- INCAS was monitoring the land use and land–use change in a spatial–explicit system, using aero photogrammetry and aerial surveillance technologies, at national level;
- NEPA was implementing a series of technical activities following the receipt of the deliverables from

the institutes and administrative activities to allow for a continuous implementation of specific activities;

- MEWF was analyzing and approving the consolidated version of the LULUCF inventory and was ensuring, depending on needs, the Romania's representation in the associated inventory review, together with NEPA and institutes.

  The implementation of activities by the four institutes previously mentioned, was based also on the allocation of adequate financial resources through the Environment Fund Administration and on individual contracts with the Environment Fund Administration.

❖ the "Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO_2) and other greenhouse gas emissions" study was carried out in 2011 by the Institute for Studies and Power Engineering (ISPE); specific elements comprise:

➢ package 1 activities – improving NS:

- evaluation of NS and of the relevant technical assistance projects previously implemented;
- establishing the measures necessary for improving the institutional capacity and structure for implementing the NS–the contractor identified the institutional, legal and procedural measures for assuring the compliance of the NGHGI with the applicable standards, including solutions for improving the sectorial databases;
- elaboration of draft legal proposals for an efficient administration of the NGHGI. The GD no. 1570/2007 was updated accordingly;
- general training session for improving the expertise of the personnel working in the climate change field, at the central administration and subsequent level.

➢ package 2 activities – developing the institutional capacity for reporting the GHG emissions/ removals:

- evaluation of the Romanian capacity to report the GHG emissions according to the European Union requirements;
- improving the reporting capacity of the authorities in Romania;
- specific training session for improving the expertise of NEPA team on the attributions/ responsibilities of administrating the NS/ NGHGI.

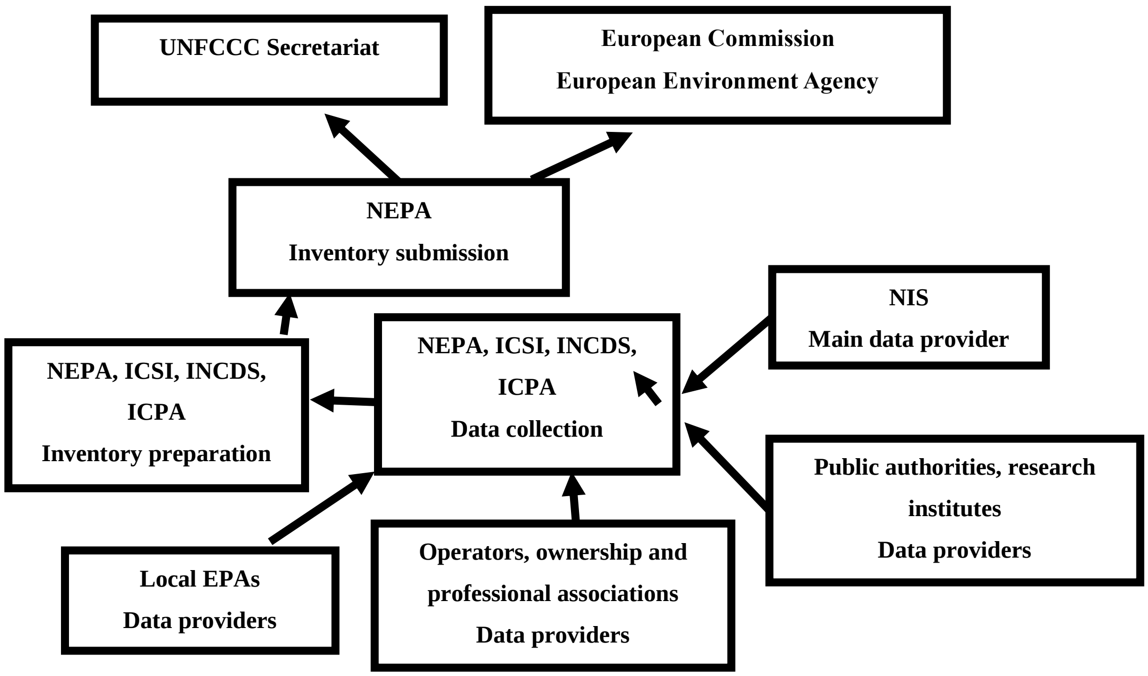
➢ package 3 activities–establishing the programs and measures necessary for determining the emission factors and other national relevant parameters.

❖ during 2011–january 2012, NEPA performed an analysis on improving the institutional and legal arrangements part of the NS;

❖ the results of previously two specified activities were corroborated and were also used for updating the GD no. 1570/2007;

❖ the Ministry of Environment, Waters and Forests officially considers and approves the National GHG Inventory Report; NEPA submits the National GHG Inventory Report to the UNFCCC Secretariat, the European Commission and the European Environment Agency taking into account the specific deadlines.

Figure 1.1 Current national inventory system description



Legal and procedural arrangements

The legal and procedural framework specific to the NIA include:

❖ GD no. 1022/2016 for modifying the GD no. 1570/2007 for establishing the National System for the estimation of anthropogenic greenhouse gas emissions levels from sources and removals by sinks of all GHGs, regulated through the KP, and the GD no. 120/2014 for modifying and completing the GD no. 1570/2007 for establishing the National System for the estimation of anthropogenic greenhouse gas emissions levels from sources and removals by sinks of all GHGs, regulated through the KP, and also for establishing some measures on implementing the Regulation (EU) no. 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and relealing Decision no. 280/2004/EC;

❖ GD no. 1000/2012 on the reorganization and functioning of the National Environmental Protection Agency and of the subordinated public institutions;

❖ GD no. 38/2015 on the organization and functioning of the Ministry of Environment, Waters and Forests;

- ❖ GD no. 668/2012 for modifying and completing the GD no. 1570/2007 for establishing the National System for the estimation of anthropogenic greenhouse gas emissions levels from sources and removals of CO_2 by sinks, regulated through the KP;
- ❖ GD no. 1570/2007 for establishing the National System for the estimation of anthropogenic greenhouse gas emissions levels from sources and removals of CO_2 by sinks, regulated through the KP;
- ❖ GD no. 600/2022 on establishing some measures for implementing the provisions in Art. 26.2 in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council;
- ❖ Government Urgency Ordinance no. 9/2016 for modifying and completing the Government Urgency Ordinance no. 195/2005 on the environment protection, as well as modifying Article 3 in the Government Urgency Ordinance no. 32/2015 on the establishment of Forestry Guards;
- ❖ Government Decsion no. 284/2016 for modifying and completing the Government Decision no. 38/2015 on organization and functioning of the Ministry of Environment, Waters and Forests, as well as other normative acts;
- ❖ Governmental Decision no. 1415/2024 for defining the obligations on the administration of the Agriculture subdomain and of the LULUCF subdomain, part of the Climate change domain;
- ❖ Ministry of Environment Order (MoEO) no. 1376/2008 for approving the Procedure on NGHGI reporting and the modality for answering to the observations and questions raised following the NGHGI review;
- ❖ MoEO no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI;
- ❖ MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels;
- ❖ MoEO no. 1602/2014 on approving the Quality Assurance and Quality Control Plan associated to the National Greenhouse Gas Inventory;
- ❖ Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior, on the preparation of Road transport category estimates based on COPERT 4 model.

B. Ensure sufficient capacity for timely performance of the NIA functions, including data collection for *estimating anthropogenic GHG emissions by sources and removals by sinks and arrangements for technical competence of the staff involved in the inventory development process*

Specific elements include:

- ❖ following the implementation of the Governmental Urgency Ordinance no. 9/2016, of the Governmental Decision no. 284/2016 and of an additional decision, 11 posts are available in the National System for Estimating the GHG Emissions Unit in the Climate Change Directorate in the NEPA, exclusively for administrating the NIA/NIR;
- ❖ previously, following the 2013 governmental decision on government restructuration and ulterior reorganizations, 12 posts were available in the National System for Estimating the GHG Emissions Unit–Climate Change General Directorate in the MEWF, exclusively for administrating the NIA and NS/NGHGI; the activity continued in an optimal manner, considering also that the attributions and responsibilities have been reallocated to existing personnel;
- ❖ previously, following the governmental approval of taking over the NEPA climate change related structure, personnel, attributions and responsibilities, starting with 1 April 2013, 14 people (out of 16 available posts) in the National System for Estimating the GHG Emissions Unit–Climate Change General Directorate in the MECC had exclusively the responsibilities of administrating the NS/NGHGI.

Taking over the NEPA climate change related structure, personnel, attributions and responsibilities by MECC, was performed in order to improve the institutional arrangements and capacity within the climate change domain, thus increasing the efficiency in activities implementation also in respect to the NIA and NS/NGHGI administration. Appropriate working space, facilities and necessary IT equipment were provided to the MECC personnel took over from NEPA.

- ❖ following the governmental approval of establishing a new unit at NEPA and as a result of finalization of the recruitment procedure (end of August 2011), 16 people in the National System for Estimating the GHG Emissions Unit–Climate Change and Sustainable Development Directorate had exclusively the responsibilities of administrating the NS/NGHGI (previously, 5 out of maximum 14 people in the Climate Change Unit–Climate Change, Sustainable Development Directorate of NEPA had the responsibilities of administrating the NS/NGHGI while the Climate Change Unit covered also the administration of the European Union Emission Trading Scheme, of the National GHG Emissions Registry and of other climate change domain related issues);
- ❖ additionally to the elements presented at second point:
  - o appropriate working space and facilities have been provided;
  - o the necessary IT equipment has been procured through the support of study “Environmental Integrated Informational System”;

- training the dedicated staff was subject to the UNFCCC training courses and of the study performed in 2011 “Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO_2) and other greenhouse gas emissions”; additionally, the European Environment Agency (EEA) through the European Topic Centre for Air pollution and Climate change Mitigation provided both in 2011 and 2012 technical assistance to the NS/NGHGI dedicated team;
- on contractual basis, the NEPA personnel administrating the NGHGI Energy Sector received in 2011 technical assistance from the Environment Agency of Austria, the results being incorporated in the NGHGI 2012;
- training was based on the Schedule for training of new staff part of the NEPA team dedicated to the administration of the NS and the NGHGI, respectively (Table 1);
- general training session for improving the expertise of the personnel working in the climate change field, at the central administration and subsequent level, including personnel from NGHGI data/information providers/potential providers, was held in 2011 in the context of the “Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO_2) and other greenhouse gas emissions” study;
- training of NEPA team dedicated to the administration of the NS and the NGHGI and of other partners in the NS on key category analysis and uncertainty analysis related issues was also performed in 2012 by the Environment Agency of Austria and University of Graz consortium in the general framework of implementation of the study “Environmental Integrated Informational System” (by the SC Asesoft International SA–SC Team Net International SA–SC Star Storage SRL consortium); additional training on the use of the key category analysis and, respectively, uncertainty analysis related software developed by the Environment Agency of Austria and University of Graz consortium, have been provided to NEPA team by the SC Asesoft International SA–SC Team Net International SA–SC Star Storage SRL consortium in 2013.

❖ additional training in respect to the LULUCF Sector has been provided to NEPA in 2017 through the development of the study “Report on the technical specifications necessary for the Terms of Reference for acquiring the study Administration of the Land Use, Land–Use Change and Forestry Sector of NGHGI (CRT Sector 4) according with the obligations under the United Nations Framework Convention on Climate Change and with the obligations under the Kyoto Protocol”;

❖ starting with November 2024, the implementation of the technical activities related to the Land Use, Land-Use Change and Forestry (LULUCF) Sector is subject to the Governmental Decision no. 1415/2024 for defining the obligations on the administration of the Agriculture subdomain and of the LULUCF subdomain, part of the Climate change domain; based on the mentioned decision, responsibilities of administrating the Agriculture and LULUCF Sector of the inventory were allocated as follows:

- the National Research and Development Institute for Cryogenic and Isotopic Technologies Rm. Valcea:
  - in respect to the Agriculture Sector: administrates directly and/or through collaboration with other organizations a series of technical parameters;
  - in respect to the LULUCF Sector: is monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/removals in soils; the institute is also the technical coordinator of the LULUCF Sector activities.
- National Institute for Research and Development in Forestry "Marin Dracea" is monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;
- National Research and Development Institute for Soil Science, Agrochemistry and Environment Bucharest is monitoring and estimating/reporting the GHG emissions/removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- the National Environmental Protection Agency is implementing a series of technical activities following the receipt of the deliverables from the institutes and administrative activities to allow for a continuous implementation of specific activities;
- the Ministry of Environment is analyzing and approving the consolidated version of the LULUCF inventory and is ensuring, depending on needs, the Romania's representation in the associated inventory review, together with NEPA and institutes.
- the implementation of activities by the three institutes previously mentioned, is based also on the allocation of adequate financial resources through the Environment Fund Administration and on individual contracts with the Environment Fund Administration.

❖ based on the Governmental Decision no. 590/2019, during August 2019–December 2023 period, the responsibilities of administrating the LULUCF Sector of the inventory were allocated as follows:

- ICSI was monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/removals in soils; the institute is also the technical coordinator of the LULUCF Sector activities;
- INCDS was monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;
- ICPA was monitoring and estimating/reporting the GHG emissions/removals associated to the soils in

Cropland, Grassland, Wetlands, Settlements and Other Land categories;

- INCAS was monitoring the land use and land-use change in a spatial–explicit system, using aero photogrammetry and aerial surveillance technologies, at national level;
- NEPA was implementing a series of technical activities following the receipt of the deliverables from the institutes and administrative activities to allow for a continuous implementation of specific activities;
- MEWF was analyzing and approving the consolidated version of the LULUCF inventory and was ensuring, depending on needs, the Romania’s representation in the associated inventory review, together with NEPA and institutes;
- the implementation of activities by the four institutes previously mentioned, was based also on the allocation of adequate financial resources through the Environment Fund Administration and on individual contracts with the Environment Fund Administration.

❖ following the establishment of new arrangements on administrating the LULUCF Sector in 2019 (as presented above), ICSI, INCDS, ICPA, INCAS and NEPA personnel received specific training through the implementation of the “Support for Capacity Building in MS to implement FRLs and improvements of GHG inventories as requested by the LULUCF Regulation (EU) No 2018/841” workshop, support provided by representatives of the International Institute for Applied Systems Analysis and the European Commission under the project Support for the Technical Support for capacity building in Member States to implement Forest Reference Levels and improvements of greenhouse gas inventories;

❖ based on the GD no. 1570/2007 as ulteriorly modified and completed, all entities/organizations involved in implementing the NIA functions are obliged to ensure sufficient capacity for timely performance of NIA functions and arrangements for technical competence of the staff involved in the inventory development process.

Table 1.2 Schedule of training of new staff part of the NEPA team dedicated to the administration of the NS and NGHGI

No	Activity	Period/ Deadline	Persons subject to training	Responsible persons	Documents to be considered
1	Improving the technical knowledge based on international and national documents related to the National System for Estimating the Greenhouse Gas Emissions/ Removals (NS) and the Greenhouse Gas Inventory (NGHGI)	1 September 2011–10 March 2012	All new Sectorial Experts (SEs)	GHG Inventory coordinator	Governmental Decision (GD) no. 1570/2007, Ministry of Environment Order (MoEO) no. 1376/2008 for approving the Procedure on NGHGI reporting and the modality for answering to the observations and questions raised following the NGHGI review; MoEO no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI; NEPA’s President Decision no. 23/2009 for approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels; NEPA’s President Decision no. 24/2009 for approving the QA/QC Procedure related to the NGHGI, National Inventory Report-Romanian version-NGHGI 2009, NGHGI 2011, 2010, 2009, Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11 (UNFCCC Reporting Guidelines), IPCC good practice guidance (IPCC GPG 2000), IPCC good practice guidance for LULUCF (IPCC GPG 2003), IPCC 1996.
2	Training in the context of the study “Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO_2) and other greenhouse gas emissions”	31–Oct–11	All new SEs	GHG Inventory coordinator	

No	Activity	Period/ Deadline	Persons subject to training	Responsible persons	Documents to be considered
3	On-line UNFCCC Secretariat and GHG Management Institute reviewer training courses	3 October–31 December 2011	All new SEs	GHG Inventory coordinator	UNFCCC Secretariat and GHG;Management Institute on–line training courses, IPCC GPG 2000, IPCC GPG 2003, IPCC 1996
4	Training provided by the – European Environment Agency and European Topic Centre for Air pollution and Climate change Mitigation in respect to Energy, Industrial processes, Solvents and other product use and Waste NGHGI Sectors; –European Commission–Joint Research Centre, in respect to the Agriculture and Land Use, Land–Use Change and Forestry (LULUCF) Sectors	15 October–31 December 2011	All new SEs	GHG Inventory coordinator	IPCC GPG 2000, IPCC GPG 2003, IPCC 1996
5	Implementing together with the more senior staff, based on a sectorial approach, all activities pertaining to the NS and NGHGI administration, including the activities related to NGHGI preparation plan and NGHGI improvement plan	1 September 2011–10 May 2012	All new SEs	GHG Inventory coordinator, QA/QC coordinator, older SEs	All documents at point 1, as well as other relevant documents

C. Prepare national annual inventories in a timely manner in accordance with the relevant decisions of the COP and/or CMA

Specific elements comprise:

- ❖ as a Party to the UNFCCC, PA and as a Member State of the European Union, Romania annually submits the NIR;
- ❖ 2025 submission of the NIR constitutes the 34th complete submission of the Romania's inventory;
- ❖ Romania submits the NIR within the relevant deadline: 15 January and 15 March, to the European Commission and to the European Environment Agency, and 15 April, to the UNFCCC Secretariat;
- ❖ the NIR is prepared in accordance with relevant decisions of the COP, COP/MOP and/or CMA.

D. Undertake specific functions relating to inventory planning, preparation and management

Romania is undertaking all specific functions relating to inventory planning, preparation and management, in accordance with the specific provisions under the UNFCCC, PA and EU; their implementation is described below.

The elements on the implementation of NIA inventory planning specific functions are presented below:

A. Designate a single national entity with overall responsibility for the national inventory

According to the legal provisions in place, the single national entity with overall responsibility for the national inventory, including with the responsibility of administrating the NIA, is NEPA.

B. *Make available the postal and electronic addresses of the national entity responsible for the inventory*

The name and contact information for the national entity and its designated representative with overall responsibility for the national inventory are:

- ❖ national entity:
  - ➢ name: National Environmental Protection Agency;
  - ➢ address: Splaiul Independenţei no. 294, Sector 6, Bucharest;
  - ➢ telephone: +40-21-2071101; fax: +40-21-207.11.03.
- ❖ designated representative with overall responsibility:
  - ➢ name: Sorin Deaconu;
  - ➢ telephone: +40-21-2071101; fax: +40-21-2071103.
  - ➢ e-mail: sorin.deaconu@anpm.ro.

C. Define and allocate specific responsibilities in the inventory development process, including those relating to choice of methods, data collection, particularly activity data and emission factors from statistical services and other entities, processing and archiving, and QC and QA

Elements on defining and allocating specific responsibilities in the inventory development process include:

- ❖ the roles of, and cooperation between, government organizations and other entities involved in the inventory preparation, are established within the GD no. 1570/2007 as ulteriorly modified and completed, in the GD no. 1415/2024 and, respectively, in the GD no. 600/2022;

- ❖ every person part of NEPA team managing the NIA/NIR has assigned specific/clear attributions/ responsibilities comprising (through individual Job fiche):
  - ➢ sector management;
  - ➢ implementation of other sector relevant activities:
    - ▪ key category analysis;
    - ▪ uncertainty analysis;
    - ▪ QA/QC;
    - ▪ data/information archiving;
    - ▪ coordinating the QA/QC activities;
    - ▪ coordinating the team/ activities relevant to the NIA/NIR administration;
    - ▪ managing the archiving system.

D. Elaborate an inventory QA/QC plan which describes specific QC procedures to be implemented during the inventory development process, facilitate the overall QA procedures to be conducted, to the extent possible, on the entire inventory and establish quality objectives

Specific elements comprise:

- ❖ QA/QC plan is intended to ensure the fulfillment of the NIR principles in Romania.
- ❖ QA/QC plan is part of the QA/QC Programme and of the MoEO no. 1602/2014 on approving the Quality Assurance and Quality Control Plan associated to the National Greenhouse Gas Inventory;

Main objectives of the plan include:

- ❖ applying greater QC effort for key categories and for those categories where data and methodological changes have occurred recently;
- ❖ periodically checking the validity of all information as changes in reporting, methods of collection or frequency of data collection occur;
- ❖ conducting the general procedures outlined in QC procedures (Tier 1) on all parts of the inventory over a complete exercise.

Detailed specific elements are presented within Section 1.2.3.

E. Establish processes for the official consideration and approval of the inventory, including any recalculations, prior to its submission and to respond to any issues raised by the inventory review process

Specific elements for the official consideration and approval of the inventory, including any recalculations, prior to its submission, comprise:

- ❖ defined within the GD no. 1570/2007 as ulteriorly modified and completed, within the GD no. 1020/2012 and within the MoEO no. 1376/2008;

- ❖ NIR verification and evaluation is performed at ME level;
- ❖ NEPA personnel considers the observations and comments received, and as appropriate updates the NIR, aiming to its improvement, as soon as possible considering the relevant reporting guidelines.

In respect to the establishment of a process for responding to any issues raised by the inventory review process:

- ❖ based on legal provisions in place, NEPA ensures the availability of human and financial resources for the implementation of review activities;
- ❖ NEPA ensures an efficient collaboration with the review teams under the coordination of the UNFCCC Secretariat, through the provision of all information and responses to the associated observations and questions, according to the relevant legal provisions;
- ❖ ICSI, INCDS and ICPA participates as technical expert to represent Romania within the review of the LULUCF Sector of the inventory, under UNFCCC and PA, and to provide additional elements and/ or updated elements following the request of the Technical Expert Review Team under the coordination of the UNFCCC Secretariat, together with NEPA representatives.

Elements relevant to the implementation of the NIA specific inventory preparation functions are described below:

A. Identify key source categories following the methods described in the IPCC good practice guidance

Specific elements comprise:

- ❖ key category analysis (KCA) is performed according to the provisions in Chapter 4 in Volume 1 of IPCC 2006, following the Approach 1;
- ❖ KCA was conducted both considering the exclusion and inclusion of the LULUCF sector and, also, both level and trend criteria;
- ❖ all IPCC sectors and categories, sources and sinks (as suggested in Table 4.1 of Volume 1 of IPCC 2006), and gases were analyzed;
- ❖ KCA was conducted for every year of the characterized period;
- ❖ KCA has been performed in the context of the ETF GHG Inventory Reporting Tool;
- ❖ results are presented in NID, within:
  - ➢ Chapter 1, at general level;
  - ➢ Annex 1.
- ❖ in the context of the ETF GHG Inventory Reporting Tool use, the results of the key category analysis are presented in CRT table 7, for every year in the 1989–2023 period;
- ❖ KCA is used for prioritize efforts for improving the quality of the NIR-the relevant implemented and

future studies referring mainly to the use of higher Tier methods in key categories.

Further elements are presented in Section 1.4.

B. Prepare estimates in accordance with the methods agreed to be used under UNFCCC and PA, and ensure that appropriate methods are used to estimate emissions from key source categories

Specific elements comprise:

- ❖ emissions from non-LULUCF Sectors are estimated following the IPCC 2006;
- ❖ emissions/removals from LULUCF Sector are estimated following the IPCC 2006, Wetlands Supplement and KP Supplement;
- ❖ estimation methods selection is based on MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels;
- ❖ higher estimates/tier estimates and a significant decrease of the number of categories characterized using the NE notation key are available for the majority of non-LULUCF key categories due to:
  - NEPA's/MECC's work;
  - to the implementation of dedicated studies,
    - in 2011, the study mentioned in Annex V.15 Table 4–row 1;
    - in 2013, the studies mentioned in Annex V.15 Table 2–rows 1 and 2;
    - in 2014, the studies mentioned in Annex V.15 Table 1–rows 1, 2 and 3.
  - to the implementation of the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior.
- ❖ development of emission/removal factors, higher estimates/tier estimates and a significant decrease of the number of categories characterized using the NE notation key are available for the LULUCF Sector under the UNFCCC through the implementation of:
  - ICSI's, INCDS's and ICPA's work;
  - ICSI's, INCDS's, ICPA's and INCAS's work, during August 2019–December 2023 period;
  - the studies:
    - in 2011, the study mentioned in Annex V.15 Table 4–row 2;
    - in 2012, the studies mentioned in Annex V.15 Table 3–rows 3 and 4;
    - in 2013, the studies mentioned in Annex V.15 Table 2–rows 3 and 4;
    - in 2014, the study mentioned in Annex V.15 Table 1–row 4.
  - the Protocol of collaboration no. 3029/MMP-RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS.
- ❖ EMEP/EEA air pollutant emission inventory guidebook 2019 methodology was applied in case of the NIR

Solvent use category.

Further specific elements are presented in Sections 1.2.2 and 1.3.

C. Collect sufficient activity data, process information and emission factors as are necessary to support the methods selected for estimating anthropogenic GHG emissions by sources and removals by sinks

Specific elements include:

- steps of data collection:
  - identification of data requirements;
  - identification of potential data suppliers;
  - preparation of specific templates;
  - submitting the requests and templates to the potential suppliers of data;
  - data collection;
  - data verification: activity data received are examined (time series discrepancies, large changes in values from the previous to the current inventory year), and double-checked against similar databases.
- the main activity data provider is the National Institute for Statistics;
- sources of emission factors/increment rates are: national studies, IPCC 2006, national research institutes and plants, in a limited number;
- data processing is performed according to the GD no. 1570/2007, as ulteriorly amended and completed, to the MoEO no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI and to other relevant legal provisions in place (as previously presented). Primary data processing is mostly carried out by NEPA, ICSI, INCDS and ICPA;
- emission factors (EFs) selection is performed according to the provisions in the MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels and to other relevant legal provisions in place (as previously presented);
- a significant amount of activity data and emission factors has been collected/processed/developed, enabling the development of higher estimates/tier estimates and the significant decrease of the number of categories characterized using the NE notation key for the majority of non–LULUCF key categories, due to:
  - NEPA's/MEWF's work;
  - the implementation of dedicated studies:
    - in 2011, the study mentioned in Annex V.15 Table 4–row 1;
    - in 2013, the studies mentioned in Annex V.15 Table 2–rows 1 and 2;
    - in 2014, the studies mentioned in Annex V.15 Table 1–rows 1, 2 and 3.
  - the implementation of the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses

and Vehicles Registration in the Ministry of Administration and Interior.

- optimizing the informational fluxes on data collection from the operators for the Energy Industries, Manufacturing Industries and Construction categories in the Energy Sector and for the Solid Waste Disposal on Land and Waste Water Handling categories in the Waste Sector was implemented subject to the study mentioned in Annex V.15 Table 3–row 2 and in Table 4–row 4;
- a significant amount of activity data and emission factors has been collected/processed/developed, enabling the development of higher estimates/tier estimates and a significant decrease of the number of categories characterized using the NE notation key for the LULUCF Sector, under the UNFCCC, through the implementation of:
  - ICSI's, INCDS's and ICPA's work;
  - ICSI's, INCDS's, ICPA's and INCAS's work, during August 2019–December 2023 period;
  - the studies:
    - in 2011, the study mentioned in Annex V.15 Table 4–row 2;
    - in 2012, the studies mentioned in Annex V.15 Table 3–rows 3 and 4;
    - in 2013, the studies mentioned in Annex V.15 Table 2–rows 3 and 4;
    - in 2014, the study mentioned in Annex V.15 Table 1–row 4.
  - the Protocol of collaboration no. 3029/MMP–RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS.

Further elements are presented within the Section 1.3.

D. Make a quantitative estimate of inventory uncertainty for each source category and for the inventory in total, following the IPCC good practice guidance

Elements specific to the implementation of the NIR uncertainty analysis comprise:

- based on Approach 1 according to the provisions in Chapter 3 in Volume 1 of the IPCC 2006;
- performed both for 1989 and 2023, both excluding and including the LULUCF;
- based on national (NIS, studies mentioned in Annex V.15 Table 4–rows 1–2, Table 3–row 3, Table 2–rows 1–4, and Table 1–rows 1–4), study on Romanian uncertainty information and data performed in 2012 by the Environment Agency of Austria–University of Graz consortium (uncertainty data have been collected through interviews, based on the collaboration between "Environmental Integrated Informational System" study contractor, Environment Agency of Austria–University of Graz consortium, data providers and NEPA), ICSI and INCDS related data and information, and on default AD and EFs uncertainty sources;
- results are presented within the NID, in:
  - Uncertainties and time series consistency sub–sectorial sections;
  - in Annex II.

- uncertainty analysis results are used for prioritize efforts for improving the quality of the NIR–in the implementation of progresses, highest priority is attributed to categories having associated high uncertainty level.

Further elements are provided within the Section 1.6.

E. Ensure that any recalculations of previously submitted estimates of anthropogenic GHG emissions by sources and removals by sinks are prepared in accordance with the IPCC good practice guidance and relevant decisions of the COP and/or CMA

The elements associated to the implementation of recalculations comprise:

- based on IPCC 2006 (and previous to 2015 submission on IPCC GPG 2000 and on IPCC GPG 2003), Romania implemented significant recalculations in order to account for better AD and/or EFs, mainly based on:
  - NEPA's/MEWF's work;
  - ICSI's, INCDS's and ICPA's work;
  - ICSI's, INCDS's, ICPA's and INCAS's work, during August 2019–December 2023 period;
  - on the studies implemented:
    - in 2011, the studies mentioned in Annex V.15 Table 4–rows 1–2;
    - in 2012, the study mentioned in Annex V.15 Table 3–row 3;
    - in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–4;
    - in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–4;
    - in 2017, "Report on the technical specifications necessary for the Terms of Reference for acquiring the study Administration of the Land Use, Land–Use Change and Forestry Sector of NGHGI (CRT Sector 4) according with the obligations under the United Nations Framework Convention on Climate Change and with the obligations under the Kyoto Protocol".
  - on the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior, and on the Protocol of collaboration no. 3029/MMP–RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS.
- the recalculations resulted in significant increase of the accuracy, completeness and consistency of data series;
- the recalculations are presented in NID in:
  - Source–specific recalculations, including changes made in response to the review process sub–sectorial sections, including the quantified impact;
  - Chapter 10 Recalculations and improvements.

F. Compile the national inventory in accordance with the relevant provisions under UNFCCC and PA

Specific elements on the compilation of the national inventory include:

- ❖ NIR was compiled according to the specific provisions for GHG inventories set out in Decision 18/CMA 1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement and in Decision 5/CMA 3 Guidance for operationalizing the modalities, procedures and guidelines for the enhanced transparency framework referred to in Article 13 of the Paris Agreement.

G. Implementing the QA/QC and verification procedures in accordance with its QA/QC plan following the IPCC good practice guidance

The elements specific to the implementation of QA/QC procedures are:

- ❖ the QA/QC Programme and the QA/QC Procedure comprise information on:
  - ➢ the national authority responsible for the coordination of QA/QC activities;
  - ➢ the objectives envisaged within the QA/QC framework;
  - ➢ the QA/QC Plan;
  - ➢ the QC procedures;
  - ➢ the QA procedures.
- ❖ according to the GD no. 1570/2007 as ulteriorly modified and completed establishing the national inventory arrangements and national system, to the MoEO no. 1602/2014 on approving the Quality Assurance and Quality Control Plan associated to the National Greenhouse Gas Inventory and to other legal provisions in place (as previously presented), NEPA represents the competent authority responsible with the implementation of the QA/QC activities; additionally, based on the specific provisions in the GD no. 1415/2024, ICSI and INCDS implemented QA/QC and verification activities related to the LULUCF Sector related data and documented them;
- ❖ the QA/QC coordinator is designated by NEPA;
- ❖ QC activities were implemented:
  - ➢ by every sectorial expert during all phases of inventory preparation;
  - ➢ by NGHGI improvement studies contractors:
    - o in 2011, the studies mentioned in Annex V.15 Table 4–rows 1–2;
    - o in 2012, the study mentioned in Annex V.15 Table 3–row 3;
    - o in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–4;
    - o in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–4.
  - ➢ documented within sectorial QC lists consistently used across the dedicated NIA/NIR dedicated team;
  - ➢ greater effort was applied to key categories.

- QA activities:
  - NGHGI was subject to the annual internal review under EU–Monitoring Mechanism;
  - in 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the NGHGI was reviewed under the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020; additionally, in 2020 and 2025, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013;
  - involvement of third party reviewers in the context of developing studies for NGHGI quality improvement;
  - based on previous bilateral cooperation;
  - based on annual review process under UNFCCC;
  - performed by national experts: in respect to the Industrial Processes and Product Use Sector, Ms. Mihaela Bălănescu, a senior expert with significant experience related to the GHG industrial emissions, both considering her researcher, industry consultant, study developer, UNFCCC international expert reviewer profile, implemented a series of QA activities.
- verification–where available, national versus international datasets are compared (e.g. comparison of national with Food and Agriculture Organization data);
- based on the specific provisions in the GD no. 590/2019, ICSI and INCDS implemented QA/QC and verification activities related to the LULUCF Sector related data and were documenting them, during August 2019–December 2023 period;
- NIR improvement plan is annually updated by the QA/QC coordinator based on the results of the previously mentioned checks; the NIR improvement plan is linked with the NIR preparation plan administered by the NIR coordinator;
- greater effort was applied to the implementation of sector-specific QC, QA and verification activities.

Further relevant information is presented under Section 1.2.1.3.

Elements characterizing the implementation of the NIA inventory management related functions are described below:

A. Archive inventory information for each year in accordance with relevant decisions of the COP and/or CMA

Elements specific to the archiving of NIR data/information include:

- the activities are implemented based on the GD no. 1570/2007, as ulteriorly modified and completed, on the MoEO no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI and on other relevant provisions in place (as previously presented); additionally, based on the specific legal provisions in the GD no. 1415/2024, ICSI, INCDS and ICPA are archiving all documents corresponding to the implementation of their roles in the administration of the LULUCF Sector and are providing the documentation to NEPA for archiving;

- both electronic and paper documentation, as far as needed to reconstruct and interpret inventory data and to describe the national inventory arrangements and their functions, is archived;
- the archive is managed by NEPA, ICSI, INCDS and ICPA; at the single national entity level, the archive is accessible at a single location at the NEPA's headquarters in Bucharest;
- all information officially submitted is available in English, while not all background information is available in English;
- security of databases and confidentiality of the background data, both for electronic and paper data, are ensured through implementation of restricted access conditions;
- NEPA designated the manager of the archiving system.

More relevant detailed elements are provided within Section 1.2.3.

B. Provide review teams with access to all archived information used by the Party to prepare the inventory, in accordance with relevant decisions of the COP and/or CMA

Based on GD no. 1570/2007, as ulteriorly modified and completed, on MoEO no. 1376/2008 for approving the Procedure on NGHGI reporting and the modality for answering to the observations and questions raised following the NGHGI review and on other relevant legal provisions in place (as previously presented), NEPA is providing review teams with access to all archived information used to prepare the inventory, in accordance with relevant decisions of the COP and/or CMA. ICSI, INCDS and ICPA participates as technical expert to represent Romania within the review of the LULUCF Sector of the inventory, both under UNFCCC and PA, and provides additional elements and/or updated elements following the request of the Technical Expert Review Team under the coordination of the UNFCCC Secretariat, together with NEPA representatives.

C. Respond to requests for clarifying inventory information resulting from the different stages of the review process of the inventory information, and information on the national inventory arrangements and national system, in a timely manner

Relevant elements comprise:

- based on GD no. 1570/2007, as ulteriorly modified and completed, on MoEO no. 1376/2008 for approving the Procedure on NGHGI reporting and the modality for answering to the observations and questions raised following the NGHGI review and on other relevant legal provisions in place (as previously presented), NEPA ensures the availability of human and financial resources for the implementation of review activities;

- ❖ NEPA ensures an efficient collaboration with the review teams under the coordination of the UNFCCC Secretariat, through the provision of all information and responses to the associated observations and questions, according to the relevant legal provisions;
- ❖ based on the specific provisions ICSI, INCDS and ICPA participates as technical expert to represent Romania within the review of the LULUCF Sector of the inventory, under UNFCCC and PA, and provides additional elements and/or updated elements following the request of the Technical Expert Review Team under the coordination of the UNFCCC Secretariat, together with NEPA representatives.

Based on the requirement in the Art. 26.3 and Annex V Part 1 (l) of the Regulation (EU) no. 1999/2018, corroborated with Art. 18 of the Regulation (EU) no. 1208/2020, please consider that in respect to the Romania's national registry the changes occurred compared to the associated description in the previous submission of the National Inventory Document are described in Annex V.9.

1.2.1.2 Overview of inventory planning, preparation and management

According to the GD no. 1570/2007 as ulteriorly modified and completed and to other relevant legal provisions in place (as previously presented), the single national entity with overall responsibility for the national inventory, including with the responsibility of administrating the NIA, is NEPA; more detailed elements of inventory planning are included in Section 1.2.1.1 NEPA has also the obligation of the preparation and management of the GHG inventory; in this sense, the Governmental Decision no. 1570/2007 as ulteriorly modified and completed, the subsequent relevant procedures and other relevant legal provisions in place (as previously presented) supports NEPA by defining a legal, institutional and procedural framework to involve actively all the relevant responsible public authorities, different research institutes, economic operators, and professional associations. Central public authorities and the institutions under their authority, in their coordination or subordination, different research institutes, and the economic operators have the responsibility for submitting activity data needed for the GHG emissions/removals calculation. The main activity data supplier is the National Institute for Statistics (NIS) through the yearly-published documents like the National Statistical Yearbook and the Energy Balance.

Starting with November 2024, the implementation of the technical activities related to the Land Use, Land-Use Change and Forestry (LULUCF) Sector is subject to the Governmental Decision no. 1415/2024 for defining the obligations on the administration of the Agriculture subdomain and of the LULUCF subdomain, part of the Climate change domain; based on the mentioned decision, responsibilities of administrating the Agriculture and LULUCF Sector of the inventory were allocated as follows:

- ❖ the National Research and Development Institute for Cryogenic and Isotopic Technologies Rm. Valcea:
  - in respect to the Agriculture Sector: administrates directly and/or through collaboration with other organizations a series of technical parameters;
  - in respect to the LULUCF Sector: is monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/removals in soils; the institute is also the technical coordinator of the LULUCF Sector activities.
- ❖ National Institute for Research and Development in Forestry "Marin Dracea" is monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;
- ❖ National Research and Development Institute for Soil Science, Agrochemistry and Environment Bucharest is monitoring and estimating/reporting the GHG emissions/removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- ❖ the National Environmental Protection Agency is implementing a series of technical activities following the receipt of the deliverables from the institutes and administrative activities to allow for a continuous implementation of specific activities;
- ❖ the Ministry of Environment is analyzing and approving the consolidated version of the LULUCF inventory and is ensuring, depending on needs, the Romania's representation in the associated inventory review, together with NEPA and institutes.

The implementation of activities by the three institutes previously mentioned, is based also on the allocation of adequate financial resources through the Environment Fund Administration and on individual contracts with the Environment Fund Administration.

In 2011 the Forest Research and Management Planning Institute administrated the NGHGI LULUCF Sector, both under the UNFCCC and the KP, based on a contract with MEF, in the context of the implementation of the study "NGHGI LULUCF both under the UNFCCC and KP obligations"; the main activities implemented comprise also:

- ❖ preparation of the LULUCF emissions/removals estimates according also with the provisions in the IPCC GPG 2003; consequently, the completion of databases and associated CRF Tables and elaboration of NIR;
- ❖ implementing the QC activities;
- ❖ documenting associated to the NGHGI LULUCF Sector;
- ❖ representing Romania during the annual review coordinated by the UNFCCC Secretariat.

During the period 2012-2014, ICAS continued the implementation of activities on administrating the LULUCF Sector, both under the UNFCCC and the KP, based on the Protocol of collaboration no. 3029/MMP–RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS; ICAS also contributed by developing, in 2012, the studies “Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations”, study concluded with the establishment of methodologies for determining national values for emissions/removals factors, and “Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land–Use Change and Forestry Sector both under the UNFCCC and KP obligations” based on contracts with Ministry of Environment and Forests. In 2013, ICAS contributed to the determination of country–specific emissions–removals factors, elaborating the study “Determination of emission-removal factors for the pools in forest areas and in areas in conversion from and to forest according with the obligations assumed as a Party to the UNFCCC and to the KP, for the 2014 year reporting” and to the compilation of the NGHGI LULUCF Sector through developing the study “Compilation of the National Greenhouse Gas Inventory Land Use, Land–Use Change and Forestry Sector for the 2014 year associated reporting, according with the obligations assumed as a Party to the UNFCCC and to the KP”. In 2014, ICAS contributed further by developing the study “Administration of the NGHGI Land Use, Land–Use Change and Forestry Sector (CRF Sector 4), according to the obligations in the United Nations Framework Convention on Climate Change, including those in the Kyoto Protocol”; in this context activity data and emissions-removals factors continued to be developed while the compilation of the LULUCF Sector was continued.

The collection of necessary data/information and the use of appropriate methods for estimating the emissions for the KP Annex A key categories have been significantly improved during 2011 following the implementation by ISPE, based on a contract with the MEF, of the study “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”; main activities part of the study comprised:

- collect/process/develop specific data/information in order to support the use of appropriate methods for key categories;
- document the collected/processed/developed data/information;
- implement QA/QC checks;
- provide associated uncertainty values.

ISPE contributed further to the development of country-specific data by developing:

- in 2013 the study mentioned in Annex V.15 Table 2–row 2;
- in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–3.

Based on the implementation in 2013 of the study mentioned in Annex V.15 Table 2–row 1, Denkstat improved the system of administrating the HFCs, PFCs and SF_6 data and information. On an undetermined period, the preparation of Road transport category estimates based on COPERT 4 model is administered also based on the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior.

In 2017, the LULUCF Sector both under the UNFCCC and KP has been further supported through the development of the study "Report on the technical specifications necessary for the Terms of Reference for acquiring the study Administration of the Land Use, Land–Use Change and Forestry Sector of NGHGI (CRF Sector 4) according with the obligations under the United Nations Framework Convention on Climate Change and with the obligations under the Kyoto Protocol", by GEOSTUD.

The National Environmental Protection Agency submits officially the national GHGI to the UNFCCC Secretariat, the European Commission and the European Environment Agency taking into account the specific deadlines.

Based on the Governmental Decision no. 590/2019, during August 2019–December 2023 period, the responsibilities of administrating the LULUCF Sector of the inventory were allocated as follows:

- the National Research and Development Institute for Cryogenic and Isotopic Technologies Rm. Valcea was monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/removals in soils; the institute was also the technical coordinator of the LULUCF Sector activities;
- National Institute for Research and Development in Forestry "Marin Dracea" was monitoring and estimating/ reporting the GHG emissions/removals associated to the Forest Land category;
- National Research and Development Institute for Soil Science, Agrochemistry and Environment Bucharest was monitoring and estimating/ reporting the GHG emissions/ removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- the National Institute for Aerospace Research "Elie Carafoli" was monitoring the land use and land–use change in a spatial–explicit system, using aero photogrammetry and aerial surveillance technologies, at national level;
- the National Environmental Protection Agency was implementing a series of technical activities following the receipt of the deliverables from the institutes and administrative activities to allow for a continuous implementation of specific activities;
- the Ministry of Environment was analyzing and approving the consolidated version of the LULUCF inventory and was ensuring, depending on needs, the Romania's representation in the associated inventory

review, together with NEPA and institutes.

The implementation of activities by the four institutes previously mentioned, was based also on the allocation of adequate financial resources through the Environment Fund Administration and on individual contracts with the Environment Fund Administration.

1.2.1.3 Quality assurance, quality control and verification plan on GHG inventory

Romania established the QA/QC Procedure based on the UNFCCC's and PA's provisions related to the national GHG inventory and NIA, the IPCC 2006 provisions, on the Governmental Decision no. 1570/2007 establishing the National System for the estimation of the anthropogenic GHG emissions levels from sources and removals by sinks, as ulteriorly modified and completed and on the other relevant legal provisions in place (as previously presented). QA/QC activities are both described within the QA/QC Programme and within the QA/QC Procedure related to the NGHGI, approved by the MoEO no. 1602/2014.

QA/QC procedures

The QA/QC Programme and the QA/QC Procedure comprise information on:

- ❖ the national authority responsible for the coordination of QA/QC activities;
- ❖ the objectives envisaged within the QA/QC framework;
- ❖ the QA/QC Plan;
- ❖ the QC procedures;
- ❖ the QA procedures.
- ❖ according to the GD no. 1570/2007 as ulteriorly modified and completed establishing the national inventory arrangements and national system, to the MoEO no. 1602/2014 on approving the Quality Assurance and Quality Control Plan associated to the National Greenhouse Gas Inventory and to other legal provisions in place (as previously presented), NEPA represents the competent authority responsible with the implementation of the QA/QC activities; additionally, based on the specific provisions in the GD no. 1415/2024, ICSI and INCDS are implementing QA/QC and verification activities related to the LULUCF Sector related data and are documenting them.

For this purpose, NEPA is performing the following activities:

- ❖ ensures that specific QA/QC objectives are established;
- ❖ develops and regularly updates a QA/QC plan;
- ❖ implements the QA/QC procedures.

Considering the provisions of relevant regulations, NEPA designated a QA/QC coordinator.

The overall objective of the QA/QC Programme is to develop the national GHG inventory in line with the requirements of the IPCC 2006, Wetlands Supplement and KP Supplement, with the provisions of the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council and, respectively, with the provisions of the Commission Implementing Regulation (EU) no. 1208/2020 and of other subsequent legislation.

Romania's QA/QC plan closely follows the definitions, guidelines and processes presented in Chapter 6 – Quality Assurance/Quality Control and Verification in Volume 1 of IPCC 2006. The QA/QC plan constitutes the heart of the QA/QC procedures. It outlines the current and planned QA/QC activities. The specific QA/QC activities are performed during all stages of the inventory preparation. The QA/QC plan is reviewed periodically, if needed, and can be modified as appropriate when changes in processes occur or based on the advice from independent reviewers. The QA/QC plan is intended to ensure the fulfillment of the national GHG inventory principles in Romania. The objectives of the plan include:

- applying greater QC effort for key categories and for those categories where data and methodological changes have occurred recently;
- periodically checking the validity of all information as changes in reporting, methods of collection or frequency of data collection occur;
- conducting the general procedures outlined in QC procedures (Tier 1) on all parts of the inventory over a complete exercise;
- balancing efforts between development and implementation of QA/QC procedures and continuous improvement of inventory estimates;
- customizing the QC procedures to the resources available and the particular characteristics of Romania's greenhouse gas inventory;
- confirming that the national statistical institute and other agencies supplying activity data to NEPA have implemented QC procedures.

QC activities

QC activities were implemented by every sectorial expert during all phases of inventory preparation, greater effort being applied to key categories. The following QC activities are conducted annually before and during the preparation of estimates (15 September–30 October):

- checking the specific requirements regarding the reporting deadlines;
- verification of the collection of data against the information needed;
- checking the correct transcription of input data from the format they were provided into the calculation sheets;
- checking the correctness of conversion factors to be used in calculation;
- checking the data structures integrity and the disaggregation of activity data at calculation sheets level;

- ❖ checking the concordance between the measurement units of data in the calculation sheets and the equivalent data in the ETF GHG Inventory Reporting Tool format;
- ❖ checking the consistency and the data values magnitude order used in the AD and EF series, at the calculation sheets level;
- ❖ identifying parameters common to multiple source or sink categories and checking the values consistency between source or sink categories;
- ❖ checking the emissions/removals calculation into the calculation sheets by reproducing a representative sample calculation;
- ❖ checking the correctness of the aggregation of estimated emissions/removals at the calculation sheets level.

The following QC activities are conducted annually during and after the preparation of estimates (15 October – 10 January – 10 March):

- ❖ checking the emissions/removals estimates existence for all sources and sinks and for the entire time series;
- ❖ checking the explanations existence when the emissions/removals estimates are lacking;
- ❖ checking the trends for identifying the outliers and re–analyze the values;
- ❖ checking the correctness and consistency of choosing the AD, EF and methods used along the entire time series;
- ❖ checking the correctness of recalculations and the existence of explanations;
- ❖ checking the recording and archiving of AD, EF and methods used;
- ❖ checking the correctness and the completeness of the data transcription from the calculation sheets level to the ETF GHG Inventory Reporting Tool level;
- ❖ checking the correctness and the completeness of the data transcription from the ETF GHG Inventory Reporting Tool level to the CRTs level;
- ❖ checking the data used in the NID against the CRTs and calculation sheets;
- ❖ checking the correctness of applied methods descriptions, at the NID’s level;
- ❖ checking the references completeness at the NID’s level;
- ❖ checking the archiving of the CRTs, NID, ETF GHG Inventory Reporting Tool’s specific databases and the calculation sheets;
- ❖ checking the key categories persistency along the time series;
- ❖ checking the adequate qualification of individuals providing expert judgments on the uncertainty estimates and the archiving of documentation regarding the qualification and the expert judgments;
- ❖ checking the uncertainty calculation correctness by partially replying the Monte Carlo analysis;
- ❖ verification of the ERT recommendations implementation;

- ❖ checking the completeness of the QA/QC documentation archiving: QA/QC programme, checklists, ERT report, improvements lists;
- ❖ checking the QA/QC Programme performance and propose improvements.

Within the specified deadlines, the previously mentioned activities are performed at sectorial level. Based on specific sectorial responsibilities allocated within the sector, the QC checks are performed for certain category by a sectorial expert not being involved in the administration, including estimating emissions/removals, of that category (cross–checking approach). The results of all checks outlined above are documented in the annual QC checklists for inventory preparation. For this purpose QC checklists are used consistently throughout the years by all experts involved in the inventory preparation. Additionally, QC activities were performed by the study contractors implementing the NGHGI improvement studies:

- ❖ in 2011, the studies mentioned in Annex V.15 Table 4–rows 1–2;
- ❖ in 2012, the studies mentioned in Annex V.15 Table 3–rows 3–4;
- ❖ in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–4;
- ❖ in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–4.

QA activities

By becoming an European Union Member State from the 1st of January 2007, Romania has the obligation to prepare and submit the national GHG inventory according to the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council and, respectively, to the Commission Implementing Regulation (EU) no. 1208/2020 and to other subsequent legislation, which provides for a QA activity after the first submission of data on 15th of January and a final QA for all 28 EU Member States during first half of March, for the preparation of the EC inventory. In this respect, starting with 2007, Romania has the possibility to verify the inventory twice before the official submission to the UNFCCC Secretariat. In order to get an objective assessment of the inventory quality and for identifying areas where improvements can be made, MEWF involved third party reviewers at the QA activities level according to the provisions in IPCC good practice guidance, depending on the availability of resources. In this scope, MEWF developed the specific procedural arrangements. NEPA through its international contacts and bilateral agreements identifies the available processes for ensuring the implementation of QA activities. Until now, NEPA was the beneficiary of technical support provided by the Austrian Environment Agency (as part of the twinning project RO/2006/IB/EN/09). One of the most important activities performed within this framework was the review of different sectors of the NGHGI. Austrian experts provided specific recommendations comprising:

- ❖ improvement of transparency at sectorial level considering the trend and recalculations description;
- ❖ improvement of transparency at sectorial level by providing a cumulative table on the status of emissions/ removals estimation for every sub–sector;

- ❖ improvement on knowledge on practical ways of performing and documenting the QA/QC activities;
- ❖ improvement of the NGHGI archiving structure.

Until first half of 2011, NGHGI team was the beneficiary of a Netherlands Government to Government (G2G) project. One of its main aims is to develop the reporting capacity of the NGHGI team also by assessing the possibility to use higher tier methods. Specific activities comprised:

- ❖ advices on improving the NGHGI sectorial data documentation (through the use of the documentation list);
- ❖ training courses/presentations on use of data specific to other reporting mechanisms at the GHG Inventory level:
  - ➢ use of ETS data;
  - ➢ use of COPERT model.
- ❖ discussions/advices on methodological issues (data collection, emissions estimation) on GHG emissions recovery within the Industrial Processes and Waste activities;
- ❖ advices on moving to higher Tier levels in the Energy Sector:
  - ➢ calculation of specific emission factors;
  - ➢ use of COPERT model in estimating the Road Transport emissions;
  - ➢ advices on using national data for the calculation of natural gas transit fugitive emissions;
  - ➢ advices on moving on Tier 2 at the Enteric Fermentation, Manure Management and Agricultural Soils levels:
    - precise identification of activity data needs;
    - workshop on elaborating the specific requirements for a emission factors/other parameters study development;
    - other relevant advices.
- ❖ advices on moving on First Order Decay method at the Solid Waste Disposal Sites level;
- ❖ other advices relevant to the Waste Sector;
- ❖ identification of the practical ways to complete the estimation of emissions/removals specific to Kyoto Protocol's Art. 3.3 and 3.4 activities: afforestation/reforestation/deforestation, forest management and revegetation.

QA activities were also performed, according to the relevant provisions in IPCC good practice guidance, in the context of elaboration of the NGHGI improvement studies:

- ❖ in 2011, the study mentioned in Annex V.15 Table 4–row 1;
- ❖ in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–4;
- ❖ in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–4.

Additionally, in 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the NGHGI has been subject to a thorough review within the European Union, review under the Decision 406/2009/EC on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020; also, in 2015, the inventory was reviewed in the context of annual monitoring and compliance cycle. In 2020 and 2025, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) no. 525/2013.

National inventory submissions to the UNFCCC Secretariat are subject to the review under UNFCCC, PA and procedures defined in the relevant COP and/or CMA decisions.

All recalculations planned and done (including those following the UNFCCC ERT review) are mentioned in the improvements lists.

The results of QA checks (excepting those of checks performed under Regulation (EU) no. 1999/2018 of the European Parliament and of the Council and the subsequent legislation, under the Regulation (EU) no. 842/2018 and, respectively, by ERT) are documented in the annual QA checklists for inventory preparation. For this purpose, QA checklists are used consistently throughout the years by all inventory experts involved in the inventory compilation. QA activities were also performed by national experts: in respect to the Industrial Processes and Product Use Sector, Ms. Mihaela Bălănescu, a senior expert with significant experience related to the GHG industrial emissions, both considering her researcher, industry consultant, study developer, UNFCCC international expert reviewer profile, implemented a series of QA activities.

Verification activities

Several verification activities were performed by the national GHG inventory team, as follows:

- ❖ Energy – comparison of activity data used with Eurostat equivalent data; additionally, comparison of country–specific CO_2 emission factors values with equivalent data in the NGHGI of Bulgaria;
- ❖ Agriculture – comparison of data sets used with relevant FAO and, respectively, Eurostat data; additionally, country–specific parameters were compared with similar parameters in the Bulgarian and Hungarian NGHGI and, respectively, with default parameters;
- ❖ Waste – comparison of data sets used with Eurostat data.

All verification activities are described in detail within the sectorial Category–specific QA/QC and verification sections. Greater effort has been applied to the implementation of sector–specific QC, QA and verification activities; the following sector–specific QC, QA and verification activities are conducted annually before, during and after the preparation of estimates:

- ❖ intra-sectoral activities:

- automated data validation within the Excel model–validation is implemented on the consideration of any activity data value provided through the Energy Balance and concerning an inventory specific activity, and on the range of the determined country–specific emission factors as defined within the relevant IPCC methodologies; the model is directly linked to the International Energy Agency and Eurostat versions of the Energy Balance provided by the National Institute for Statistics and to the determination of the country–specific or default emission factors spreadsheets (Energy Sector–stationary combustion and Reference Approach);
- manual checks on all spreadsheets part of the model presented at the previous point (Energy Sector–stationary combustion and Reference Approach);
- manual checks on all spreadsheets on renewable fuel combustion; the spreadsheets are directly linked to the International Energy Agency and Eurostat versions of the Energy Balance and to the default emission factors spreadsheets (Energy Sector–stationary combustion and Reference Approach);
- manual checks on all spreadsheets on Fugitive Emissions Subsector; the spreadsheets are directly linked to the International Energy Agency and Eurostat versions of the Energy Balance and to the used emission factors spreadsheets (Energy Sector–Fugitive Emissions from Fuels Subsector);
- implementing an analysis on the share of European Union-Emission Trading Scheme to Energy Balance fuel consumption data, in respect to equivalent activity categories (Energy Sector except the Fugitive Emissions from Fuels Subsector, Reference Approach);
- checks specific to country-specific emission factors determination, based on background data reported under the European Union Emission Trading Scheme and validated through the reports of Romanian Accreditation Association (RENAR) accredited verifiers (Energy Sector except the Fugitive Emissions from Fuels Subsector, Reference Approach);
- checks on the correlation between energy demand and energy resources data in the Energy Balance (Energy Sector except the Fugitive Emissions from Fuels Subsector, Reference Approach);
- implementation of a comparative analysis of country-specific emission factors and associated uncertainties with equivalent international data, mostly from the countries having similar national circumstances (technologies, the same fuels sources) (Energy Sector except the Fugitive Emissions from Fuels Subsector);
- check on the potential double accounting cases through the use of carbon balance (Industrial Processes and Product Use Sector);
- implement cross–category checks for emissions from categories calculated using Tier 1 default emission factors that do not specifically account for the sources of carbon (Industrial Processes and Product Use Sector);

- ➢ implementing an analysis on the share of European Union-Emission Trading Scheme to National Greenhouse Gas Inventory data, in respect to equivalent activity categories (Industrial Processes and Product Use Sector);
- ➢ comparison of the Enteric Fermentation and Manure Management Subsectors country–specific emission factors data and information with equivalent international data and information, especially in respect with elements available within countries with similar technical conditions (livestock characteristics, Animal Manure Management Systems characteristics) (Agriculture Sector–Enteric Fermentation and Manure Management Subsectors).

❖ intersectoral activities:

- ➢ checks of the outliers on the fuel mix and on the energy consumption data changes, and of double accounting potential cases (Energy Sector except the Fugitive Emissions from Fuels Subsector and Reference Approach, and Industrial Processes and Product Use Sector);
- ➢ check on the correct allocation of the emissions estimates/potential double accounting cases associated with the recovery of the energy resulted from the biomass incineration (Energy Sector–stationary combustion and Agriculture Sector–agricultural soils);
- ➢ check on the correct allocation of the emissions estimates/potential double accounting cases associated with the recovery of the energy resulted from the biomass incineration (Energy Sector–stationary combustion and Land–Use, Land–Use Change and Forestry Sector);
- ➢ comparison of activity data on the CH_4 recovery for valorizing from solid waste disposal on land facilities with corresponding data in the Energy Sector (Energy Sector–stationary combustion and Waste Sector–Solid Waste Disposal Subsector);
- ➢ check on the correct allocation of the emissions estimates/potential double accounting cases associated with the recovery of the energy resulted from the waste incineration (Energy Sector–stationary combustion Subsector and Waste Sector-Incineration and Open Burning of Waste Subsector);
- ➢ check the potential occurrence of double accounting cases between the Agriculture and Land Use, Land–Use Change and Forestry Sectors (Agriculture and Land Use, Land–Use Change and Forestry Sectors);
- ➢ comparison between Agriculture and Waste Sectors data in the National Greenhouse Gas Inventory and at the level of Food and Agriculture Organization and Eurostat (Agriculture and Waste Sectors).

The QA/QC and verification activities have been enhanced as a result of:

- ❖ increased number of NEPA NS/NGHGI dedicated staff;
- ❖ enhancing the institutional, legal and procedural arrangements on the administration of the LULUCF Sector of the inventory in the context of the GD no. 590/2019, during the August 2019–December 2023 period;

❖ training of NEPA, ICSI, INCDS, ICPA, INCAS and data providers representatives through several training instruments;

❖ using a cross–checking QC approach within MECC/NEPA;

❖ applying on a significantly larger scale sector–specific QC, QA and verification activities;

❖ their implementation also in the context of development of the NGHGI improvement studies:

- in 2011, the studies mentioned in Annex V.15 Table 4–rows 1–2;
- in 2012, the studies mentioned in Annex V.15 Table 3–rows 3–4;
- in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–4;
- in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–4.

❖ continuous consideration of QA, third party support (collaborations with Austria and Netherlands, implementation of the NGHGI improvement related studies, EU internal reviews, review under Article 8 of the KP).

National Inventory Report improvement plan, is annually updated by the QA/QC coordinator based on the results of the previously mentioned QA/QC and verification checks; the NIR improvement plan is linked with the NIR preparation plan administered by the NIR coordinator.

Treatment of confidentiality issues

Due to the confidentiality clause assigned to some activity data on Industrial Processes and Product Use related activities, also in the Statistical Law context, all specific measures have been taken in this sense. All aspects pertaining to assuring the data confidentiality are described within the Methodological issues sections of the relevant categories.

1.2.1.4 Changes in the national inventory arrangements and national system since previous annual GHG inventory submission

Changes in the national inventory arrangements and national system are presented in Annex V.15 of the NID.

1.2.2 Inventory preparation process

1.2.2.1 GHG inventory

The present NID was compiled according to the specific provisions set out in Decision 18/CMA 1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement and in Decision 5/CMA 3 Guidance for operationalizing the modalities, procedures and guidelines for the enhanced transparency framework referred to in Article 13 of the Paris Agreement and includes detailed information on the inventories for all years from the base year to the year 2022, in order to ensure the transparency of the inventory. The emissions are estimated using the IPCC 2006, Wetlands Supplement and KP Supplement. According to the Governmental Decision no. 1570/2007 establishing the NIA and NS for the estimation of the GHG emissions levels from sources and removals by sinks, as ulteriorly modified and completed, the implementation of the National Inventory Arrangements ensures the national GHG inventory quality in three phases:

- ❖ planning;
- ❖ preparation;
- ❖ management of the national GHG inventory preparation activities.

1.2.2.2 Data collection, processing and storage

Data collection

Data collection process comprises the following steps:

- ❖ identification of data requirements;
- ❖ identification of potential data suppliers;
- ❖ preparation of specific questionnaires;
- ❖ submitting the questionnaires to the potential suppliers of data;
- ❖ data collection;
- ❖ data verification: activity data received are examined (time series discrepancies, large changes in values from the previous to the current inventory year).

Emission factors selection is performed according to the provisions in the MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels.

A significant amount of activity data and emission factors has been collected/ processed/ developed, enabling the development of higher estimates/ tier estimates and the significant decrease of the number of categories characterized using the NE notation key for the majority of non-LULUCF key categories, due to:

- ➢ NEPA’s/MEWF’s work;
- ➢ the implementation of dedicated studies:
  - ▪ in 2011, the study mentioned in Annex V.15 Table 4–row 1;
  - ▪ in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–2;
  - ▪ in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–3.

- the implementation of the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior.

A significant amount of activity data and emission factors has been collected/processed/developed, enabling the development of higher estimates/tier estimates and a significant decrease of the number of categories characterized using the NE notation key for the LULUCF Sector, both under the UNFCCC and KP, through the implementation of:

- ICSI’s, INCDS’s and ICPA’s work;
- ICSI’s, INCDS’s, ICPA’s and INCAS’s work, during August 2019–December 2023 period;
- the studies:
  - in 2011, the study mentioned in Annex V.15 Table 4–row 2;
  - in 2012, the studies mentioned in Annex V.15 Table 3–rows 3–4;
  - in 2013, the studies mentioned in Annex V.15 Table 2–rows 3–4;
  - in 2014, the study mentioned in Annex V.15 Table 1–row 4.
- the Protocol of collaboration no. 3029/MMP–RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS.

Optimizing the informational fluxes on data collection from the operators for the Energy Industries, Manufacturing Industries and Construction categories in the Energy Sector and for the Solid Waste Disposal on Land and Waste Water Handling categories in the Waste Sector was implemented subject to the study mentioned in Annex V.15 Table 3–row 2 and Table 4–row 4.

Data processing and emissions/removals calculation

Data processing is done according to the provisions in the Ministry of Environment Order no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI and to other legal relevant provisions in place (as previously presented).

Primary data processing is mostly carried out by NEPA, ICSI, INCDS and ICPA. Also, the activities were carried out mostly at MEWF, ISPE, ICAS and Denkstat, as contractors of studies:

- in 2011, the studies mentioned in Annex V.15 Table 4–rows 1–2;
- in 2012, the studies mentioned in Annex V.15 Table 3–rows 3–4;
- in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–4;
- in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–4.

During August 2019–December 2023 period, data processing in respect to the LULUCF Sector was carried out by ICSI, INCDS, ICPA and INCAS, based on the specific provisions in the GD no. 590/2019.

Specific activities comprise:

- ❖ primary data processing;
- ❖ check the completeness of all data and information for all years and categories within the analyzed period;
- ❖ complete the datasets, using also default IPCC interpolation/ extrapolation and/ or alternative techniques;
- ❖ check the accuracy and consistency of datasets;
- ❖ values transformation in order to reach the measurement unit adequate within the method used;
- ❖ data aggregation/disaggregation considering the IPCC classification;
- ❖ calculation and/or adjustment of different parameters considering the available data.
- ❖ selection of the emission factors and of the methods;
- ❖ application of methods;
- ❖ emissions/removals estimates, using the most recent data;
- ❖ internal review (errors are rectified);
- ❖ preparation of the national inventory report.

Activities previously presented were/ are also implemented within the collaboration between:

- ❖ MEWF, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Internal Affairs, in the framework of the Protocol of collaboration no. 3136/MMP/9.07.2012, on preparation of Road transport category estimates based on COPERT 4 model;
- ❖ MEWF, NEPA and ICAS, in the framework of the Protocol of collaboration no. 3029/MMP-RP/3.07.2012, on administrating by ICAS of the LULUCF Sector, both under UNFCCC and KP.

1.2.3 Archiving of information

Data archiving is done according to the provisions of the Ministry of Environment Order no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI and to other relevant legal provisions in place (as previously presented); additionally, based on the specific legal provisions in the GD no. 1415/2024, ICSI, INCDS and ICPA are archiving all documents corresponding to the implementation of their roles in the administration of the LULUCF Sector and provide the documentation to NEPA for archiving. NEPA, ICSI, INCDS and ICPA team managed and maintained the NGHGI database and the documentation of specific inventory information. According to the provisions in IPCC 2006, the NIR documentation includes:

- ❖ assumptions and criteria for selection of AD and EF;
- ❖ EF used, including references to the IPCC documents for default factors or to published references or other

documentation for emission factors used in higher tier methods;

- ❖ AD or sufficient information to enable activity data to be traced to the referenced source;
- ❖ information on the uncertainty associated with AD and EF;
- ❖ rationale for choice of methods;
- ❖ methods used, including those used to estimate uncertainty;
- ❖ changes in data inputs or methods from previous years;
- ❖ identification of individuals providing expert judgment for uncertainty estimates and their qualifications to do so;
- ❖ worksheets and interim calculations for category estimates and aggregated estimates and any recalculations of previous estimates;
- ❖ details of electronic databases or software used in production of the inventory, including versions, operating manuals, hardware requirements and any other information required to enable their later use;
- ❖ final inventory report and any analysis of trends from previous years;
- ❖ QA/QC plans and outcomes of QA/QC procedures.

All inventory information, as far as needed to reconstruct and interpret inventory data and to describe the national system and its functions, is accessible. The archive is managed by NEPA, ICSI, INCDS and ICPA; at the single national entity level, the archive is accessible at a single location at the NEPA's headquarters in Bucharest. While all information officially submitted according to the requirements of the UNFCCC and PA is translated into English, this is not possible for all background information made available during the review process as the official inventory documentation language is Romanian.

Specific NIR data are archived as follows:

- ❖ electronically – all available documents;
- ❖ on paper – the documents used for the NIR preparation unavailable in electronic format and the correspondence with different organizations.

In order to ensure the security of databases and the confidentiality of the background data, both paper and electronic data are kept under restricted access conditions. Furthermore, electronic data backup activities are undertaken on NEPA's server with daily frequency during the generation of the official submission and weekly in rest of cases. Considering the provisions of relevant regulations, NEPA designated the manager of the archiving system.

1.2.4 Processes for official consideration and approval of inventory

Specific elements on the processes for official consideration and approval of inventory are provided in 1.2.1.1

Institutional, legal and procedural arrangements section.

1.3 Brief general description of methodologies (including tiers used) and data sources used

Estimation methods selection is done according to the provisions in the MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels and to the other legal provisions in place (as previously presented). The emissions from non-LULUCF Sectors are estimated following the IPCC 2006. Emissions/removals from LULUCF Sector are estimated using IPCC 2006, Wetlands Supplement and KP Supplement. EMEP/EEA air pollutant emission inventory guidebook 2019 methodology was applied in case of the solvent use related categories in the NIR Industrial Processes and Product Use Sector. The main data sources used for activity data are presented within the following table.

Table 1.3 Main activity data sources

Sector	Data sources
Energy	National Institute for Statistics – Energy Balance Energy producers Ministry of Economy Romanian Civil Aviation Authority Transgaz SA National Authority on Regulating in Energy National Agency for Mineral Resources
Industrial Processes and Product Use	National Institute for Statistics- Statistical Yearbook and other data sources Industrial operators through 42 Local/Regional Environmental Protection Agencies Direct information from industrial operators
Agriculture	National Institute for Statistics
LULUCF	National Institute for Statistics through Statistical Yearbook Ministry of Agriculture, Forests and Rural Development (MADR)–Forests General Directorate (2007–2008); Ministry of Environment and Forests-Forests General Directorate (2009–2011); MECC-Department for Waters, Forests and Fish Faming (2012) National Forest Administration (RNP)

Sector	Data sources
Waste	National Institute for Statistics National Environmental Protection Agency Public Health Institute National Administration “Romanian Waters” Food and Agriculture Organization Landfill operators through 42 Local/Regional Environmental Protection Agencies

A significant amount of activity data and emission factors has been also collected/processed/developed through:

❖ the NEPA’s/MEWF’s, ICSI’s, INCDS’s and ICPA’s work;
❖ during August 2019-December 2023 period, the ICSI’s, INCDS’s, ICPA’s and INCAS’s work, based on specific provisions in the GD no. 590/2019;
❖ the implementation by ISPE, ICAS and Denkstat, of the studies:
  - in 2011, the studies mentioned in Annex V.15 Table 4–rows 1–2;
  - in 2012, the studies mentioned in Annex V.15 Table 3–rows 3–4;
  - in 2013, the studies mentioned in Annex V.15 Table 2–rows 1–4;
  - in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–4.
❖ the implementation of the:
  - Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior, on the preparation of Road transport category estimates based on COPERT 4 model;
  - Protocol of collaboration no. 3029/MMP-RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS, on administrating the LULUCF Sector, both under the UNFCCC and the KP.

The sources of the emission factors/increment rates used are: national studies, IPCC 2006, Wetlands Supplement, KP Supplement, national research institutes and plants, in a limited number.

Higher estimates/tier estimates and a significant decrease of the number of categories characterized using the NE notation key are available for the majority of Annex A key categories have been achieved, due to:

- NEPA’s/MEWF’s work;
- the implementation of dedicated studies:
  - in 2011, the study mentioned in Annex V.15 Table 4–row 1;
  - in 2013, the study mentioned in Annex V.15 Table 2–row 1;

- in 2014, the studies mentioned in Annex V.15 Table 1–rows 1–3.

➢ the implementation of the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior.

Higher estimates/tier estimates and a significant decrease of the number of categories characterized using the NE notation key for the LULUCF Sector, both under the UNFCCC and KP, have been achieved through the implementation of:

➢ ICSI, INCDS and ICPA work;

➢ ICSI, INCDS, ICPA and INCAS work, during the August 2019–December 2023 period, based on the specific provisions in the GD no. 590/2019;

➢ the studies:

- in 2011, the study mentioned in Annex V.15 Table 4–row 2;
- in 2012, the studies mentioned in Annex V.15 Table 3–rows 3 and 4;
- in 2013, the studies mentioned in Annex V.15 Table 2–rows 3–4;
- in 2014, the study mentioned in Annex V.15 Table 1–row 4.

➢ the Protocol of collaboration no. 3029/MMP-RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS.

Optimizing the informational fluxes on data collection from the operators for the Energy Industries, Manufacturing Industries and Construction categories in the Energy Sector and for the Solid Waste Disposal on Land and Waste Water Handling categories in the Waste Sector was implemented subject to the study mentioned in Annex V.15 Table 3–row 2 and Table 4–row 4.

1.4 Brief description of key categories

The key category analysis has been performed according to the provisions in Chapter 4 in Volume 1 of IPCC 2006, following the Approach 1. Separate key category analysis were conducted taking into account both the exclusion and inclusion of the LULUCF sector and also both level and trend criteria; all IPCC sectors and categories, sources and sinks (as suggested in Table 4.1 of Volume 1 of IPCC 2006), and gases were analyzed. KCA has been performed in the context of the ETF GHG Inventory Reporting Tool application. KCA was conducted for every year of the characterized period. The results of the key category analysis are presented:

➢ in NID within:

- Chapter 1, at general level;
- Annex I.

- in the context of the ETF GHG Inventory Reporting Tool application use, the results of the key category analysis are presented in CRT table 7, for every year in the 1989–2023 period.

KCA is used for prioritize efforts for improving the quality of the NGHGI–the relevant implemented and future studies referring mainly to the use of higher Tier methods in key categories.

1.5 Brief general description of QA/QC plan and implementation

Specific elements on the description of QA/QC plan and its implementation are provided in 1.2.1.1 Institutional, legal and procedural arrangements and 1.2.1.3 Quality assurance, quality control and verification plan on GHG inventory sections.

1.6 General uncertainty assessment, including data pertaining to the overall uncertainty of inventory totals

The present NID comprises a full quantitative assessment of the uncertainty. Romania carried out the uncertainty analysis on the basis of Approach 1 according to the provisions in Chapter 3 of Volume 1 of IPCC 2006. The uncertainty calculation was performed for 1989 and 2023, both excluding and including the LULUCF sector; it is based on national (NIS, studies mentioned in Annex V.15 Table 4–rows 1–2, Table 3–row 3, Table 2–rows 1–4, and Table 1–rows 1–4), study on Romanian uncertainty information and data performed in 2012 by the Environment Agency of Austria–University of Graz consortium (uncertainty data have been collected through interviews, based on the collaboration between “Environmental Integrated Informational System” study contractor, Environment Agency of Austria–University of Graz consortium, data providers and NEPA), on ICSI and INCDS related data and information, and on default AD and EFs uncertainty sources.

Considering the 2024 NIR and the Tier 1 method:

- the total NIR uncertainty for 2022 excluding LULUCF was 19.4%, while including LULUCF was 39.6%;
- the uncertainty introduced into the trend in total national emissions, for 2022, was 1.8% when considering excluding LULUCF criteria and 2.4%, including LULUCF;
- the total NIR uncertainty for 1989 excluding LULUCF was 13.4%, while including LULUCF was 14.5%.

Considering the 2025 NIR and the Tier 1 method:

- the total NIR uncertainty for 2023 excluding LULUCF was 20.5%, while including LULUCF was 44.1%;

- ❖ the uncertainty introduced into the trend in total national emissions, for 2023, was 1.8% when considering excluding LULUCF criteria and 2.5%, including LULUCF;
- ❖ the total NIR uncertainty for 1989 excluding LULUCF was 13.4%, while including LULUCF was 14.5%.

Based on data and information associated with the 2025 NIR, a important contribution of LULUCF Sector at the uncertainty data presented in paragraph above can be observed.

The results of the uncertainty analysis are presented within the NID both at the Uncertainties and time series consistency sub–sectorial sections and in Annex II.

Uncertainty analysis results are used for prioritize efforts for improving the quality of the NIR-in the implementation of progresses, highest priority is attributed to categories having associated high uncertainty level.

1.7 General assessment of completeness

1.7.1 Information on completeness (including information on non-reported categories or any methodological or data gaps in the inventory)

The inventory covers all sectors and all gases in the period 1989–2023 and is complete in terms of geographical coverage. Additional elements are presented below, as follows:

(a) the categories which were reported as not estimated (NE), as defined in the transparency MPGs, and detailed explanations for the use of this notation key especially where the greenhouse gas inventory guidelines provide methods for estimation of greenhouse gases

All the sources/sinks not estimated and the relevant justifications are presented in the CRT 9 and Annex V.7.

(b) the geographical coverage of the greenhouse gas inventory, and any differences between the geographical coverage under the UNFCCC and the Paris Agreement and under Regulation (EU) 1999/2018

The inventory covers all sectors and all gases in the period 1989–2023 and is complete in terms of geographical coverage. Emissions are presented by sector, by sub-sector and by gas.

1.7.2 Description of insignificant categories, if applicable

No category in the inventory is considered insignificant.

1.7.3 Total aggregate emissions considered insignificant, if applicable

Information on total aggregate emissions considered insignificant is not relevant, as no category in the inventory is considered insignificant.

1.8 Metrics

The Global Warming Potential values from the IPCC Fifth Assessment Report were used.

1.9 Summary of any flexibility applied

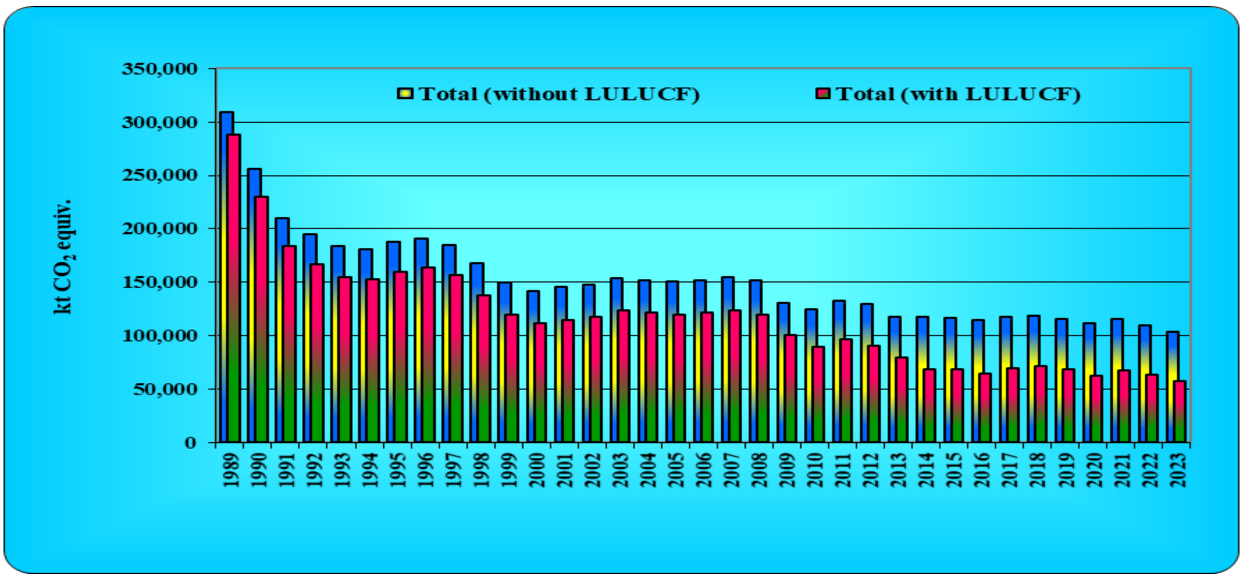
Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

2 Trends in greenhouse gas emissions and removals

2.1 Description of emission and removal trends for aggregated GHG emissions and removals

The total GHG emissions in 2023, excluding removals by sinks, amounted to 103,862.45 kt CO_2 equivalent. The total GHGs emissions (without considering sinks) decreased by 66.45% in 2023 in comparison to 1989 while the net GHG emissions/ removals (taking into account the CO_2 removals) decreased by 80.09%.

Figure 2.1 Trends of the aggregated GHG emissions



The GHG emissions trend reflects the main trends in the economic development of the country. In the last decade of the 20th century the GHG emissions decreased with more than 50 per cent due to the transition of Romania to a market economy, including the restructuring of the economy, the disappearance of inefficient industries and the start-up of the first reactor at the Cernavoda nuclear power plant. In the period 2000–2008 GHG emissions slightly increased and later stabilized as consequence of the economic revitalization. Due to the global financial and economic crisis, GHG emissions decreased again in the period 2009–2012 and stabilized in 2013–2016 period. In 2017–2018, GHG emissions increased slowly and in 2019–2020 they decreased, related to the level of economic activities. In 2021, emissions increased again, and in 2022, GHG emissions decreased compared to 2021. In 2023, excluding LULUCF, the largest contributing substance to the GHG emissions is CO_2 on average 65 per cent followed by CH_4 on average 24 per cent and N_2O on average 9 per cent. The remaining GHGs (HFCs, PFCs, SF_6, NF_3) contribute around 2 per cent.

Description and interpretation of emissions trends by gas

The greatest attention during the preparation was payed to the direct GHGs mentioned through Annex A of the Kyoto Protocol – CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3. In addition, the indirect GHGs (NOx, CO, NMVOCs, and SO_2) were also taken into account. All GHG emissions, except HFCs and SF_6, decreased comparing with the base year. The shares of GHG emissions have not significantly changed during the period. The largest contributor to total GHG emissions is CO_2, followed by CH_4 and N_2O. In the base year, the shares of GHG emissions were: 67.51% CO_2, 23.93% CH_4, 7.27% N_2O, 1.29% PFCs. In 2023, the shares of GHG emissions were: 65.34% CO_2, 23.8% CH_4, 8.9% N_2O, 0.0008% PFCs. The F gases started to be used as substitutes for ODS in refrigerating and air conditioning systems since 1991. In 2023, the contribution of these gases to the total GHG emissions is negligible: 1.91% HFCs and 0.05% SF_6. Next table presents the trend of the aggregated emissions, split by gas.

Table 2.1 Trends by gas [kt CO_2 equivalent]

Year	CO_2 excluding LULUCF	CO_2 including LULUCF	CH_4 excluding LULUCF	N_2O excluding LULUCF	HFCs	PFCs	SF_6
1989	208,986.76	187,676.87	74,067.02	22,504.23	0.14	4,005.32	0.49
1990	176,535.11	150,099.79	59,041.71	18,529.34	0.16	2,530.06	0.48
1995	125,675.39	97,251.89	46,798.59	13,717.05	2.47	2,120.74	0.92
2000	93,206.26	62,911.13	35,901.07	11,151.34	66.79	1,507.48	8.55
2005	101,336.60	70,199.28	36,720.38	11,870.77	348.70	85.68	13.71
2010	84,487.91	49,177.15	29,695.29	9,667.23	899.30	8.21	54.93
2011	92,390.71	56,453.82	28,864.90	9,944.07	999.14	11.43	40.31
2012	89,847.71	51,333.17	29,045.51	9,205.62	1,091.89	6.68	42.01
2013	78,795.47	40,144.39	28,323.55	9,512.01	1,181.21	5.53	47.43
2014	79,335.35	30,017.76	28,093.70	9,375.12	1,260.07	5.71	40.62
2015	78,045.99	29,566.52	27,911.21	9,417.89	1,381.34	5.91	39.76
2016	76,586.92	26,009.93	27,264.41	9,408.41	1,538.35	4.89	36.11
2017	79,432.34	30,653.31	26,792.17	9,838.72	1,696.40	5.02	39.40
2018	79,874.42	33,035.79	26,325.11	10,534.07	1,761.12	4.47	45.90
2019	76,690.36	29,850.00	26,577.12	10,200.74	1,780.66	3.45	59.61

Year	CO_2 excluding LULUCF	CO_2 including LULUCF	CH_4 excluding LULUCF	N_2O excluding LULUCF	HFCs	PFCs	SF_6
2020	73,946.38	24,736.25	26,068.13	9,593.62	1,847.44	3.19	62.45
2021	77,501.27	29,634.63	25,573.59	10,338.32	1,908.25	3.40	50.17
2022	73,186.03	27,350.49	25,258.46	9,198.68	1,972.13	1.28	50.68
2023	67,866.02	21,307.31	24,715.80	9,243.15	1,980.23	0.83	56.42

Carbon dioxide (CO_2) – the most significant anthropogenic greenhouse gas is the carbon dioxide. The decrease of CO_2 emissions (from 208,986.76 kt in 1989 to 67,866.02 kt in 2023) is caused by the decline of the amount of fossil fuels burnt in the energy sector (especially in the public electricity and heat production, and manufacturing industries and constructions sectors) as a consequence of activity decline.

Methane (CH_4) – the methane emissions, related mainly to the Fugitive emissions from fossil fuels extraction and distribution and to the livestock, decreased in 2023 by 66.63% compared with the level in 1989. The decrease of CH_4 emissions in Agriculture is due to the decrease of the livestock level.

Nitrous oxide (N_2O) – the N_2O emissions are mainly generated within the Agricultural Soils activities in the Agriculture sector and within the Chemical industry activities in the Industrial Processes sector. The decline of these activities (decline of livestock, decline of N synthetic fertilizer applied on soils amounts, decrease of the crop productions level) is reflected in the N_2O emissions trend. The N_2O emissions in 2023 decreased by 58.93% in comparison with the level in the base year.

Fluorocarbons and SF_6 (HFCs, PFCs, SF_6) – Fluorocarbon emissions showed a strong decrease (99.98% in 2023 comparing with the level in 1989) for the PFCs emissions from the primary aluminium production and an increase for HFCs and SF_6 emissions.

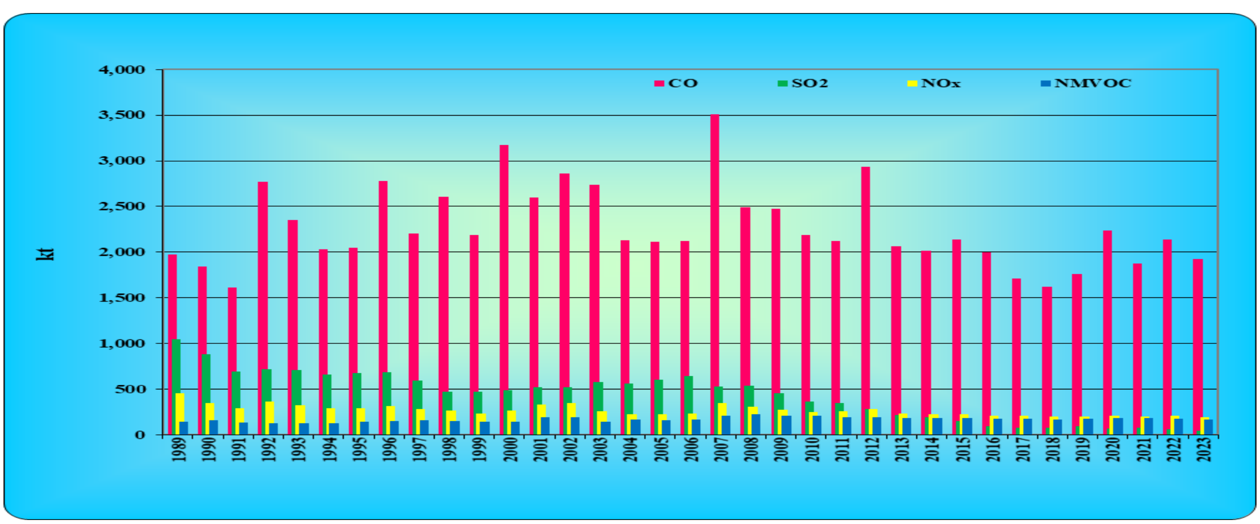
Description and interpretation of emissions trends for indirect greenhouse gases and SO_2

The trends of the indirect GHGs are similar with the GHGs trends (Table 2.2). The CO, NO_x, NMVOC and SO_2 emissions evolution follows the general direct GHG emissions trend. The SO_2 emissions decrease is caused by the decline of the fuels burnt for energy and the decrease of sulphur content in fuels. The indirect GHG emissions trends are presented in Figure 2.2.

Table 2.2 Indirect GHG emissions levels [kt]

Year	NO_x	CO	NMVOC	SO_2
1989	453.02	1,976.48	142.80	1,045.32
1990	345.50	1,840.95	156.28	885.63
1995	290.20	2,050.81	140.29	673.03
2000	270.19	3,174.42	147.03	490.47
2005	226.61	2,110.81	163.58	603.12
2010	250.49	2,186.55	207.68	366.25
2011	257.43	2,123.19	191.77	346.08
2012	280.99	2,931.29	192.37	284.43
2013	233.68	2,060.67	185.87	219.05
2014	226.88	2,011.92	186.23	193.89
2015	226.24	2,134.64	186.26	155.52
2016	211.46	1,996.74	174.99	96.41
2017	205.17	1,707.95	174.47	79.43
2018	203.31	1,621.96	169.21	78.04
2019	203.17	1,759.66	174.05	91.01
2020	208.00	2,238.40	185.19	68.78
2021	197.89	1,873.40	182.95	75.30
2022	207.89	2,136.46	172.89	60.04
2023	191.45	1,925.04	166.47	43.36

Figure 2.2 Indirect GHG emissions trends [kt]

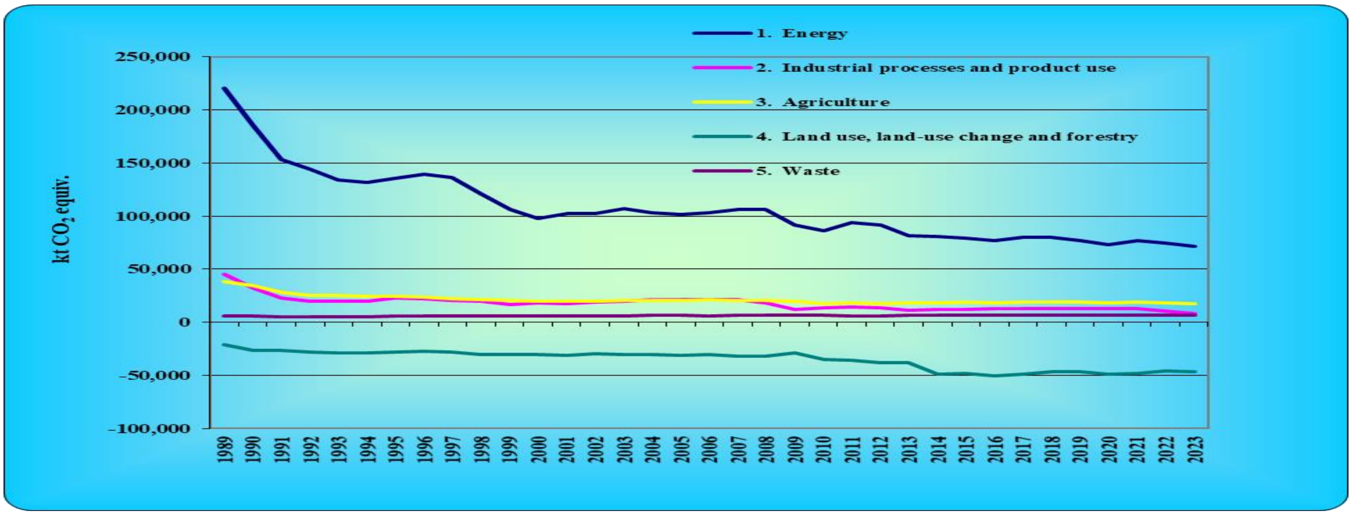


2.2 Description of emission and removal trends by sector and by gas

The figure below shows the GHG emissions trends by each sector.

The GHG emissions are expressed in Gg CO_2 equivalent.

Figure 2.3 Trends by sector



Energy - represents the most important sector in Romania. The Energy sector accounted for 68.58% of the total national GHG emissions in 2023. The GHG emissions resulted from the Energy sector decreased by 67.69% compared with the base year.

Industrial processes and product use - contributes to total GHG emissions with 8.11% in 2023. The direct GHG emissions reported in this sector are associated with CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3. In 2023, Mineral Industry, Metal Industry and Product uses as substitutes for ODS have the highest share of GHG emissions of the Industrial Processes and Product Use sector, 51.14%, 16.15% and 23.52% respectively. Compared with 1989, GHG emissions from this sector have decreased by 81.30% in 2023, mainly due to the decrease of the industrial production.

Agriculture - GHG emissions have also decreased. The GHG emissions in 2023 are 53.31% lower in comparison with the 1989 emissions due to:

- the decline of livestock;
- the decrease of rice cultivated area;
- the decrease of crop productions level;
- the decline of N synthetic fertilizer applied amounts.

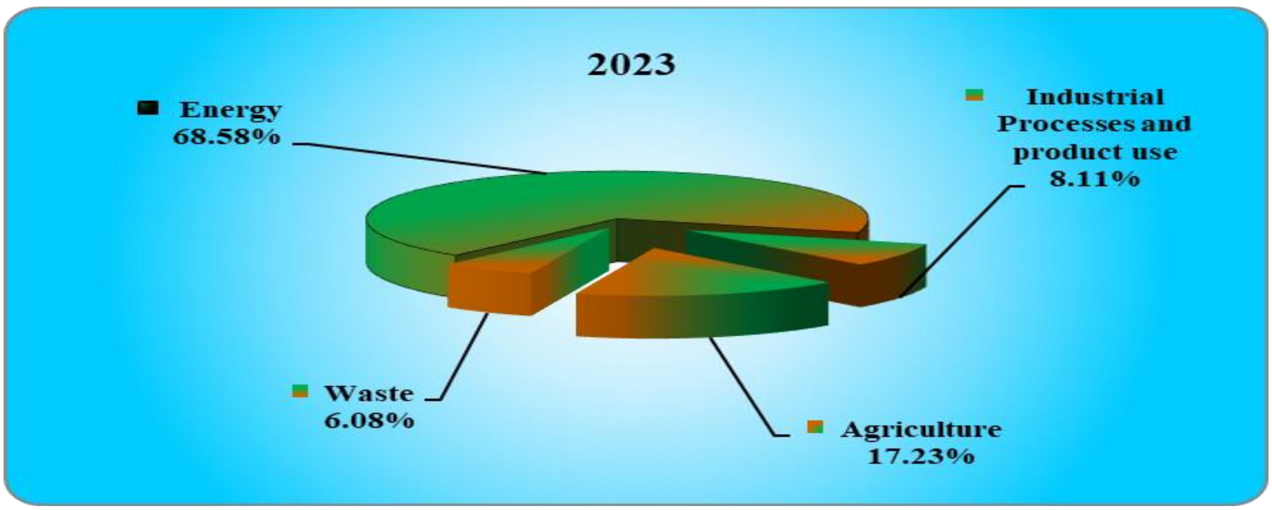
In 2023 year, 17.23% of the total GHG emissions resulted from the agriculture sector.

LULUCF - The net GHG removals/emissions level is 119.77% higher in 2023 in comparison with the level in the base year.

Waste sector **-** emissions have increased in 2023 with 10.29% in comparison with the level in 1989. The contribution of the waste sector to the total GHG emissions in 2023 is 6.08%.

The participation of sectors to GHG emissions (excluding LULUCF) is presented in the next figure.

Figure 2.4 Sectorial GHG emissions in 2023 [%]



3 Energy (CRT sector 1)

3.1 Overview of the sector and background information

This chapter includes GHG emissions estimates in the Energy Sector. According to IPCC the following categories are included in this sector:

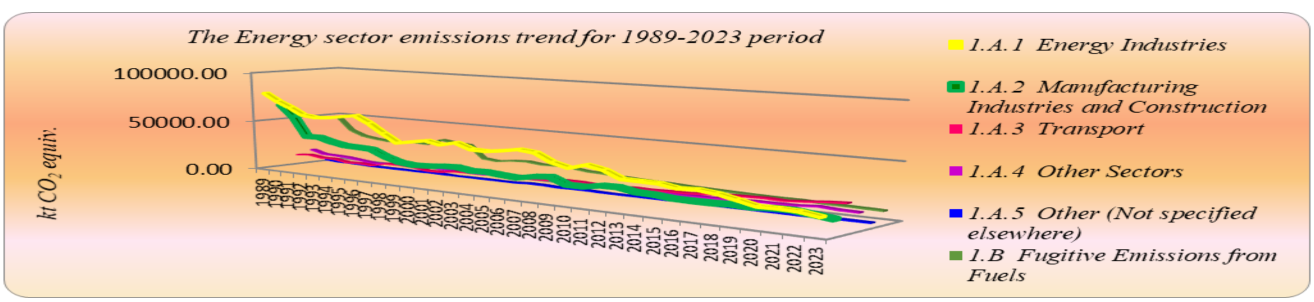
- 1.A.1 Energy industries;
- 1.A.2 Manufacturing Industries and Construction;
- 1.A.3 Transport;
- 1.A.4 Other sectors (commercial/institutional, residential, agriculture/forestry/fisheries);
- 1.A.5 Other (stationary, mobile);
- 1.B Fugitive Emissions from Fuels;
- 1.C CO_2 Transport and storage;
- 1.D Memo items.

Compared to the other GHG emissions sectors (Industrial Processes and Product Use, Agriculture, LULUCF, Waste), the Energy sector represents the largest source of anthropogenic GHG emissions in Romania. . In 2023, the Energy sector was responsible for about 68.58% of the total GHG emissions 103,862.45 kt CO_2 equiv.

Emission trends

In 2023, emissions from the Energy sector have decreased by 67.69% (71,232.52 kt CO_2 equiv. compared to 220,493.44 kt CO_2 equiv. in 1989, base year).

Figure 3.1 The energy sector emission trend for the period 1989–2023



The emissions trend reflects the changes in this period characterized by a process of transition to a market economy. With the entire economy in transition, some energy intensive industries reduced their activities, and this are reflected in the GHG emissions reduction. The decline of economic activities and energy consumption in the period 1989–1992 had directly caused the decline in total emissions in that period. Emissions have started to increase until 1994, because of economy revitalization. Considering the starting of the operation at the first reactor at the Cernavoda nuclear power plant (1996), the emissions started to decrease again. The decrease continued until 1999. The increased trend after 1999 reflects the economic development in the period 1999–2004. At the end of 2007, the second unit of the Cernavoda nuclear plant was functioning, therefore the decrease in emission trend is not very noticeable; for 2008 it was noticed a slight tendency of decrease of emissions. According to the Energy Balance, the primary energy production in 2017 increased by 619 thousands toe in comparison with 2016 and continued to retain its significant share of total energy resources, accounting for 58.6% compared to the previous year. The most significant increase was production of usable natural gas, representing +9.5% over the previous year. Primary electricity production decreased by 10.5% compared to the previous year; also, a decrease in the production of crude oil (4.5%). On types of energy carriers, crude oil and petroleum products, natural gas and coal (including coke) increased by +104 thousands toe. Electricity consumption remained relatively stable compared to last year. In 2017, the share of coal consumption in the total consumption for the thermoelectric power generation was 45.5% and 19.9% of gaseous hydrocarbons. The total energy resources available in 2018 remained at a relatively constant level with those of the previous year, the decrease of primary energy production (-1.7%) being offset by increased amounts of energy resources (+ 4.2%). In 2018, the primary energy resources were over the previous year (+ 2.2%). On types of energy carriers, crude oil and petroleum products increased and electricity consumption, increased usable natural gas and coal (including coke) decreased in comparison with 2017. In 2019, the primary energy resources decreased to 444 thousand toe in comparison with 2018, mainly due to the decrease in the production of usable natural gas, hydroelectric energy and coal, but continued to maintain its significant share in total energy resources, representing 55.6% of them. Final energy consumption in 2019 increased (+ 1.1%) compared to 2018, in the industry (including construction) recorded an increase of 0.6% compared to the previous year, mainly due to increased consumption from the chemical industry and pharmaceuticals, rubber products and plastics. According to the Energy Balance, the primary energy resources in 2021 were 22,999 thousand toe, increased to 648 thousand toe in comparison with 2020, mainly due to the increase in the production of usable natural gas (34 thousand toe), hydroelectric energy and coal (+141 thousand toe, respectively +414 thousand toe), but the crude oil production decreased (-150 thousand toe). On types of energy carriers in 2021, the gross domestic electricity consumption increased (+265 thousand toe) for natural gas, (+711 thousand toe) for crude oil and petroleum products and (+566 thousand toe) for coal (including coke), respectively, compared to the previous year. Final energy consumption in 2021 increased by 1857 thousand toe (+7.9%) compared to 2020, this increased in all types of economic activities, the most significant being the increases consumption of the population, the tertiary sector and transport, compared to the previous year. As a share in total final consumption energy, population consumption kept its first place (34.5%), followed by transport and industry, with 27.5% and respectively 27.1%. The primary energy resources in 2022 were 22,262 thousand toe, decreased to 737 thousand toe in comparison with 2021, mainly due to the decrease in the production of crude oil (-183 thousand toe), hydroelectric energy and coal (-231 thousand toe, respectively -231 thousand toe), but the usable natural gas production increased (+98 thousand toe). On types of energy carriers in 2022, the gross domestic electricity consumption decreased (-1,597 thousand toe) for natural gas, (-314 thousand toe) for electricity and (-543 thousand toe) for coal (including coke), respectively, compared to the previous year. Final energy consumption in 2022 decreased by 1,339 thousand toe (-5.3%) compared to 2021, due to decreases in industry, agriculture and forestry, but also in the population. However, consumption in transport and the tertiary sector increased (8.3%, 3.5% respectively). As a share in total final consumption energy, population consumption kept its first place (32.9%), followed by transport and industry, with 31.4% and respectively 23.9%. The primary energy resources in 2023 were 21,918 thousand toe, decreased to 344 thousand toe in comparison with 2022, mainly due to the decrease in the production of crude oil (-141 thousand toe) and coal (-530 thousand toe), but the hydroelectric energy usable natural gas production increased (+437 thousand toe, respectively +129 thousand toe). On types of energy carriers in 2023, the gross domestic electricity consumption decreased (-512 thousand toe) for natural gas and (-928 thousand toe) for coal (including coke), respectively, compared to the previous year. Final energy consumption in 2023 decreased by 765 thousand toe (-3.2%) compared to 2022, due to decreases in industry (-13.8%), agriculture and forestry (-2.7%), also in the population (-4.3%). Consumption in transportation and other branches of the economy increased by 3.9% and 3.8%, respectively. In total final energy consumption, consumption in transport has the highest share (33.7%), followed by population consumption (32.5%) and industry consumption (21.3%) (Source – Romanian National Institute for Statistics).

In 2023, emissions from the Energy sector have decreased by 61.49% (71,232.52 kt CO_2 equiv.) compared to 1990 (184,958.87 kt CO_2 equiv.) and by 4.95% (71,232.52 kt CO_2 equiv.) compared to 2022 (74,945.33 kt CO_2 equiv.).

Table 3.1 Shares of GHG emission categories within the Energy sector, in 2023

Energy sector-categories	Percentages for 2023
Energy industries	21.80
Manufacturing Industries and Construction	16.10
Transports	31.06

Energy sector-categories	Percentages for 2023
Other sectors	16.93
Other	1.67
Fugitive emissions	12.43

The most important GHG in the sector is CO_2; small amounts of CH_4 and N_2O are also emitted.

Figure 3.2 The different GHG's contribution to the 2023 Energy sector

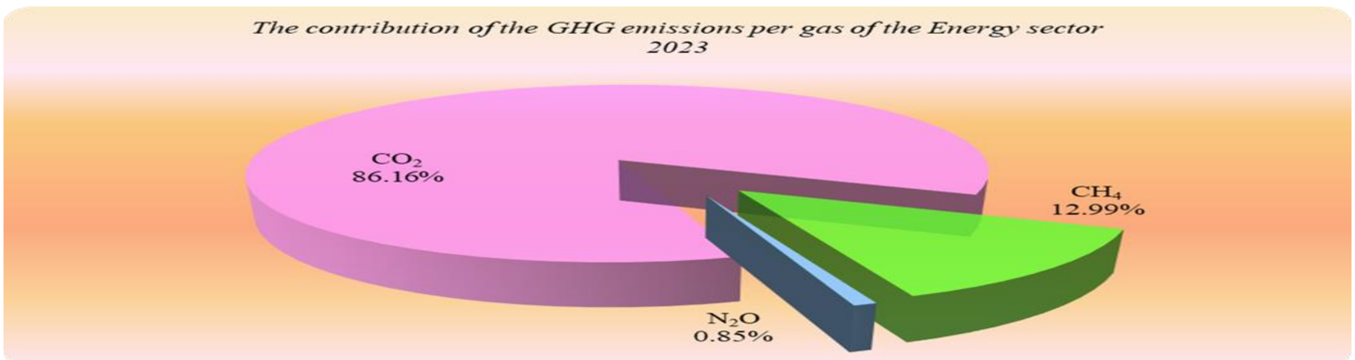


Table 3.2 Status of emissions estimation within the Energy Sector for 2023

IPCC category-Energy Sector	**Emissions estimation status**		
	CO_2	**CH_4**	**N_2O**
1.A.A Fuel Combustion – Sectorial Approach			
1.A.1 Energy Industries			
1.A.1.a Public Electricity and Heat Production	✓	✓	✓
1.A.1.b Petroleum Refining	✓	✓	✓
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries	✓	✓	✓
1.A.2 Manufacturing Industries and Construction	✓	✓	✓
1.A.2.a Iron and Steel	✓	✓	✓
1.A.2.b Non Ferrous Metals	✓ , NO, IE	✓ , NO, IE	✓ , NO, IE
1.A.2.c Chemicals	✓	✓	✓
1.A.2.d Pulp, Paper and Print	✓	✓	✓
1.A.2.e Food Processing, Beverages and Tobacco	✓	✓	✓

IPCC category-Energy Sector	**Emissions estimation status**		
	CO_2	**CH_4**	**N_2O**
1.A.2.f Non-Metallic Minerals	✓	✓	✓
1.A.2.g Other (as specified in table 1.A(a)s2)	✓	✓	✓
1.A.2.g.i Manufacturing of machinery	✓	✓	✓
1.A.2.g.ii Manufacturing of transport equipment	✓	✓	✓
1.A.2.g.iii Mining (excluding fuels) and quarrying	✓	✓	✓
1.A.2.g.iv Wood and wood products	✓	✓	✓
1.A.2.g.v Construction	✓	✓	✓
1.A.2.g.vi Textile and leather	✓	✓	✓
1.A.2.g.vii Off–road vehicles and other machinery	NO, NA	NO, NA	NO, NA
1.A.2.g.viii Other	✓	✓	✓
1.A.3 Transport			
1.A.3.a Civil Aviation	✓	✓	✓
1.A.3.b Road Transportation	✓	✓	✓
1.A.3.c Railways	✓	✓	✓
1.A.3.d Navigation	✓	✓	✓
1.A.3.e Other Transportation – pipeline	✓	✓	✓
1.A.4 Other Sectors	✓	✓	✓
1.A.4.a Commercial/Institutional	✓	✓	✓
1.A.4.b Residential	✓	✓	✓
1.A.4.c Agriculture/Forestry/Fisheries	✓	✓	✓
1.A.5 Other	✓	✓	✓
1.A.5.a Stationary	✓	✓	✓
1.A.5.b Mobile	IE	IE	IE
1.B Fugitive Emissions from Fuels			
1.B. Solid Fuels			
1.B.1.a Coal Mining and handling	NA	✓	NA
1.B.1.a.i Underground mines	NA	✓	NA
1.B.1.a.i.1 Post – Mining Underground activites	NA	✓	NA
1.B.1.a.i.3 Abandoned Underground mines	NA	✓	NA
1.B.1.a.i.1 Surface mines	NA	✓	NA

IPCC category-Energy Sector	Emissions estimation status		
	CO_2	CH_4	N_2O
1.B.1.a.i.1 Post – Mining Surface activites	NA	✓	NA
1.B.1.b Solid fuel transformation	NA	NO	NA
1.B.1.c Other	NA	NA	NA
1.B.2 Oil and Natural Gas			
1.B.2.a Oil	✓ , NO	✓	✓
1.B.2.a.i Venting oil	✓ , NO	✓	NA
1.B.2.a.ii. Flaring oil	✓ , NO	✓	✓
1.B.2.a.iii.1 Exploration	✓ , NO	✓	NA
1.B.2.a.iii.2 Production and upgrading	✓ , NO	✓	NA
1.B.2.a.iii.3 Transport	✓ , NO	✓	NA
1.B.2.a.iii.4 Refining and storage	✓ , NO	✓	NA
1.B.2.a.iii.5 Distribution of oil products	NO	NO	NO
1.B.2.a.iii.6 Other	✓ , NO	IE	NA
1.B.2.b Natural Gas	✓	✓	✓
1.B.2.b.i Venting gas	✓	✓	NA
1.B.2.b.ii Flaring gas	✓	✓	✓
1.B.2.b.iii.1 Exploration	IE, NO	IE	NA
1.B.2.b.iii.2 Production	✓ , NO	✓	NA
1.B.2.b.iii.3 Processing	✓	✓	NA
1.B.2.b.iii.4 Transmission an storage	✓	✓	NA
1.B.2.b.iii.5 Distribution and storage	✓	✓	NA
1.B.2.b.iii.6 Other	NO	✓	NA
1.B.2.d Other	NO	NO	NA
1.D Memo items			
1.D.1 International Bunkers			
1.D.1.a Aviation	✓	✓	✓
1.D.1.b Marine	✓	✓	✓
1.D.2 Multilateral operation	✓ NA	✓ NA	✓ NA
1.D.3 CO_2 emissions from biomass	✓	✓ NA	✓ NA
1.D.4 CO_2 captured	✓ NO	✓ NO	✓ NO

IPCC category-Energy Sector	Emissions estimation status		
	CO_2	CH_4	N_2O
1.C CO_2 transport and storage	✓ NO	✓	✓
1.A.B Fuel Combustion – Reference Approach	✓		

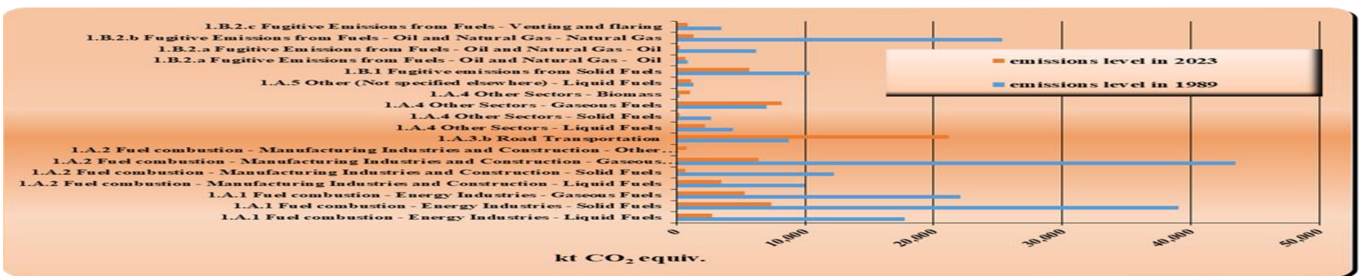
Key sources

Table 3.3 Key categories overview - Energy 2023

Key categories	GHG	Criteria (L and/or T)	Contribution in total GHG emissions[%]	Methodological tier used
1.A.3.b Road Transportation	CO_2	L, T	20.44%	T1, T3
1.A.1 Fuel combustion – Energy Industries – Solid Fuels	CO_2	L, T	7.13%	T1, T2, T3
1.A.4 Other Sectors – Gaseous Fuels	CO_2	L, T	7.86%	T1, T2
1.A.2 Fuel combustion – Manufacturing Industries and Construction – Gaseous Fuels	CO_2	L, T	6.18%	T1, T2, T3
1.B.1 Fugitive emissions from Solid Fuels	CH_4	L, T	5.41%	T1, T2
1.A.1 Fuel combustion – Energy Industries – Gaseous Fuels	CO_2	L, T	5.09%	T1, T2, T3
1.A.2 Fuel combustion – Manufacturing Industries and Construction – Liquid Fuels	CO_2	L, T	3.39%	T1, T2, T3
1.A.1 Fuel combustion – Energy Industries – Liquid Fuels	CO_2	L, T	2.69%	T1, T2, T3
1.A.4 Other Sectors – Liquid Fuels	CO_2	L, T	2.13%	T1, T2
1.B.2.b Fugitive Emissions from Fuels – Oil and Natural Gas – Natural Gas	CH_4	L, T	1.25%	T1
1.A.5 Other (Not specified elsewhere) – Liquid Fuels	CO_2	L, T	1.14%	T1, T2
1.A.4 Other Sectors – Biomass	CH_4	L, T	1.02%	T1
1.B.2.c Fugitive Emissions from Fuels – Venting and flaring	CH_4	L	0.87%	T1
1.A.2 Fuel combustion – Manufacturing Industries and Construction – Other Fossil Fuels	CO_2	L, T	0.74%	T1, T2, T3

Key categories	GHG	Criteria (L and/or T)	Contribution in total GHG emissions[%]	Methodological tier used
1.A.2 Fuel combustion – Manufacturing Industries and Construction – Solid Fuels	CO_2	L, T	0.68%	T1, T2, T3
1.B.2.a Fugitive Emissions from Fuels – Oil and Natural Gas – Oil	CO_2	L, T	0.63%	T1, T2, T3
1.B.2.a Fugitive Emissions from Fuels – Oil and Natural Gas – Oil	CH_4	T	0.23%	T1

Figure 3.3 Key categories, both by level and trend criteria, overview – Energy Sector, 2023



3.2 Fuel combustion (CRT 1.A), including detailed information on:

3.2.1 Comparison of the sectoral approach with the reference approach

According to the IPCC documents ("IPCC 2006 Guidelines"), two separate approaches have to be applied in order to estimate the emissions from fuel combustions activities. In calculating GHG emissions from the Energy Sector, were used two methods indicated in the previously mentioned documents:

❖ Reference Approach;

❖ Sectoral Approach.

The Reference Approach is a top-down methodology, which uses a national balance (taking into account the non–energy use of fuels), calculated from the following quantities:

❖ Production;

❖ Import and export;

❖ Stock changes;

❖ International bunkers.

The Reference Approach (RA) is a method for estimating CO_2 combustion emissions using a simplified methodology. For the purpose of the RA the apparent consumption of each fuel is calculated. The Sectoral Approach is a more detailed methodology (a bottom–up method), using the fuel consumption for each of the subsectors:

- ❖ Energy Industries (Public Electricity and Heat Production, Petroleum refining, Manufacture of the solid fuels and other energy industries);
- ❖ Manufacturing Industries and Construction (Iron and steel, Non-ferrous metals, Chemicals, Pulp, paper and print, Food processing, beverages and tobacco, Non-metallic minerals, Other);
- ❖ Transport (Domestic aviation, Road transportation, Railways, Domestic navigation, Other transportation);
- ❖ Other Sectors (Commercial/Institutional, Residential, Agriculture/Forestry/Fisheries);
- ❖ Other (Stationary, Mobile).

Methodology

The applied methodologies are in accordance with the IPCC 2006 Worksheets provisions. The activity data for the reference approach are provided through the Romanian Energy Balances. The conversion factor used to calculate the apparent energy consumption for solid fuels was obtained calculating the NCV weighted average from the NCVs of production, imports and exports provided through the Energy Balance–solid fuels. For the liquid fuels, as conversion factors the average of net calorific values provided through the Energy Balance–liquid fuels are used to calculate the apparent energy consumption. For the liquid fuels reported on the EU–ETS monitoring reports, the national values for the the corresponding NCVs were derived and used as averages, as follows: for the Romanian EU–ETS reporting period, 2007–2010 years, annual averages of the NCVs were used; for the rest of the time series the averages of the reporting EU–ETS period for the liquid fuels were used. The NCVs used within the Reference Approach are included in Annex V.1 and Annex V.6. For the fuels having associated determined country–specific carbon content, Tier 2 method is applied. For the fuels having associated default carbon content values, Tier 1 method is applied. According to the information provided by the National Institute for Statistics, some operators, reporting under the EU–ETS for the years 2007–2010, had reported quantities of industrial waste co–incinerated in cement installations as biomass and not as industrial waste. In order to avoid the potential underestimation of emissions in the inventory, from these emissions was subtracted the percentage representing real biomass, and the CO_2 emissions were accounted under the energy sector – corresponding activity category (1A2g). In order not influence the RA–SA difference, the consumption and the corresponding CO_2 emissions were also added in the Reference Approach, as production of industrial wastes and corresponding emissions. Regarding the previous ERT observation that the energy consumption values for several oil products are consistently higher in the IEA data than in the CRT (for lubricants, around 20 per cent higher; for bitumen, around 11 per cent; for residual fuel oil and gasoline around 1 to 2 per cent, respectively), Romania, as declared before, uses the National Statistics Institute activity data provided through the Energy Balance and reported also to EUROSTAT and IEA. Also, for the above type of fuels, as conversion factors, the NCVs reported through the Energy Balance – liquid fuels and assumed for the entire time series or national determined value, are used.

Results of the Reference Approach

In the bellow graphs the emissions according to the both approaches in terms of all fuels, liquid fuels, solid fuels, gaseous fuels, other fuels, are compared.

Figure 3.4 Comparison of the sectorial approach with the reference approach

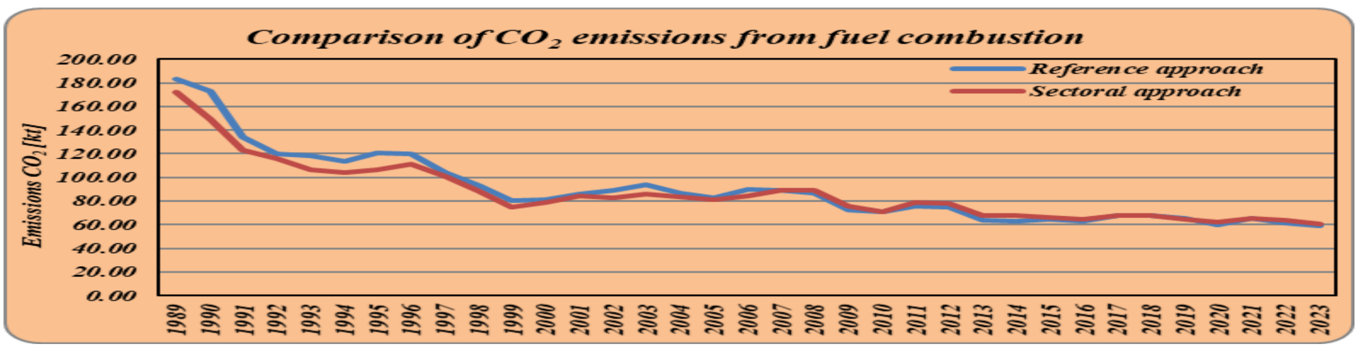


Figure 3.5 Comparison of the sectorial approach with the reference approach – liquid fuels

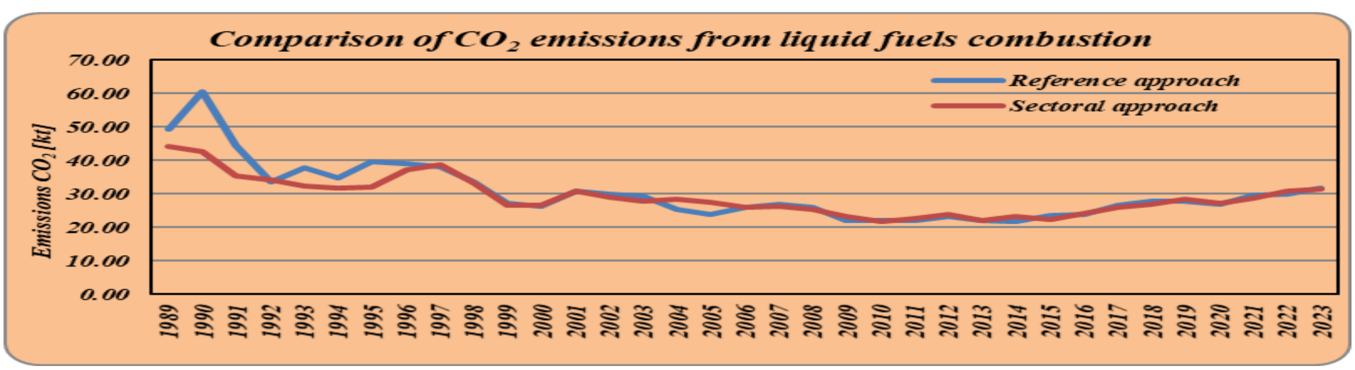


Figure 3.6 Comparison of the sectorial approach with the reference approach – solid fuels

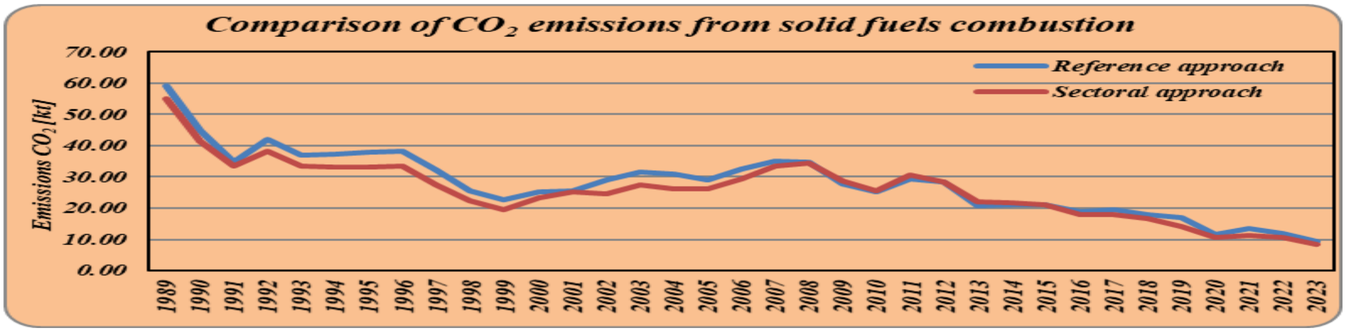


Figure 3.7 Comparison of the sectorial approach with the reference approach – gaseous fuels

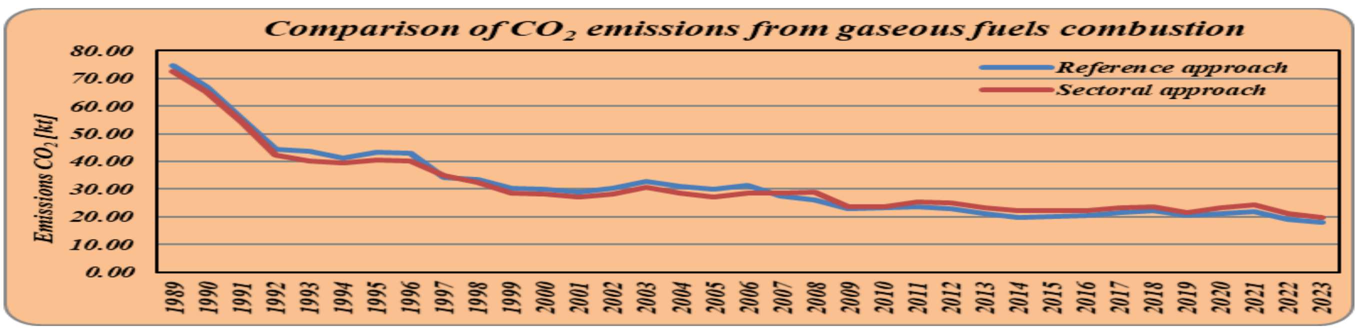
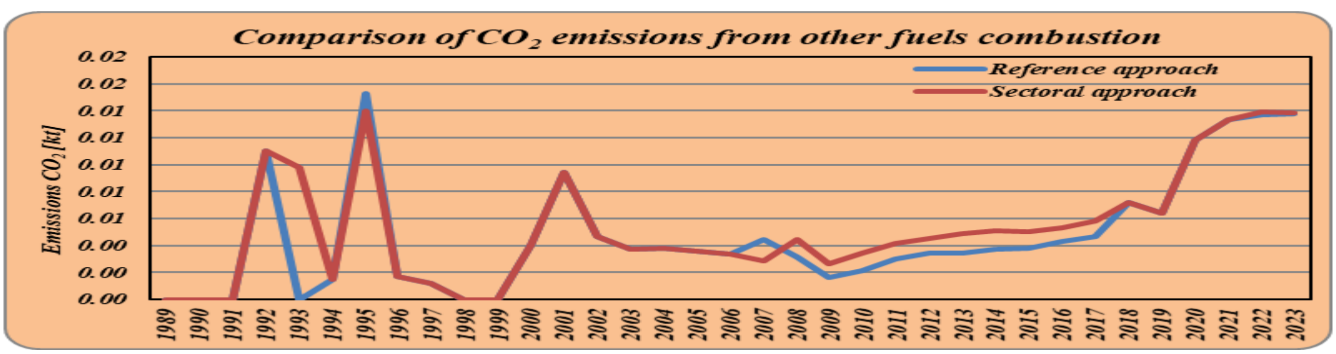


Figure 3.8 Comparison of the sectorial approach with the reference approach – other fuels



Explanation of Differences

A comparison between the RA and the SA indicates differences in both the energy consumption data and CO_2 emissions, -4.58% in terms of energy consumption and -2.11% in terms of CO_2 emissions for 2023. One of the reasons for these differences refers to the fact that the Reference Approach deals with the non–energy uses of fuels as if they are combustion activities. A correction is done by subtracting the non–energy use from the aparent consumption of the fuels. Thus, the consumption reported through the Energy Balances as being non–energetic in the sectoral activities, were subtracted from the Reference Approach. In addition, the following processes consumption were subtracted from the Reference Approach:

- In 1.A.1.b Petroleum refining category, the reported quantities of the petroleum coke, on the entire time–serie, were subtracted. Further to a dialog between energy sector experts and the operators from Refineries domain, it was concluded that the petroleum coke is reported in the Energy Balance as refinery fuel, in fact being the quantity of the "catalyst coke" deposited on the catalyst during refining processes and representing process emissions which are accounted as fugitive emissions. The RA–SA difference was affected in the sense of decreasing of this difference. The petroleum coke was subtracted from 1.A.1.b Petroleum Refineries category, and reported under the Fugitive emissions 1.B.2.a.6 oil, other category.
- Due to the fact that Coke Oven Coke is used as reduction agent in Blast Furnace, Iron and Steel Production activity, this non–energy use of the fuel from the Reference Approach, was subtracted. The result is a balanced approach in respect of the used methodology for the CO_2 emissions estimation in the Reference Approach in comparison with the Sectoral Approach.
- In 1.A.2.c Chemicals category, the reported quantities of the natural gas consumption, used in energy goal, on the entire time–series were subtracted. These quantities are reported in the IPPU sector in 2.B.1 Ammonia Production category, in according to the 2006 IPCC methodology;
- In 1.A.2.a category, the reported quantities of the coal is accounted in the IPPU sector, other than the coke_oven_coke used in Blast oxygen furnaces. Also, these quantities are not corrected in the RA.

The institution in charge with data provision to the inventory compiler, through the Energy Balances (the same data being transmitted to the international institutions–IEA/ EUROSTAT, UNECE) is the National Institute for Statistics. In the context of the inventory review under “2012 technical review of GHG emission inventories under the EU Effort Sharing Decision (ESD)”, during the developing of the project “Environmental Integrated Informational System (Romania)–International consultant for Key Category Analysis and Uncertainty Analysis for Romanian National GHG Inventory” by the representatives of Austrian Environmental Federal Agency–Umweltbundesamt and University of Graz, Institute for Systems Science, Innovation and Sustainability Research, the response is contained in the word files, Country_practice_template_Romania 2012, who clarifying the country practice in Energy Statistics and sent as reference to the “Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics provisions”. In addition, because the statistical differences are the main reason for the differences between RA and SA, in order to explain these differences, the methodological note of the domestic Energy Balance, provides the following note: Statistical differences are calculated as difference between “available for final consumption”– from which was subtracted the non-energy use – and "final energetic consumption" observed through statistical investigation. The statistical differences comprise the statistical registered stocks variations, the energy consumption in military purposes (excluding those for industrial production, which are included in the industrial activities) as well as the differences generated by the statistical investigation system: the energy producers are exhaustively registered while the consumers are surveyed based on a representative sample, being admitted a range of error. The statistical difference could be negative or positive as the consumption is lower or higher than the available supply in the reference period". Overall, the estimation on the KP period – fuels is overestimated, due to the negative differences (Sectoral Approach higher than Reference Approach). The main reason for this are the differences in fuels consumption resulting from the significant amounts of refinery loses reported and the reported statistical differences. An explanation for the differences between the two approaches is provided by the Energy Balance: for some of years being reported a significant statistical differences which generated by the statistical investigation system (while the energy producers are exhaustive recorded, the consumers are inquired on census or on a sampling base, admitting a margin of error). Data are collected by country statistical offices (40 counties) and compiled to regional totals before being sent to the national agency. Electronic checking procedures allow to eliminate errors in compiling the national total. Statistical procedures allow to match missing data. The response rate is above 90%, however. Supply (from census) and consumption (from census and survey) are being reconciled by checking the energy balance. Transformation factors allow to assess losses, again input versus outputs are being checked. In reconciling, statistical errors are being corrected but company information is maintained. The highest differences between the two approaches are observed in the period 1990–1996, and most notably in 1990, 1993 and in 1995. The analysis showed that the main reason for this are the differences in liquid fuels consumption resulting from the significant amounts of refinery loses reported (6.1% of total refinery intake in 1995 was reported as refinery losses in comparison with the refinery intake observed reported consumption) and the reported statistical differences. For the fuels reported on the EU–ETS, the national parameter of the NCVs were determined and used: annualy for the EU–ETS period (2007–2010 years) and average of the EU–ETS period for the rest of the back time series; it is the case of the following fuels: Transport Diesel, Refinery Gas, Petroleum Coke, Residual Fuel Oil, Heating and Other Gasoil.

Country specific values NCVs and CO_2 EFs have determined and used for the 2007–2023 period.

Oxidation factors – the full oxidation was assumed for all reported fuels, as it is provided through the IPCC 2006 GL.

Emission factors – for the fuels not having determined country specific values, the default carbon content provided through the IPCC 2006 GL – Vol. 2.1, Chapter 1, are used.

The difference between the two approaches is influenced by the usage of the EU-ETS activity data in 1.A.1.a, 1.A.1.b, 1.A.1.c, 1.A.2.a, 1.A.2.b, 1.A.2.c, 1.A.2.d, 1.A.2.e, 1.A.2.f and 1.A.2.g categories for 2007–2023 period. This correction is not implemented in the RA. Another reason about the difference between the two approaches is due to the use of emission factors including the oxidation factors in the calculation of emissions for the sectoral approach (SA) compared to the use of emission factors excluding the oxidation factors to calculate CO_2 emissions from the reference approach (RA), this difference is because the consumption of fuels is variable. The CO_2 emission factors with oxidation is higher than CO_2 emission factors without oxidation because they depend on the annual variation in the number of the economic operators under EU–ETS (the number of operators is decreasing) and on the variations in the fuel consumption of each economic operator.

3.2.2 International bunker fuels

The International Bunkers category comprise data and information on the fuels and the emissions resulting from international air and marine transport of passengers and cargo. These GHG related data and information are also subject to the inventory and they are reported, but the GHG emissions are not included in the total sum of the emissions of the country. The Energy Balance provides a split between the domestic and international fuel consumption.

3.2.2.1 International Aviation (CRT 1.D.1.a)

The activity data for International Aviation category were provided through the IEA/Eurostat Questionnaire and values for emissions factors used are provided through the IPCC 2006. The fuels consumption for domestic and international aviation were calculated for the cycles of the fly LTO (landing/ take off)/ Cruise. The fuel consumption/ LTO is provided through the Eurostat website/ Aircraft traffic data by reporting country [avia_tf_acc] (see Annex V.3). In 2023 the emissions from International Aviation category represent 1.31% (288.64 kt CO_2 equiv.) of total emissions from the Transport sector (22,124.76 kt CO_2 eq). In 2023 the emissions from the International Aviation category have decreased by 66.48% compared to the base year 1989 due to the fuel consumption. The Tier1 and Tier 2 methods were used and are presented in section 3.2.7.2.2. The values of CH_4 and N_2O emissions for Domestic and International Aviation were calculated for each cycle type of aircraft flight (kg fuel/ LTO) using the 2006 IPCC methodology vol 2, chapter 3 Table 3.6.9, page 3.70 (see Annex 3.3). The fuel consumption for 1.D.1.a category, according to the IEA/ Eurostat Questionnaire, is differentiated in non–bio jet kerosene and aviation gasoline. Regarding the consumption of non-bio jet kerosene from international aviation, for the period 1989–2017 according to the statistical energy methodology used, both fuel consumption on the Romanian territory and fuel consumption upon return to Romania are included. Starting with 2018, a new methodological approach has been implemented by the National Institute of Statistics (NIS); thus, according to the "Remarks" sheet from IEA / Eurostat Questionnaire 2018, the fuel of non-bio jet kerosene purchased abroad by the resident companies for the returning international aviation flights is no longer reported as consumption in international aviation. All these issues reflects the decrease by half of non-bio jet kerosene consumption in 2018, compared to 2017; in this respect, the NIS confirmed that it will continue to maintaine the change regarding the methodological approach to fuel consumption in the IEA/Eurostat Questionnaire for International Aviation. In 2023, there is a increase in non–bio jet kerosene consumption compared to 2022.

Figure 3.9 GHG emissions from International Aviation category for 1989–2023 period

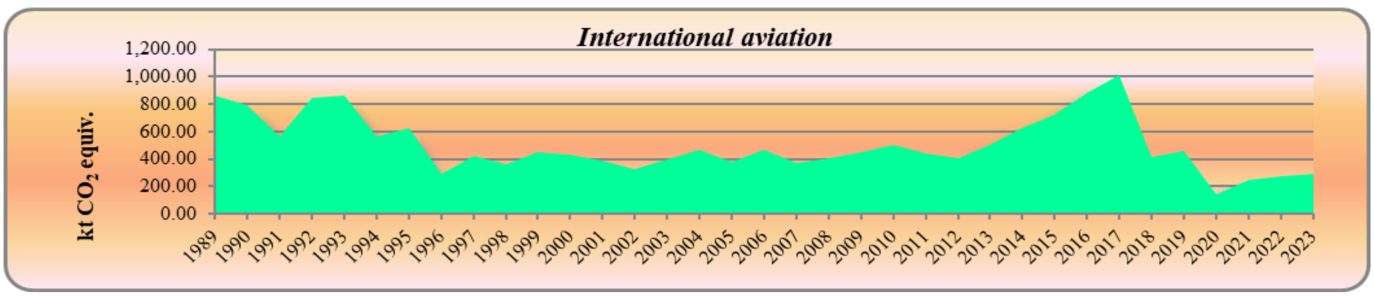
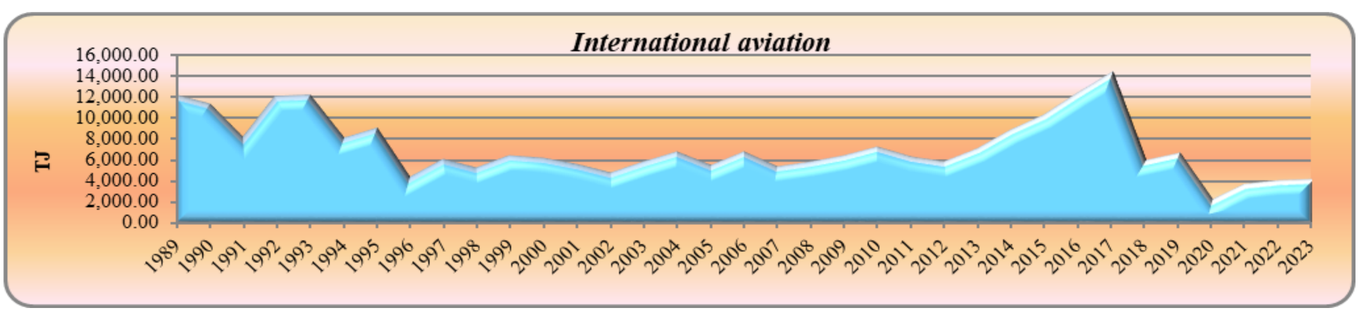


Figure 3.10 Total fuel consumption from International Aviation category for 1989–2023 period



3.2.2.2 International Navigation (CRT Sector Marine 1.D.1.b)

The activity data for International Navigation category are provided through the IEA/Eurostat Questionnaire; emission factors values used are both country specific and default, provided through the IPCC 2006. In 2023 the emissions from International Navigation category represent 0.31 % (68.09 kt CO_2 equiv) from total emissions of Transport sector (22,124.76 kt CO_2 equiv). The lack of data provided by the

National Statistics Institute for the consumption of diesel oil, for the periods 1989–1997 and 1999–2006, as well as for the consumption of residual fuel oil for the period 1989–2007 are transposed in figure 3.11, where fuel consumption growth is reflected by the peaks of 1998 and 2006–2008. Beginning with 2009, fuel consumption is starting to fall again, but started with 2012, there is another growth, culminating with the 2014 peak. In the 2023 year, the fuel consumption level associated with the International Navigation category increased with 28.45% compared with 2022 year. The Tier1 and Tier 2 method have been used and are presented in section 3.2.7.4.2.

Figure 3.11 Total GHG emissions from International Navigation category for 1989–2023 period

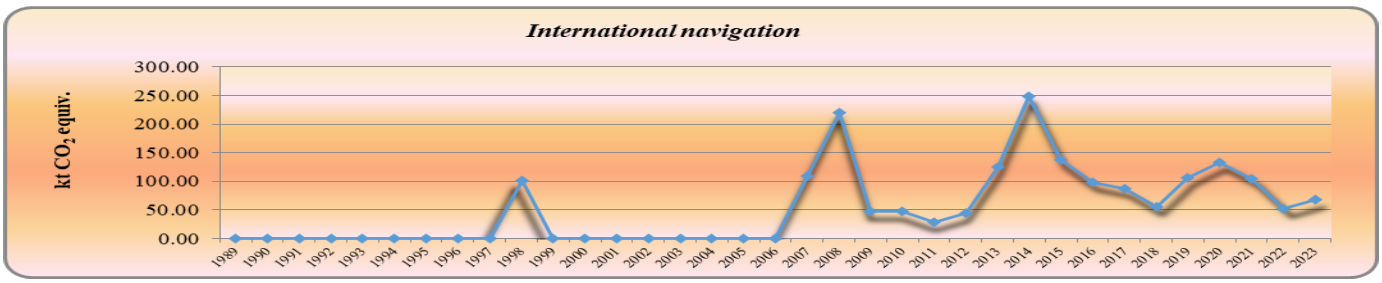
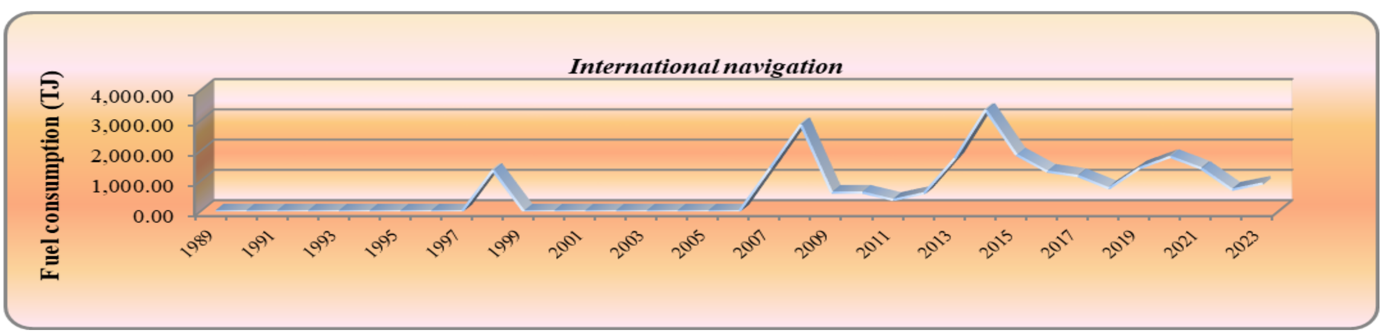


Figure 3.12 Total fuel consumption from International Navigation category for 1989–2023 period



3.2.3 Feedstocks and non-energy use of fuels

The Energy Balance provides information concerning the non–energy use of the fuels. In response of ERT recommendation, “Romania further investigate and elaborate on the non–energy use of fuels reported in the energy balance, which is not reported in the energy sector, and assess whether the country specific carbon storage factors are appropriate”, Romania investigated the non–energy use of fuels reported in the energy balance; consequently, Romania subtracted the non–energy use from the Sectoral Approach and the corresponding quantities non–energy use of the products from the Reference Approach. At the same time, the consumption reported as energy consumption in line with the Energy Balance completion methodology, in fact being used in industrial processes, was accounted as non–energy use and subtracted from the sectoral approach and consequently from the Reference Approach; it is the case of coke_oven_coke which is used as reduction agent in Blast Furnaces and petroleum coke, which is used as catalyst coke and is deposited on the catalyst during refining processes.

Methodology

Non-energy use of fuels is reported in the Energy balance for the following fuels on the entire time–series:

- ❖ Lubricants;
- ❖ Bitumen;
- ❖ Naphtha;
- ❖ LPG;
- ❖ Refinery gas;
- ❖ Motor Gasoline;
- ❖ Kerosene Type Jet Fuel;
- ❖ Other Kerosene;
- ❖ Gas-Diesel Oil;
- ❖ Petroleum Coke;
- ❖ Residual Fuel Oil;
- ❖ Natural Gas as Feedstock;
- ❖ Other Products;
- ❖ Paraffin waxes;
- ❖ White spirit;
- ❖ Lignite;
- ❖ Brown Coal;
- ❖ Coal Oil and Tars (from coking coal);
- ❖ Other Bituminous Coal.

For the liquid fuels reported on the EU–ETS, the national parameter of the NCVs were determined and used to calculate the non–energy use of the fuels: annualy for the EU–ETS period (2007–2010 years) and average of the EU–ETS period for the rest of the back time series; it is the case of the following fuels: Transport Diesel, Refinery Gas, Petroleum Coke, Residual Fuel Oil, Heating and Other Gasoil. Country specific values NCVs and CO_2 EFs have determined and used for 2007–2023 period. The following type of fuels have been added to the Table1.A(d) “Feedstocks, reductants and other non–energy use of fuels–Other fuels” category: Refinery gas, Paraffin waxes, White spirit. According to the 2006 IPCC Guidelines provisions, Volume 3, Chapter 5: Non–Energy Products from Fuels and Solvent Use, the following methodology to report in the CRT Table 1.A(d) Feedstocks, reductants and other non–energy use of fuels, was used:

– Bitumen: the carbon is reported as being full stored in the final product;
– Naphta, Refinery gas, Other kerosene, Gas Diesel–Oil, Petroleum Coke, Residual Fuel Oil, Other products, White spirit: the carbon was presumed that is fully emitted and not stored, having the full oxidation during use (in according with the IPCC 2006 GL, Volume 2, Chapter 6, Reference Approach, page 6.11);
– Paraffin Waxes and Lubricants: the fraction of carbon stored is 0.8, the rest of 0.2 being emitted. Lubricating oil statistics usually cover not only use of lubricants in engines but also oils and greases for industrial purposes and heat transfer and cutting oils. All deliveries of lubricating oil should be excluded from the Reference Approach. This avoids a potential double count of emissions from combustion of waste lubricants covered in the Reference Approach under “other fossil fuels” but ignores the inclusion of emissions from lubricants in two–stroke engines.

There are some fluctuations of the reported consumption of some of the fuels during the time series–unstable trends in the exports imports, or production. The non–energy use of fuels is an average of 9.04% from the total apparent energy consumption during the period 1989–2008, and arround 6.73% for the 2009–2023 period. This could be in tight relation with the developing of the industry after 2000 until the economic crisis to have effects on the industry branches. In the 2015–2023 period the share of the non–energy use of the fuels in total consumption is about 5.86% and for 2023 year is about 3.71%. The most significant fuels used as feedstock are natural gas, bitumen, naphtha and lubricants. Also, the Coke_Oven_Coke used as reduction agent in Blast Furnace, the associated emissions being accounted in Industrial Processes sector, represents an important non–energy use quantity. For coal oil and tars the assumption suggested in the methodology (5.91% from the coking coal consumption is assumed to be stored in products) was applied.

Table 3.4 Non-energy use of fuels compared to total apparent energy consumption

Year	Non-energy use [PJ]	Apparent energy consumption incl. non-energy use [PJ]	[%]
1989	164.10	2,541.78	6.06
1990	117.98	2,241.23	5.00
1995	119.22	1,596.92	6.95
2000	141.24	1,239.08	10.23
2005	192.47	1,293.57	12.95

Year	Non-energy use [PJ]	Apparent energy consumption incl. non-energy use [PJ]	[%]
2006	184.63	1,324.07	12.24
2007	175.94	1,364.41	11.42
2008	148.50	1,388.47	9.66
2009	119.80	1,222.09	8.93
2010	117.14	1,189.66	8.96
2011	121.16	1,262.61	8.76
2012	96.92	1,256.92	7.16
2013	86.83	1,124.68	7.17
2014	86.49	1,115.66	7.19
2015	75.31	1,121.02	6.30
2016	76.28	1,089.51	6.54
2017	70.65	1,139.03	5.84
2018	70.05	1,157.10	5.71
2019	78.07	1,118.47	6.52
2020	81.50	1,077.71	7.03
2021	81.39	1,162.02	6.55
2022	53.29	1,126.81	4.52
2023	41.27	1,069.86	3.71

Figure 3.13 Comparison between the energy and non–energy use of the fuels in the energy sector

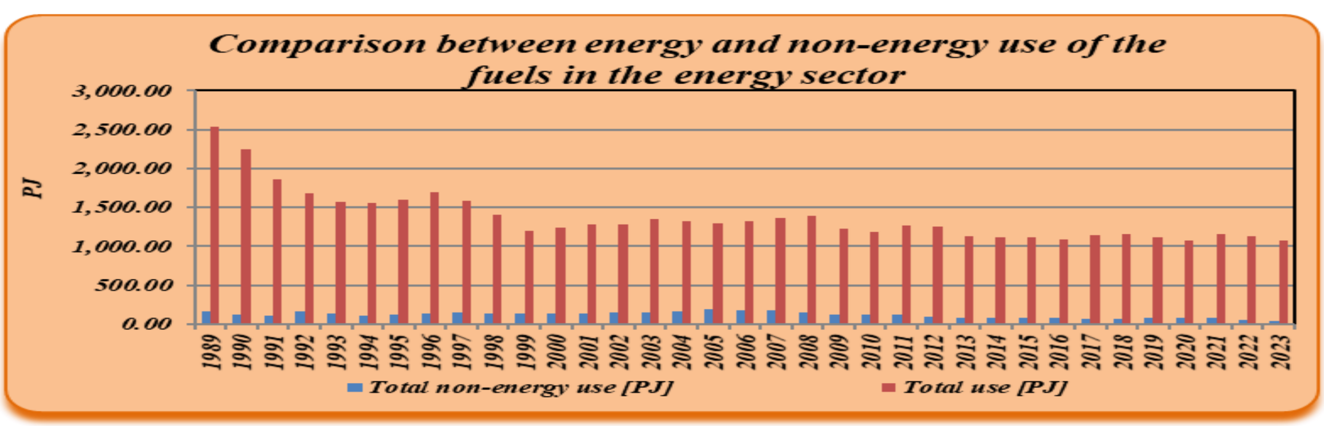
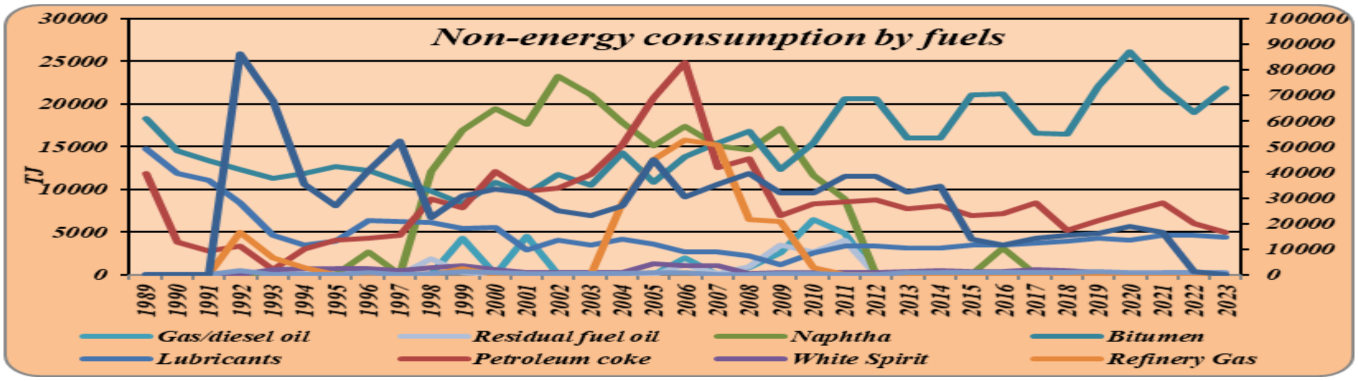


Figure 3.14 The most important non–energy consumption of the fuels



Recalculations performed on Feedstock's and non-energy use of fuels (1.AD category)

Activity data

Liquid Fuels

Recalculations were made for Petroleum coke for the period 1990–2022 due to the update of activity data (Net Calorific Value); this resulted in the updating of emissions for this period.

3.2.4 Fuel combustion (CRT 1.A)

The fuel consumption of the following subcategories is included in this category:

- ❖ 1.A.1 Energy Industries;
- ❖ 1.A.2 Manufacturing Industries and Construction;
- ❖ 1.A.3 Transport;
- ❖ 1.A.4 Other Sectors;
- ❖ 1.A.5 Other.

3.2.4.1 Category description

CO_2 emissions from fuel combustion activities accounted for 62,376.54 Gg CO_2 equiv. in 2023. Within the fuel combustion sector, 24.90% of the CO_2 equiv. emissions correspond to 1.A.1 Energy Industries category, 18.39% of the CO_2 equiv. correspond to 1.A.2 Manufacturing Industries and Construction, 35.47% of the CO_2 equiv. emissions correspond to 1.A.3 Transport, 19.34% of the CO_2 equiv. emissions correspond to 1.A.4 Other Sectors and 1.90% from the CO_2 equiv. emissions correspond to 1.A.5 Other (Not specified elsewhere). It is observed that the Transport category are the main source of GHG emissions from fuel combustion with 22,124.76 Gg CO_2 equiv. of the emissions in 2023. In general, there is a notable drop in the country emissions after 1990–1991 due to the transition from planned economy to market economy, which happened in the country. Generally, there is a decrease of the GHG emissions up to 1999 and slow increase after 2000, after the national economy started to grow and due to the new technologies used. In the recent years (2009–2010) due to the economic crisis the emissions are decreasing again, under the 1999 levels. In the last years of the time–series, 2012–2023, the GHG emissions in this category encountered a decreasing, a contribution to this trend being from the usage on a larger scale of the renewable sources: the emissions of CO_2 equiv. decreased in 2023 in comparison with 2022, in the 1.A.1 Energy Industries, with 13.73%, in the 1.A.2 Manufacturing Industries and Construction category the GHG emissions of CO_2 equiv. with 12.77%, in the 1.A.3 Transport category the GHG emissions of CO_2 equiv. encountered a increased with 4.57%, in the 1.A.4 Other Sectors category the GHG emissions of CO_2 equiv. encountered a decreased with 1.80% and in the 1.A.5 Other category the GHG emissions of CO_2 equiv. encountered a increased with 1.20%.

Figure 3.15 Total GHG CO_2 equiv. emissions associated with the Fuel Combustion Activities by categories

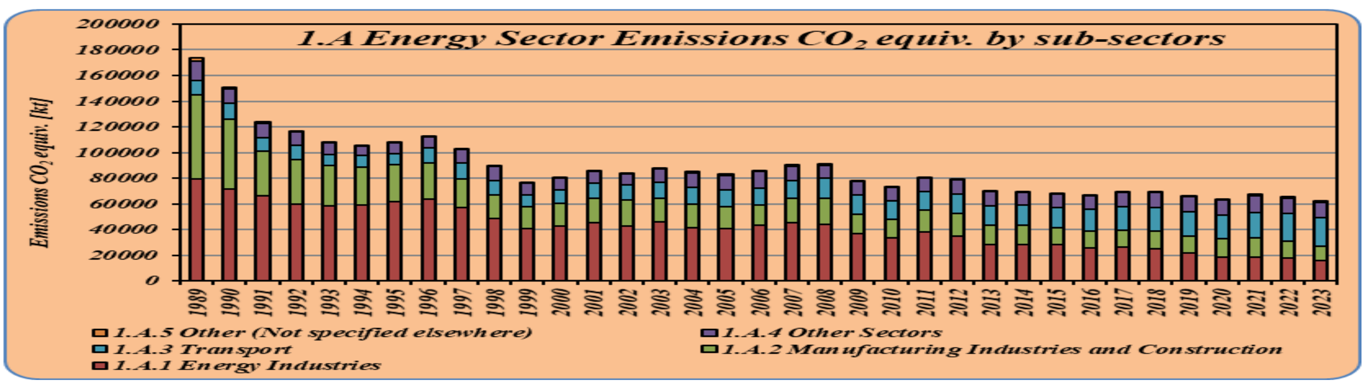
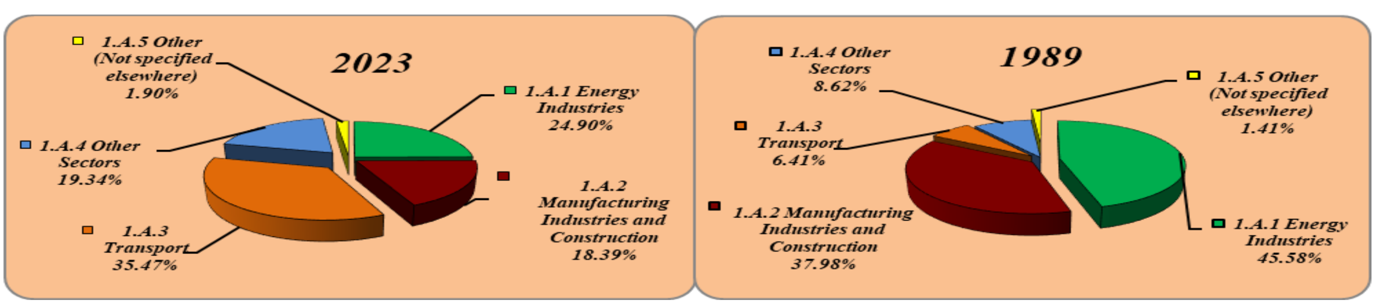
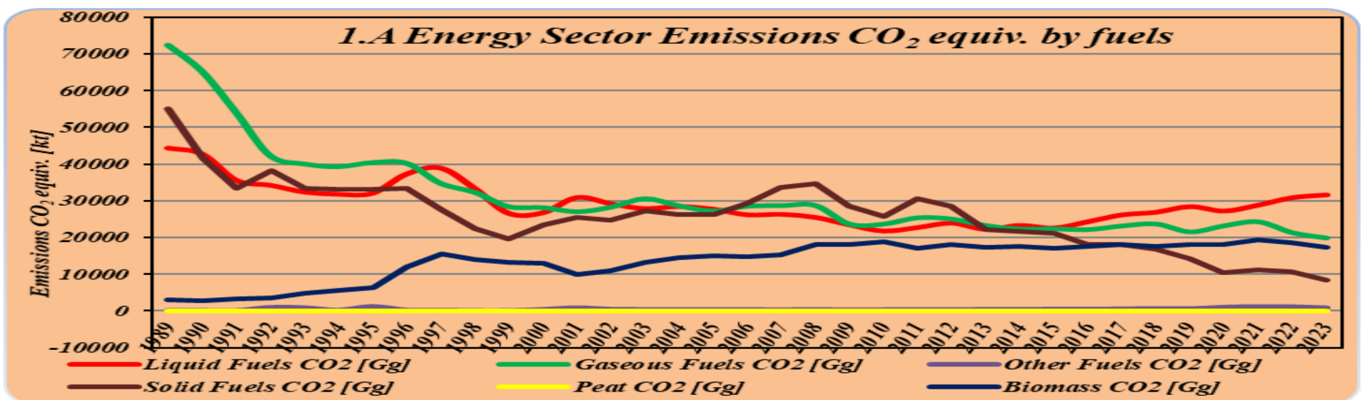


Figure 3.16 Base year and current year comparison in respect to the contribution of Fuel Combustion Activities Subsector categories emissions in total Subsector emissions



The demand for energy from fossil fuels is lower than in precedent year due to the fact that in 2013, 2014 the usage of the renewables sources (wind) registered an increasing; additional, the thermal regime was not very severe and the necessary of the energy for heating was slower than in precedent years. Overall, the fossil fuels emissions of the greenhouse gas have a decreased trend in 2023 in comparison with 2022, with than 1.00%. In the period 2006–2012 the main contribution to CO_2 emissions was from solid fuels, having a pick in 2007–2008. In 2023 the contribution of the liquid fuel was about 40.53%, solid 10.70%, gaseous 25.55%. It could be observed that, the three main fuels have, each of them, a significant contribution to the total of the Energy Industry CO_2 emissions. Only within the period of 2005–2008, the trend presents an increase of the solid fuels, mostly due to the energy industries growth and a decrease in liquid and gaseous fuels share.

Figure 3.17 Total CO_2 emissions [kt] from Fuel combustion by fuel type



3.2.4.2 Methodological issues

Stationary Combustion

Methodology

In the development of estimates, it was primarily utilized default EFs obtained from the IPCC 2006 Guidelines. To achieve the estimations of the CO_2 emissions on the national circumstances, a study, “Elaboration/documentation of national emission factors/other parameters relevant to National Greenhouse Gas Inventory (NGHGI) Sectors Energy, Industrial Processes, Agriculture and Waste, values to allow for the higher tier calculation methods implementation”, has determined the national emission factors based on EU–ETS operators reporting on the period of 2007–2010. For the period 2007–2023 the estimations for the CO_2 emissions were determined using the national emission factors, these values being achieved by using the methodology provided through the same study. For the 2007–2023 period the Country Specific Emission

Factors (CS EFs) determined from the EU–ETS operator reports, were used.

A) Tier 1 methodology

The IPCC Tier 1 approach (IPCC 2006 Guidelines) is used to calculate the emissions from fuel combustion in the sectors CRT 1.A.1, CRT 1.A.2, CRT 1.A.4 and CRT 1.A.5. For the gases CO_2, CH_4, N_2O and the indirect GHGs, default emission factors are used.

B) Tier 2 methodology

According to the provisions in the relevant decision trees in the IPCC 2006 GL, giving their status of key categories, the IPCC Tier 2 approach is used to calculate the CO_2 emissions from fuel combustion in the sectors CRT 1.A.1, CRT 1.A.2, CRT 1.A.4 and CRT 1.A.5. For the CO_2 gas, country specific emission factors are used.

C) Tier 3 methodology

The IPCC Tier 3 approach (IPCC 2006 Guidelines) is used to calculate the CO_2 emissions from fuel combustion in the sectors CRT 1.A.1.a, CRT 1.A.1.b, CRT 1.A.1.c, CRT 1.A.2.a, CRT 1.A.2.b, CRT 1.A.2.c, CRT 1.A.2.d, CRT 1.A.2.e, CRT 1.A.2.f and CRT 1.A.2.g. For the CO_2 gas, emission factors by fuel and tehnology type are used.

Activity Data

The activity data required for calculation of the emissions from stationary combustion is based on the National Energy Balances, which provide information about the indigenous production, imports, exports and inland consumption, by subsector, for all types of fuels. The energy balances as part of spreadsheets are updated using activity data from monitoring reports from economic operators under the EU–ETS for solid fuels (other bituminous coal, sub–bituminous coal, lignite and coke oven coke) for liquid fuels (refinery gas, LPG, transport diesel, residual fuel oil, petroleum coke and heating and other gasoil) and for gaseous fuels (natural gas). According to the sectoral approach methodology for stationary combustion, only the fuel quantities that are combusted in energy purposes are relevant, and thus considered for the emission calculations. Reported quantities of fuels for non–energy use and feedstock use, international bunker fuels, transformation and distribution losses, transformations of fuels to other fuels and internal refinery processes which have been reported in the transformation sector of the energy balances were not considered.

Due to methodological provisions and compliance with reporting rules and to avoid double counting of inventory data, updates of activity data for natural gas and refinery gas have been made as described below:

- the amount of the Refinery Gas in the Energy sector-Stationary combustion-category 1.A.1.b Petroleum Refining Category-liquid fuels for the period 2014-2023 was reduced and it was added to the IPPU sector;
- the amount of Natural Gas from the Energy sector-Stationary combustion-category 1.A.1.b Petroleum Refining Category-gaseous fuels for the period 1989-2023 was reduced and added to the IPPU sector;

- the amount of Natural Gas from the Energy sector-Stationary combustion-category 1.A.2.c Chemistry Category-gaseous fuels for the period 2014-2023 was reduced and was added to the IPPU sector;

Solid, liquid and gaseous fuels

The balances provide the consumption of fuels in natural units (mass or volume units – thousands of tones (kt) for solid and liquid fuels, cubic meters and TJ – tera joules for gaseous fuels) and the net calorific values for each fuel per subsector. The energy balances prepared by the Romanian National Institute for Statistics in the Eurostat format, were used for estimating the emissions for the years 1990–2023. For the 2007–2023 period, it was also into account the activity data from monitoring reports from economic operators under the EU–ETS. The National statistics have not prepared balances in the Eurostat format for the years before 1990, so the IEA Energy Balances (EB) were used for the year 1989. It was into account the activity data (ETS consumptions) from monitoring reports provided by the economic operators under the EU–ETS for the different years, as well as, the sum between the activity data (the non–ETS consumptions calculated based of the activity data from EB provided by the NIS minus the activity data from monitoring reports provided by the economic operators under the EU–ETS) and the ETS activity data (ETS consumptions), for the CRT categories presented below:

Solid fuels

For CRT 1.A.1.a category

- Other bituminous coal for the 2007–2023 period are used only the ETS consumptions;
- Sub-bituminous coal for the 2007–2023 period are used only the ETS consumptions;
- Lignite for the 2007, 2008, 2011, 2012 and 2014 years are used only the ETS consumptions and for the years 2009, 2010 and 2013 and the 2015–2023 period it was into account the non–ETS and ETS consumptions;

For CRT 1.A.1.b category

- Lignite for the 2019–2023 period are used only the ETS consumptions.

For CRT 1.A.2.e category

- Other bituminous coal for the 2012–2017 period are used only the ETS consumptions;
- Coke oven coke for the 2008–2011 and 2013–2023 periods are used only the ETS consumptions and for the years 2007 and 2012 it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.f category:

- Other bituminous coal for the 2007–2023 period are used only the ETS consumptions;
- Lignite for the 2013–2023 period it was into account the non–ETS and ETS consumptions;
- Coke oven coke for the 2011–2014 and 2017–2023 periods are used only the ETS consumptions.

Liquid fuels

For CRT 1.A.1.a category

- Refinery gas for the 2007–2015 period and years 2019, 2021 and 2022 it was into account the non–ETS and ETS consumptions and 2016–2018 period and years 2020 and 2023 are used only the ETS consumptions;
- Transport diesel for the 2007–2023 period it was into account the non–ETS and ETS consumptions;
- Residual fuel oil for the 2011–2012 and 2014–2017 periods are used only the ETS consumptions and for the year 2013 and periods 2007–2010 and 2018–2023 it was into account the non–ETS and ETS consumptions;
- Petroleum coke for the 2011–2016 period and 2019 year are used only the ETS consumptions and for the 2007–2010, 2017–2018 and 2020–2023 periods it was into account the non–ETS and ETS consumptions;
- Heating and other gasoil for the 2019 year are used only the ETS consumptions and for the 2007–2018 and 2020–2023 periods it was into account the non–ETS and ETS consumptions.

For CRT 1.A.1.b category

- Refinery gas for the 2007–2023 period are used only the ETS consumptions and ;
- Transport diesel for the 2014 and 2015 years are used only the ETS consumptions;
- Residual fuel oil for the 2007–2021 period are used only the ETS consumptions;
- Petroleum coke for the 2019–2023 period are used only the ETS consumptions;
- Heating and other gasoil for the 2020–2023 period are used only the ETS consumptions.

For CRT 1.A.1.c category

- Refinery gas for the 2007-2023 period it was into account the non–ETS and ETS consumptions;
- Transport diesel for the 2007–2023 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.a category

- LPG for the 2011 year and 2013–2017 period are used only the ETS consumptions and for the period 2018-2023 it was into account the non–ETS and ETS consumptions;
- Transport diesel for 2011–2023 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.b category

- Residual fuel oil for the 2007 year is used only the ETS consumptions.

For CRT 1.A.2.c category

- Transport diesel for 2015–2023 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.d category:

- Residual fuel oil for the 2008 year is used only the ETS consumptions.

For CRT 1.A.2.e category

- LPG for the 2011–2013 period it was into account the non–ETS and ETS consumptions;
- Transport diesel for 2011–2023 periods it was into account the non–ETS and ETS consumptions;
- Residual fuel oil for the 2007 and 2015 years are used only the ETS consumptions and for the 2008–2014 and 2016–2017 periods it was into account the non–ETS and ETS consumptions;
- Heating and other gasoil for the 2007–2023 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.f category

- LPG for the 2011 year and 2013–2016 period are used only the ETS consumptions and for the 2017–2023 period it was into account the non–ETS and ETS consumptions;
- Transport Diesel for the 2011–2023 periods it was into account the non–ETS and ETS consumptions;
- Residual fuel oil 2011–2015 and 2017–2023 periods are used only the ETS consumptions and for the 2008, 2016 and 2023 years it was into account the non–ETS and ETS consumptions;
- Petroleum coke for the 2008–2010 and 2017–2022 periods are used only the ETS consumptions and for the 2011–2016 period and the 2023 year it was into account the non–ETS and ETS consumptions;
- Heating and other gasoil for the 2011, 2012 and 2015 years are used only the ETS consumptions and for the 2016, 2021 and 2023 years it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.g category

- Residual fuel oil for the 2009, 2010, 2013 and 2023 years are used only the ETS consumptions and for the 2012 and 2015 years it was into account the non–ETS and ETS consumptions;

Gaseous fuels

For CRT 1.A.1.a category

- Natural gas for the 2013–2023 period are used only the ETS consumptions and for the 2007–2012 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.1.b category

- Natural gas for the 2007–2023 period are used only the ETS consumptions.

For CRT 1.A.1.c category

- Natural gas for the 2007–2023 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.a category

- Natural gas for the 2007–2020 period and 2023 year it was into account the non–ETS and ETS consumptions and for 2021–2022 period it was into account only the ETS consumptions.

For CRT 1.A.2.b category

- Natural gas for the 2007–2017 period are used only the ETS consumptions and for the 2018–2023 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.c category

- Natural gas for the 2012 year and 2018–2020 period are used only the ETS consumptions and for the periods 2007–2011, 2013–2017 and 2021–2023 it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.d category

- Natural gas for the 2011, 2012, 2018 and 2023 years are used only the ETS consumptions and for the 2007–2010 and 2013–2017 and 2019–2022 periods it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.e category

- Natural gas for the 2007–2023 periods it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.f category

- Natural gas for the 2008 year is used only the ETS consumptions and for the 2007 year and 2009–2023 period it was into account the non–ETS and ETS consumptions.

For CRT 1.A.2.g category

- Natural gas for the 2007 year and 2009–2023 period are used only the ETS consumptions and for the 2008 year it was into account the non–ETS and ETS consumptions.

Other Fuels – Industrial Wastes

Additionally, since it was found that the usage of alternative fuels (industrial waste) is reported in the energy balances for the full time series, it were calculated the emissions associated with this kind of consumption. Romanian Institute for Statistics (NIS) provided the information according which the operators using the co–incineration in the cement plants have reported this activity to the Biomass section. Further to this information, it was taken into consideration their emissions too, to the activity CRT 1.A.2.g Other Fuels – Industrial Wastes, extracting from their reports the consumption associated with biomass.

For the C*RT 1.A.2.d category – other fossil fuels* – Industrial waste for the 2016 year are used only the ETS consumptions and for the 2017–2023 period it was into account the non–ETS and ETS consumptions.

For the C*RT 1.A.2.f category – other fossil fuels* – Industrial waste for the 2007–2017 period are used only the ETS consumptions and for the 2018–2023 period it was into account the non–ETS and ETS consumptions.

Biomass

In order to estimate the emissions from biomass combustion activities a separated spreadsheet was completed, using the energetic quantities provided by Energy Balance. A wide range of biomass sources can be used to produce bioenergy in a variety of forms. In Romania different types of biomass, solid, liquid and gaseous, are consumed in the energy sector. Solid biofuels comprises the following:

- ❖ Wood and wood waste combusted directly for energy purposes;
- ❖ Liquid biofuels are bio gasoline, biodiesel and other bio liquids which are used mainly for transportation and they are analised in the corresponding sector;
- ❖ Landfill, sludge and other biogas are derived from anaerobic fermentation of biomass and solid wastes in landfills, from sludge and animal slurries and other sources, respectively.

All these types are combusted to produce heat and/or power. However, CO_2 emissions released from these processes are reported as an information item, as the CO_2 is naturally captured from the air. This is not applicable for the CH_4 and N_2O emissions, being reported and accounted for, in the total inventory emissions. The correspondence between the energy balance categories and CRT categories can be reviewed in the Annex V.1 (the sheet IEA–EUROSTAT–CRT categories).

Choice of NCV

The net calorific values (NCVs) used for converting mass or volume units of the fuel quantities into energy units [TJ], excluding the fuels which are reported through the EU–ETS reports, are provided by NIS. For the solid fuels other bituminous coal, lignite, coke_oven_coke and for the liquid fuels transport diesel, refinery gas, residual fuel oil, petroleum coke, heating and other gasoil, national values of the NCV were derived from the EU–ETS reports. For EU–ETS period, 2007–2010, annualy determination of the NCVs weighted averages values were used and, for the rest of the time series, the averages of the EU–ETS period were used. All the used NCVs for the liquids and solids are presented in Annex V.1, the sheet NCVs, and Annexes V.6. The corresponding Net Calorific Values (NCVs) from the Energy balances and from the corresponding EU–ETS determination were used in order to convert the fuel consumption reported in natural units to energy units.

For the solid fuels, not having NCVs determined from EU–ETS data, the balances provide NCVs values for the following activities:

- ❖ NCV for produced fuels – applied to Indigenous Production subcategory;
- ❖ NCV for imported fuels – applied to Total Imports subcategory;
- ❖ NCV for exported fuels – applied to Total Exports subcategory;
- ❖ NCV for fuels used in coke ovens – applied to Coke Ovens (Energy) subcategory;
- ❖ NCV for fuels used in blast furnaces – applied to Blast Furnaces (Energy) subcategory.
- ❖ NCV for fuels used in main activity plants – applied to:
    - Main Activity Producer Electricity Plants;
    - Main Activity Producer CHP Plants;
    - Main Activity Producer Heat Plants;
    - Own Use in Electricity, CHP and Heat Plants.

❖ NCV for fuels used in industry – applied to:

- Auto producer Electricity Plants;
- Auto producer CHP Plants;
- Auto producer Heat Plants;
- Iron and Steel;
- Chemical (including Petrochemical);
- Non–Ferrous Metals;
- Non–Metallic Minerals;
- Transport Equipment;
- Machinery;
- Mining and Quarrying;
- Food, Beverages and Tobacco;
- Paper, Pulp and Printing;
- Wood and Wood Products;
- Construction;
- Textiles and Leather;
- Non–specified (Industry).
- NCV for fuels used for other uses – applied to:
  - Commercial and Public Services;
  - Residential;
  - Agriculture/Forestry;
  - Fishing;
  - Non-specified (Other).

For liquid fuels the balances provide the average of NCVs, which were used in all calculations.

For gaseous fuels was used directly the amount in TJ as reported by the energy balances.

Since the reported values are Gross Calorific Values, all numbers were multiplied by 90% in order to compute the NCV (IEA Energy Statistics Manual, p. 183, Table A3.12). For all NCVs please consult Annex V.1 and Annexes V.6.

Greenhouse gas emission factors

CO_2 emission factors

The default CO_2 emission factors according to the IPCC 2006 Guidelines, Volume 2.1, Chapter 2 – Stationary Combustion Table 2.2 – Energy Industries, Table 2.3 – Manufacturing industries and construction, Table 2.4 – Commercial/Institutional, Table 2.5 – Residential and Agriculture/ Forestry/ Fishing/ Fishing farms, are used. For the fuels not having country specific emission factors determined, the full oxidation is assumed, as it is recommended in the IPCC 2006 GL. The country specific emission factors include the plant specific oxidation factors, which are reported under the EU–ETS rules for the available fuels and determines as it is explained above. The default EFs were used for the calculations, except for the following fuels, for which country–specific EFs were used:

- ❖ Lignite;
- ❖ Natural gas;
- ❖ Refinery gas;
- ❖ Other bituminous coal;
- ❖ Coke oven coke;
- ❖ Transport diesel;
- ❖ Residual fuel oil;
- ❖ Heating and other gasoil;
- ❖ Petroleum coke;
- ❖ Motor gasoline;
- ❖ Industrial waste.

For sludge gas and other biogas are used the new emission factors referenced in IPCC 2006 guidelines, Vol. II, Ch. 2, Table 2–2, Table 2–3, Table 2–4, Table 2–5.

Emission data reported under the European Emission Trading Scheme

A sum of operators has provided their verified CO_2 emission reports required under the EU–ETS for the years 2007–2023. Data from the verified ETS reports were analyzed in order to use a Tier 2 methodology for emission calculations. The number of plants, using a plant specific methodologies, made possible to achieve country specific EFs for a sum of solid and liquid fuels and natural gas. Also, the Country Specific Emission Factor (CS EF) for the industrial wastes ETS reporting, was derived. The emission factors without oxidation fraction included are derived from the verified ETS reports as a weighted average from all operators which have declared that they have used plant–specific emission factors (Tier 3 according to the Methodology for monitoring GHG emissions of operators participating in the ETS). As part of the regular process of using EU–ETS data in the inventory they was updated and implemented the values for CO_2 EFs and NCVs for 2007–2023 period, and they analyzing further the accuracy of EU–ETS data and their applicability in the inventory.

For the 1989–2006 period: the country-specific values for the CO_2 emission factors, the net calorific values and the carbon content were obtained as weighted average of associated values for 2007–2010 period; the CO_2 EFs were determined based on the EU–ETS operators reports and provided detailed data are taken as weighted averages calculated on the basis of information taken from the monitoring reports of economic operators reporting under the European Union Emission Trading Scheme (EU–ETS); the carbon content represents country specific carbon content of these fuels and it is derived from the country specific CO_2 emission factor; the country specific carbon content values are determined as weighted averages from the data reported by the operators which are reporting under the EU–ETS, such as: consumption and the associated Net Calorific Value of the fuels, CO_2 emission factors, oxidation factors and CO_2 emissions by using Tier 3 methodology.

For the 2007–2023 period: the CO_2 EFs were determined based on the EU–ETS operators reports and provided detailed data are calculated on the basis of information taken from the monitoring reports of economic operators reporting under the EU–ETS for each year; the carbon content represents country specific carbon content of these fuels and it is derived from the country specific CO_2 emission factor; the country specific carbon content values are determined as weighted averages from the data reported by the operators which are reporting under the EU–ETS, such as: consumption and the associated Net Calorific Value of the fuels, CO_2 emission factors, oxidation factors and CO_2 emissions by using Tier 3 methodology.

The method used to determine oxidation factors was based on laboratory analyzes from monitoring reports, in accordance with the Tier 3 approach, according to the provisions of Articles 32–35 of Regulation 601/2012 on monitoring and the reporting of greenhouse gas emissions in accordance with Directive 2003/87/EC of the European Parliament and of the Council, as amended and supplemented. The document detailing how operators/ laboratories should handle sampling, sampling, sample transport, including sample analysis is the *Guide No 5 on Sample Collection and Analysis*. The results for the oxidation factor are generated by accredited ISO 17025 laboratories, which are considered to have the competence and the ability to generate technically valid results using relevant analytical procedures. The laboratories are accredited by the Romanian Accreditation Association–RENAR.

The EFs were determined based on the EU–ETS operators reports and provided detailed data, including on the composition of industrial waste.

The carbon content of the coke_oven_coke or industrial wastes represents country specific carbon content of these fuels and it is derived from the country specific CO_2 emission factor.

This is valid for all fuels which have determined country specific CO_2 emission factors.

The composition of the waste used in energy purposes in the category 1A2f – cement clinker activities and reported under EU–ETS rules is, as follows: waste oil slam, coke tar mixture, other unspecified fossil fuels and those having in composition a declared fraction of biomass which is subtracted and not accounted in this category and not taken into consideration for the CS EF determination: solid mixed waste with 44% biomass, used tyres with 27% biomass, rubber waste with 17.21%, solid waste mixed with municipal waste and with 44% biomass.

The coke_oven_coke country specific emission factors were determined from the EU-ETS operator reports, food beverages and tobacco category – 1.A.2.e and cement clinker – 1.A.2.f, which are reporting on Tier 3 level. As the energy balance solid fuels shows – Annex V.6.3 to the NID, the coke_oven_coke is produced in Romania on period 1989–2009, just 2 kt in 2010, and imported in a small measure. The raw material, coking coal, is also indigenous produced and mainly imported from different suppliers on the glob; the coking coal goes in transformation in coking plants. From 2010 onwards, the necessary of the coke_oven_coke is assured only from import.

The Blast Furnace Gas from Annex V.6.3 to the NID, the Energy Balance table of solid fuels, is presented as consumed in main activity producer CHP plants. The consumption of Blast Furnace Gas are provided by the Energy Balances prepared by the Romanian National Institute for Statistics in the Eurostat format, in TJ – tera joules. The emissions for Blast Furnace Gas consumed in Main Activity producer CHP Plants are estimated in the 1.A.1.a. Public Electricity and Heat Production – solids fuel category. For Blast Furnance Gas are used the Tier 1 Methodology and Default emission factors, in the 2006 IPCC Guidelines, because is the fuel without analyze on EU–ETS reporting, or large combustion plants, are used.

Romania has developed a specific methodology for the elaboration of national values of specific CO_2 emission factors and the energy sector. Primary data are colected from EU–ETS operators, the data are further procesed and national values are developed, based on the previous mentioned. Calculations of the emission factors with oxidation and without oxidation:

- *The values of the Emission Factors (EFs) with oxidation* are calculated as the total sum of the verified CO_2 emissions (the emissions are calculated the EU–ETS operators as, multiplied the fuels consumption in TJ with Emission Factors in tCO_2/TJ and the Oxidation Factor in %) divided by the total amount of the respective energetic fuel consumption in TJ, in the corresponding activity category, as reported by the operators. Further, the weighted average is applied on activity category where the type of fuel is reported. This EFs are utilized for the Sectoral Approach to estimate actual emissions from each emission category taking into account its technology level;
- *The values of the Emission Factors (EFs) without oxidation* are calculated using the activity data (laboratory analyzes – Tier 3) provided from EU–ETS operators, as multiplied the fuels consumption in TJ [calculated multiplied the fuels consumption in tonnes with the Net Calorific Values (NCVs) in TJ/t] with the emission factors [utilising the laboratory analyzes provided the EU–ETS operators – Tier 3] in tCO_2/TJ. This EFs (equal to one) are utilized for the Reference Approach to estimate potential emissions in a comprehensive manner.

The significant decrease in CO_2 emission factors for lignite for the 2007–2023 period is due to the informations of the operators reporting under the greenhouse gas emission allowance trading scheme EU–ETS: the value depends on the values provided by the economic operators under the EU–ETS; the national value is obtained as a weighted average from all operators which have declared that they have used plant-specific emission factors (Tier 3 approach, according to the provisions of Articles 32–35 of Regulation 601/2012 on monitoring and the reporting of greenhouse gas emissions in accordance with Directive 2003/87/EC of the European Parliament and of the Council, as amended and supplemented); the value for the emission factor and oxidation factors are generated by accredited ISO 17025 laboratories, which are considered to have the competence and the ability to generate technically valid results using relevant analytical procedures; the values are reported annually by the economic operators and are verified annually by verifiers accredited by the Romanian Accreditation Association–RENAR; there are annual variations in the number of operators under EU–ETS (for the years 2007 and 2008 the number of operators is 10 compared with 2009–2015 period where the number of the operators reporting under EU–ETS is 12, 11 and 13 respectively and for the 2016–2023 period is 11, 10, 8 and 7) is decreasing; there are annual variations in the consumption of each economic operator (this has an influence in the final emission factor value as this is obtained as a weighted average value based on the reported values of emission factors and on values related to fuel consumption). The elaboration of the country specific values of the emission factors, the net calorific values and of the oxidation factors was made based on a methodology previously developed in the context of elaboration of the study "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", performed by the Institute for Studies and Power Engineering (ISPE) in 2011. Use of data of EU–ETS operators average emissions for all years, instead of only of the 2007–2010 period (the period analysed through the study "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", performed by ISPE), dont improve the accuratecy of the estimates for the 1989–2006 period. The evolution of national values in terms of emission factors for the period 2007–2023 was analyzed; it is still considered appropriate to continue to use the weighted average values associated with the period 2007–2010, for the 1989–2006 period. The use of the country–specific values associated with the Emission Factors improved the accuracy of the estimates, reflecting better the national circumstances.

The use of country–specific values for emission factors derived using EU–ETS related values is adequate for non–ETS installations/consumption as the CO_2 emission factors are not technology–dependent and the fuel characteristics do not change over the years.

Based on the EU–ETS, the derived country–specific emission factors (CS EFs) for the reported liquid, solid and gaseous fuels were used. In the Annex V.1 are presented, for the all years, the solid, liquid and gaseous fuels and the CO_2 Country Specific Emission Factors (CS EFs) from categories 1.A.1.a. Public electricity and heat production – solid, liquid and gaseous fuels CO_2 for all years (the sheet 1A1a–mix fuels), 1.A.1.c. Manufacture of solid fuels and other energy industries – solids, liquid and gaseous fuels CO_2 for the all years (the sheet 1A1c–mix fuels) and 1.A.4.b. Residential – solid, liquid and gaseous fuels CO_2 for the all years (the sheet 1A4b–mix fuels). Both, the usage of the CS EFs and the distribution of the different type of fuels consumption conduct to the fluctuation of the IEF.

Also, in the Annex V.1 is presented the comparison between the CO_2 emission factors default and the country–specific emission factors CO_2 used in calculations of the CO_2 emissions. This CO_2 EFs values come from the sum of the EF values from all operators for the same fuel in the same category for each year and are taken from the analysis bulletins and varies depending on the number of the installations whose activity data is summed for the calculation of the CO_2 emissions.

The values of the CO_2 emission factors (CO_2 EFs) used from the monitoring reports of the economic operators under the EU–ETS scheme represent laboratory analyzes and come from type B and C installations. The economic operator classifies each installation as belonging to one of the following categories:

- category A installation, where the verified average annual emissions in the marketing period immediately preceding the current marketing period, excluding CO_2 resulting from biomass and before deducting transferred CO_2, are less than or equal to 50.000 tonnes of CO_2(s);
- category B installation, where the verified average annual emissions in the marketing period immediately preceding the current marketing period, excluding CO_2 resulting from biomass and before deducting transferred CO_2, are greater than 50.000 tonnes of CO_2(e) and less than or equal to 500.000 tonnes of CO_2(e);
- category C installation, if the verified average annual emissions in the marketing period immediately preceding the current marketing period, excluding CO_2 resulting from biomass and before deducting transferred CO_2, are greater than 500.000 tonnes of CO_2(s).

According to Regulation 601/2012, the operators of category B and C installations have the obligation to carry out laboratory analyzes to determine the oxidation factor for solid fuels. Considering that the value is not 100%, it is normal for CO_2 emissions to be lower. Thus, the conditions in which the values of the EFs with the oxidation factor included are higher than the values of the EFs without the oxidation factor are:

- the values for the emission factor and oxidation factors are generated by accredited ISO 17025 laboratories, which are considered to have the competence and the ability to generate technically valid results using relevant analytical procedures;
- the values are reported annually by the economic operators and are verified annually by verifiers

accredited by the Romanian Accreditation Association–RENAR;

- there are annual variations in the number of operators under EU–ETS;
- there are annual variations in the consumption of each economic operator;
- the oxidation is complete (oxidation factor is 1).

The decrease of values of the implied emission factors (IEFs) is due to the following: the value depends on the values provided by the economic operators under the EU–ETS; there are annual variations in the number of operators under EU–ETS: the number of operators is decreasing; there are annual variations in the consumption of each economic operator (this has an influence in the final emission factor value as this is obtained as a weighted average value based on the reported values of emission factors and on values related to fuel consumption).

General approach for the greenhouse gas emission factors

CO_2 greenhouse gas

For the 1989–2006 period

❖ **Solid fuels**, EFs calculated as weighted arithmetic average (WA), on 2007–2010 period, on each EU–ETS reported activity category, oxidation included, are used.

❖ **Liquid fuels**, EFs calculated as weighted arithmetic average (WA), on 2007–2010 period, ALL EU–ETS reported activity categories, oxidation included, are used.

❖ **Gaseous fuels**, EFs calculated as weighted arithmetic average (WA), on 2007–2010 period, ALL EU–ETS reported category activities, oxidation included, are used.

For the 2007–2023 period

❖ **Solid Fuels**, EFs calculated as weighted arithmetic average (WA), on each year of 2007–2023 period, on each EU–ETS reported activity category, oxidation included, are used.

❖ **Liquid fuels**, EFs calculated as weighted arithmetic average (WA) on each year of 2007–2023 period, ALL EU–ETS reported category activities, oxidation included, are used.

❖ **Gaseous fuels**, EFs calculated as weighted arithmetic average (WA) on each year of 2007–2023 period, ALL EU–ETS reported category activities, oxidation included, are used.

❖ **Biomass**, entire time–series, EFs default are used.

❖ **Other fuels** – industrial wastes, entire time-series, CS EFs derived from the EU–ETS reports, are used.

For EU–ETS activity categories, the country specific emission factors associated to each category for the available fuels, are used.

For non–EU–ETS activity categories, the country specific emission factors associated to averages of all EU–ETS categories for the available fuels, are used.

Country specific values NCVs and CO_2 EFs have determined and used for 2007–2023 period.

CH_4, N_2O – EFs default are used.

NO_x, CO, NMVOC, SO_2 – default **EMEP** EFs are used.

SO_2 – CS emission factors for solid fuels are used. See Chapter 9 for detailed information.

The activity data are provided on Romanian Energy Balance sent by NIS to IEA/ EUROSTAT.

The NCVs used are those corresponding with that Used in Main Activity Plants (net).

For *Transport Diesel* are used the value of weighted arithmetic average of the Emission Factors for the 2014–2023 period, calculated based on activity data from period 2007–2013.

For *Heating and other gasoil* are used the value of weighted arithmetic average of the Emission Factors for the 2013–2023 period, calculated based on activity data from period 2007–2012.

General approach for the CO_2 greenhouse gas emissions

In the formula of calculation a CO_2 emissions are included the CO_2 emissions from monitoring reports provided by the economic operators under the EU–ETS (Tier 3 method) and the non–ETS CO_2 emissions (calculated based of the activity data from Energy Balances provided by the National Institute of Statistics minus the activity data from monitoring reports provided by the economic operators under the EU–ETS) in TJ multiplied with the national CO_2 emission factor from monitoring reports (Tier 3 method) for the following fuels in the CRT categories presented below:

Solid fuels

For CRT 1.A.1.a category

- Other bituminous coal for the period 2007-2023 are used only the ETS CO_2 emissions;
- Sub-bituminous coal for the period 2007-2023 are used only the ETS CO_2 emissions;
- Lignite for the years 2007, 2008, 2011, 2012 and 2014 are used only the ETS CO_2 emissions and for the years 2009, 2010, 2013 and the period 2015-2023 it was into account the non-ETS and ETS CO_2 emissions;

For CRT 1.A.1.b category

- Lignite for the years 2019-2023 are used only the ETS CO_2 emissions.

For CRT 1.A.2.e category

- Other bituminous coal for the period 2012-2017 are used only the ETS CO_2 emissions;
- Coke oven coke for the periods 2008-2011 and 2013-2023 are used only the ETS CO_2 emissions and for the 2007 and 2012 years it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.f category

- Other bituminous coal for the period 2007-2023 are used only the ETS CO_2 emissions;
- Lignite for the period 2013-2023 it was into account the non-ETS and ETS CO_2 emissions;
- Coke oven coke for the 2011-2014 and 2017-2023 periods are used only the ETS CO_2 emissions.

Liquid fuels

For CRT 1.A.1.a category

- Refinery gas for the periods 2007-2015 period and 2019 and 2021 years are used only the ETS CO_2 emissions and for the 2016–2018 period and years 2020 and 2023 it was into account the non-ETS and ETS CO_2 emissions;
- Transport diesel for the period 2007-2023 it was into account the non-ETS and ETS CO_2 emissions;
- Residual fuel oil for the periods 2011-2012, 2014-2017 are used only the ETS CO_2 emissions and for the year 2013 and periods 2007-2010, 2018-2023 it was into account the non-ETS and ETS CO_2 emissions;
- Petroleum coke for the 2011–2016 period and 2019 year are used only the ETS CO_2 emissions and for the 2007–2010, 2017–2018 and 2020–2023 periods it was into account the non–ETS and ETS CO_2 emissions;
- Heating and other gasoil for the year 2019 are used only the ETS CO_2 emissions and for the periods 2007-2018 and 2020-2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.1.b category

- Refinery gas for the 2007–2023 period are used only the ETS CO_2 emissions;
- Transport diesel for the 2014 and 2015 years are used only the ETS CO_2 emissions;
- Residual fuel oil for the 2007–2021 period are used only the ETS CO_2 emissions;
- Petroleum coke for the 2019–2023 period are used only the ETS CO_2 emissions;
- Heating and other gasoil for the 2020–2023 period are used only the ETS CO_2 emissions.

For CRT 1.A.1.c category:

- Refinery gas for the 2007-2023 period it was into account the non–ETS and ETS CO_2 emissions;
- Transport diesel for the 2007–2023 period it was into account the non–ETS and ETS CO_2 emissions.

For CRT 1.A.2.a category:

- LPG for the 2011 year and period 2013-2017 are used only the ETS CO_2 emissions and for the years 2018-2023 it was into account the non-ETS and ETS CO_2 emissions;
- Transport diesel for period 2011-2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.b category

- Residual fuel oil for the year 2007 is used only the ETS CO_2 emissions.

For CRT 1.A.2.c category

- Transport diesel for period 2015-2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.d category

- Residual fuel oil for the 2008 year is used only the ETS CO_2 emissions.

For CRT 1.A.2.e category

- LPG for the period 2011-2013 it was into account the non-ETS and ETS CO_2 emissions;
- Transport diesel for periods 2011-2023 it was into account the non-ETS and ETS CO_2 emissions;
- Residual fuel oil for the years 2007, 2015 are used only the ETS CO_2 emissions and for the periods 2008-2014, 2016-2017 it was into account the non-ETS and ETS CO_2 emissions;
- Heating and other gasoil for the period 2007-2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.f category

- LPG for the year 2011 and period 2013-2016 are used only the ETS CO_2 emissions and for the period 2017-2023 it was into account the non-ETS and ETS CO_2 emissions;
- Transport Diesel for the periods 2011-2023 it was into account the non-ETS and ETS CO_2 emissions;
- Residual fuel oil for the periods 2011-2015, 2017-2022 are used only the ETS CO_2 emissions and for the 2008, 2016 and 2023 years it was into account the non-ETS and ETS CO_2 emissions;
- Petroleum coke for the periods 2008-2010, 2017-2022 are used only the ETS CO_2 emissions and for the 2011–2016 period and the 2023 year it was into account the non-ETS and ETS CO_2 emissions;
- Heating and other gasoil for the years 2011, 2012, 2015 are used only the ETS CO_2 emissions and for the years 2016, 2021 and 2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.g category

- Residual fuel oil for the years 2009, 2010, 2013 and 2023 are used only the ETS CO_2 emissions and for the years 2012, 2015 it was into account the non-ETS and ETS CO_2 emissions.

Gaseous fuels

For CRT 1.A.1.a category

- Natural gas for the period 2013-2023 are used only the ETS CO_2 emissions and for the period 2007-2012 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.1.b category

- Natural gas for the period 2007-2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.1.c category

- Natural gas for the period 2007-2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.a category

- Natural gas for the 2007–2020 period and 2023 year it was into account the non-ETS and ETS CO_2 emissions and for the 2021-2022 period it was into account only the ETS CO_2 emissions.

For CRT 1.A.2.b category

- Natural gas for the period 2007-2017 are used only the ETS CO_2 emissions and for the 2018-2023 period it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.c category

- Natural gas for the 2012 year and 2018–2020 period are used only the ETS CO_2 emissions and for the periods 2007–2011, 2013–2017 and 2021–2023 it was into account the non–ETS and ETS CO_2 emissions.

For CRT 1.A.2.d category

- Natural gas for the 2011, 2012, 2018 and 2023 years are used only the ETS CO_2 emissions and for the 2007–2010 and 2013–2017 and 2019–2022 periods it was into account the non–ETS and ETS CO_2 emissions.

For CRT 1.A.2.e category

- Natural gas for the periods 2007-2023 it was into account the non- ETS and ETS CO_2 emissions.

For CRT 1.A.2.f category

- Natural gas for the year 2008 is used only the ETS CO_2 emissions and for the year 2007 and period 2009-2023 it was into account the non-ETS and ETS CO_2 emissions.

For CRT 1.A.2.g category

- Natural gas for the 2007 year and 2009–2023 period are used only the ETS CO_2 emissions and for the 2008 year it was into account the non–ETS and ETS CO_2 emissions.

Other fossil fuels

- For the *CRT 1.A.2.d category – other fossil fuels - Industrial waste* for the 2016 year are used only the ETS CO_2 emissions and for the 2017-2023 period it was into account the non-ETS and ETS CO_2 emissions;
- For the *CRT 1.A.2.f category – other fossil fuels - Industrial waste* for the 2007-2017 period are used only the ETS CO_2 emissions and for the 2018-2023 period it was into account the non-ETS and ETS CO_2 emissions.

Table 3.5 Country–Specific CO_2 emission factors for stationary combustion, without oxidation included, from ETS verified reports

Years/ Fuels	Country-Specific CO_2 emission factors for stationary combustion, without oxidation included, from ETS verified reports										
	Solid fuels				Liquid fuels					Gaseous fuel	Other fuels
	Other bituminous coal	Sub-bituminous coal	Lignite	Coke_Oven _Coke	Refinery gas	Transport diesel	Residual fuel oil	Heating and other gasoil	Petroleum Coke	Natural gas	Industrial Wastes
	EF [tCO_2/TJ]										
2007-2010 WA EFs	95.10	93.32	100.45	94.91	56.19	73.29	78.19	74.19	93.63	55.50	83.07
2007	93.24	93.75	103.45	94.50	54.81	74.00	78.57	74.46	0.00	55.25	83.57
2008	95.95	92.79	100.69	84.33	54.54	72.35	77.01	77.87	94.34	55.67	83.36
2009	95.20	93.83	98.32	95.83	57.94	74.04	77.92	74.45	91.85	55.49	83.16
2010	94.88	92.93	98.64	107.15	57.75	72.75	79.69	73.66	94.02	55.64	82.59
2011	91.80	92.70	94.75	97.21	57.67	72.92	79.09	73.31	98.50	55.54	83.07
2012	93.33	93.81	98.34	94.78	56.80	73.56	79.24	74.08	96.83	55.58	83.07
2013	92.18	94.27	98.57	95.37	58.04	70.66	79.61	74.19	92.80	55.53	88.58
2014	93.14	93.56	98.22	108.28	57.36	73.08	80.29	74.19	92.73	54.91	91.30
2015	92.61	92.15	98.07	106.24	55.19	73.08	78.75	74.19	95.38	55.56	92.14
2016	93.16	93.27	98.06	104.25	56.35	73.08	79.00	74.19	96.09	55.73	93.18
2017	94.92	92.87	98.09	96.16	55.62	73.08	78.85	74.19	95.67	55.69	93.68
2018	94.44	93.52	97.60	96.16	55.99	73.08	79.77	74.19	94.52	55.60	92.85
2019	94.37	94.43	96.83	96.38	55.65	73.08	79.32	74.19	94.29	55.58	87.76
2020	93.78	93.81	96.50	95.76	56.73	73.08	78.34	74.19	94.04	55.57	87.64
2021	94.26	93.81	95.77	94.79	56.75	73.08	78.11	74.19	93.22	55.47	86.43
2022	93.34	92.96	96.15	95.15	57.17	73.08	82.76	74.19	93.18	55.54	90.87
2023	94.56	93.52	98.31	94.68	57.37	73.08	79.40	74.19	95.21	55.55	89.51

Table 3.6 Country–Specific CO_2 emission factors for stationary combustion, oxidation included, from ETS verified reports

Years/ Fuels	Country-Specific CO_2 emission factors for stationary combustion, oxidation included, from ETS verified reports										
	Solid fuels				Liquid fuels					Gaseous fuel	Other fuels
	Other bituminous coal	Sub-bituminous coal	Lignite	Coke_Oven _Coke	Refinery gas	Transport diesel	Residual fuel oil	Heating and other gasoil	Petroleum Coke	Natural gas	Industrial Wastes
	EF Ox [tCO_2/TJ]										
2007-2010 WA EFs	95.56	92.86	94.32	94.99	56.11	73.60	78.06	74.30	93.73	55.21	83.07
2007	92.97	93.75	98.44	93.98	54.53	73.63	78.23	74.36	0.00	54.74	83.57
2008	95.85	92.79	94.76	84.46	54.54	73.43	76.86	78.50	94.52	55.53	83.36
2009	95.19	92.57	91.51	95.97	57.94	74.22	77.96	74.65	91.85	55.19	83.16
2010	97.04	92.05	91.51	107.16	57.75	73.29	79.71	73.67	94.02	55.46	82.59
2011	91.08	91.98	86.41	97.21	57.23	72.92	79.09	73.29	98.50	55.53	83.07
2012	93.33	93.30	91.46	94.78	56.80	73.56	79.24	74.08	96.83	55.58	83.07
2013	91.79	93.52	91.38	95.19	58.04	70.66	79.61	74.30	92.80	55.52	88.58
2014	92.78	92.54	91.00	108.28	57.41	73.33	80.29	74.30	92.34	55.59	91.30
2015	92.44	91.11	89.64	106.24	56.38	73.33	78.75	74.30	94.93	55.38	92.14
2016	92.30	92.58	89.53	104.25	56.38	73.33	79.00	74.30	95.55	55.73	92.58
2017	93.35	92.06	88.74	96.16	55.67	73.33	78.85	74.30	95.05	55.70	93.18
2018	93.62	92.02	86.03	96.16	56.22	73.33	79.77	74.30	94.06	55.60	91.69
2019	93.62	92.42	82.96	96.38	55.81	73.33	79.32	74.30	93.90	55.58	86.17
2020	93.06	92.79	81.52	95.76	56.81	73.33	78.34	74.30	93.53	55.58	86.29
2021	93.90	92.79	79.39	94.79	56.85	73.33	78.11	74.30	92.64	55.47	85.21
2022	93.08	92.23	78.24	95.15	58.31	73.33	82.76	74.30	92.30	55.54	89.73
2023	93.84	91.73	79.75	94.68	57.37	73.33	79.40	74.30	93.94	55.59	88.16

Country–Specific Emission Factors

In a similar way, country–specific emission factors were calculated as a weighted average for all the years (period of 2007–2010). The following country-specific emission factors were used for the calculations of the emissions for the 1989–2006 period and subsectors in CRT 1.A, except CRT 1.A.3. The country–specific emission factors are listed in the following table:

Table 3.7 Country–specific emission factors 2007–2010 period weighted averages

Fuels	Country–specific emission factors 2007–2010 period weighted averages										
	Solid fuels				Liquid fuels						Gaseous fuel
	Other bituminous coal	Sub–bituminous coal	Lignite	Coke_Oven _Coke	Refinery gas	Transport diesel	Residual fuel oil	Heating and other gasoil	Petroleum Coke	Motor Gasoline*	Natural gas
t/TJ (including oxidation factor)											
EF Ox CO_2	95.56	92.86	94.32	94.99	56.11	73.60	78.06	74.30	93.73	71.62	55.21
t/TJ (excluding oxidation factor)											
EF CO_2	95.10	93.32	100.45	94.91	56.19	73.29	78.19	74.19	93.63	71.62	55.50
t/TJ											
Carbon content	25.94	25.45	27.40	25.89	15.33	19.99	21.32	20.23	25.54	19.53	15.14

**** For the Motor gasoline fuel**, the country–specific emission factor is calculated based on the content of the carbon, reported by Romanian authorities and using the formula provided by the above Study.*

CH_4 emission factors for stationary sources

The default CH_4 emission factors according to the IPCC 2006 Guidelines, Vol. 2.1, Chapter 2 – Stationary Combustion Table 2.2 – Energy Industries, Table 2.3 – Manufacturing industries and construction, Table 2.4 – Commercial/ Institutional, Table 2.5 – Residential and Agriculture/ Forestry/ Fishing/ Fishing farms, are used.

N_2O emission factors for stationary sources

The default N_2O emission factors according to the IPCC 2006 Guidelines, Vol. 2.1, Chapter 2 – Stationary Combustion Table 2.2 – Energy Industries, Table 2.3 – Manufacturing industries and construction, Table 2.4 – Commercial/ Institutional, Table 2.5 –

Residential and Agriculture/ Forestry/ Fishing/ Fishing farms, are used.

3.2.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.4.4 Uncertainty assessment and time-series consistency

The values were collected/elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. Based on the above background information, the results of the uncertainties associated to the GHG emissions estimates are as follows:

AD uncertainty

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 7%;

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%.

EFs uncertainty

CO_2 gas:

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 0.8%;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 4%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 0.5%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 4%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 20%;

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 20%.

CH_4 gas:

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%.

N_2O gas:

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%.

Aggregated uncertainty

The overall uncertainties, as result of the aggregation of AD and EF related uncertainties, according to the equation 3.1 in Chapter 3 of the IPCC 2006 Guidelines, Vol. 1, are as follows:

CO_2 gas:

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 5%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 5%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 21%;

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 20%.

CH_4 gas:

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50 %;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50 %;

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%.

N_2O gas:

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50 %;

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 50%.

3.2.4.5 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Program were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

In order to have accounted in the sectoral approach only the emissions due to the fuel burning and not double account with other inventory sectors or other subsectors from the energy sector, a consultation with the refineries operators were started in order to find if the petroleum coke reported as refinery fuel is an energy consumption or is used in refinery processes; the conclusion of this consultation was that the petroleum coke reported in the energy balance as refinery fuel is used as catalyst coke and deposited on the catalyst during refining processes; this coke is not recoverable and represents process emissions. Thus, the petroleum coke was subtracted from 1.A.1.b. Petroleum Refineries category.

The energy balances present some format modifications, now the non–energy consumption not being included in the total energy consumption, being reported separately. In addition, modifications of how the values of some by–products are provided have been made. Energy balance provides some corrections of the NCV parameter for a sum of fuels. All modifications and corrections made in the energy balances provided activity data and parameters, are analyzed and incorporated in the energy sector emissions estimations.

The above corrections are described in the Chapter 3.2.4.5 – Source-specific recalculations, including changes made in response to the review process and at the Chapter 10 – Recalculations and improvements levels; the quantitative effects of this correction are described at the Chapter 3.2.4.5–Source–specific recalculations, including changes made in response to the review process.

All noted unconformities following the UNFCCC review of the 2014 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

The activity data series were also compared to those on EUROSTAT, the data being reported at the same level of aggregation and the figures comparable.

Specific to the stationary combustion, for the calculation of the emissions from CRT category 1A, it was developed an Excel spreadsheet model, which was linked directly to the Eurostat format energy balances provided by the NIS. Wherever it was possible, automated data validation was implemented within the model, but many manual checks were performed, too.

Furthermore the background data for the emission factors calculations under the ETS, were used for further QA/QC checks. In response to the ERT recommendation, there is presented in the bellow table an analysis resulting from the ISPE Study regarding the share of the EU–ETS fuel combustion to the Energy Balance reporting, within the corresponding activity category.

Table 3.8 Share of the EU–ETS installations to the National Energy Balance, 2008 year

CRT Category	Main activity	Share of the EU–ETS reporting to the EB [%]	Reporting Plants
1.A.1.a.	***Electricity and heat production***	**90,25**	
1.A.1.a-i	*Electricity production*	99,66	Nominal installed thermal power plants > 20 MWt reporting
1.A.1.a–ii	*Electricity and heat production*		
1.A.1.a-iii	*Heat production*	73,47	
1.A.1.b.	*Petroleum refining*	74,15	Emissions from fuel combustion only

CRT Category	Main activity	Share of the EU–ETS reporting to the EB [%]	Reporting Plants
1.A.1.c.	*Manufacture of solid fuels and other industries*		Nominal installed thermal power plants > 20 MWt reporting
1.A.2.	***Manufacturing industry and Construction***	**60,60**	
1.A.2.a.	*Iron and Steel*	53,92	Fuel combustion for the installations having production capacity greater than >2,5 tones/h and nominal installed thermal power plants > 20 MWt reporting
1.A.2.b.	*Non–ferrous metals (aluminum)*		Nominal installed thermal power plants > 20 MWt reporting
1.A.2.c.	*Chemical*	74,44	Nominal installed thermal power plants > 20 MWt reporting
1.A.2.d.	*Pulp, Paper and Print*	90,43	Fuel combustion for the installations having production capacity greater than >20 tones/day and nominal installed thermal power plants > 20 MWt reporting
1.A.2.e.	*Food Processing, Beverages and Tobacco*	15,10	Nominal installed thermal power plants > 20 MWt reporting
1.A.2.f.	*Other (cement, lime, ceramics, glass)*	66,35	Fuel combustion for the installations having: ○ Installation for cement clinker production with capacity > 500 tones/day; ○ Installation for lime production with capacity > 50 tones/day; ○ Installation for glass production with capacity >20 tones/day; ○ Installation for ceramics production having a capacity >75 tones/day, ○ and having on sites nnominal installed thermal power plant > 20 MWt.

Activity data checks

Trend analysis was performed regarding the activity data for all subsectors and fuels separately. The most notable data peaks/ drops were discussed and, further analysis will be conducted with the NIS in order to have an explanation of the variations. Since the source of the activity is the IEA/EUROSTAT Energy Balance, there is a fully correspondence with the CRT and IPCC methodology concerning the fuels definition and the activity categories were these fuels are consumed. Some changes in the activity data were necessary, because NCVs are not provided for some of the years for all reported fuels by the NIS. The changes consist of some assumptions of the NCVs for the years this information is not provided.

For some subsectors the activity data regarding the energy consumption and the resources were checked for correlation. Activity data peaks/drops were discussed with industrial processes experts in order to identify sectorial restructuring (closing or opening of plants) or technological changes within specific plants, which result in fuel mix or energy consumption changes. Also, these discussions were conducted in order to avoid double accounting.

Calculations checks

Manual data checks are performed in order to prevent calculation errors:

- Unit conversion checks – activity data units are checked in order to verify that appropriate conversion units are applied.
- Calculation formulas checks – cell formulas are manually checked in order to ensure consistency.
- In order to assure integrity of the calculations and to prevent possible errors due to incomplete activity data, the automatic data validation checks were implemented in the Excel model. Each cell with a validation rule is colored red in case there is a logical problem with the calculations:
  - conversion from natural units to energy units – ensure all non-negative values reported in natural units are properly converted to energy units;
  - calculation of the emissions – ensure the corresponding emissions are calculated from all non–zero values in energy units;
  - emission factors validation – ensure chosen emission factors are within the IPCC 2006 GL ranges.

The model itself and the calculations were validated by international experts, and by national experts as part of the QA procedures implemented. It was observed that in several years, some country specific emission factors are outside of the IPCC 2006 GL range: in 2013 it is the case of the lignite–CO_2 CS EF 88.84 t/TJ, coke_oven_coke–CO_2 CS EF 95.16 t/TJ, lower than the limit of the range, Heating and other gasoil–CO_2 CS EF 76.11 t/TJ – higher than the range. Also, in sper some cases the oxidation factors reported by the operators under EU–ETS rules, were lower than the limit provided by the IPCC Guidelines, such us the oxidation factor of the lignite used as fuel in the electricity and heat production activity, having a country specific oxidation factor in 2012 of 0.92. In this respect, clarifications from the EU–ETS representatives were asked. The responses provided by the concerned operators clarified the obtained values of the fuels parameters. For the oxidation factor the technical causes are linked with the following aspects: the installations combustion efficiency which could be much lower than optimum due to the old equipment or/and lower charge in functioning (due to the reducing of the energy demand); the aging of auxiliary equipment such are the coal crushing mills and the lower degree of grinding for some type of lignite conduct to an incomplete combustion and a decreased oxidation factor; the lower temperature of the air used to heat the coal before combustion, due to the aging of the concerned equipment, is an other factor causing a lower oxidation factor; some operators declared that, due to the raised price in the last years of the natural gas, used as adjuvant in combustion, they reduced the utilization of this under 1 per cent. All the above technical situations conduct to an incomplete combustion and to an increased quantity of the carbon content in the slag and ashes, thus a lower oxidation factor. For the deviation of the emission factors of the lignite, the operators responded that the quality of the fuel is very often altered by the substantially presence of the sterile, detailing the sources of the used coal, imported or acquired from internal market; also, it was explained that the stacks of coal became in time dry, by loosing the humidity, this having as consequences the decreasing of the calorific values and of the emission factors. Following the above activities the unconformities has been noted and solved; currently, further to the quality/control assurance activities undertaken, as part of the GHG emissions estimates, there were no recalculations required.

- ➢ The calculation model is directly linked to the activity data.
- ➢ Currently the data from the calculation models is entered manually into CRT reporter. In order to ensure that there are no differences due to technical errors, additional comparisons were made between the numbers in the calculation models and the CRT generated by CRT application.

Transparency

All calculation sheets are linked to the necessary information for the estimating of the emissions, such as:

- ❖ the activity data (Energy Balance–transmitted by Romanian Institute for Statistics to the IEA/ EUROSTAT);
- ❖ conversion factors (provided in Energy Balance) and determined from the EU–ETS reports;
- ❖ emission factors (default according to the IPCC methodology, CO_2 EFs – resulted from the ISPE Study and derived from the EU–ETS reports, SO_2 emission factors – resulted from the reporting of the Large Combustion Plants);
- ❖ all the results are summed in a global calculation sheet for Stationary Fuel Combustion, linked with the spreadsheets of the model (having results for all greenhouse gases emissions from solid, liquid and gaseous fuels on the entire time–series), other fuel – industrial wastes sheet, biomass sheets (having results for emissions accounted from solid and gaseous biomass combustion; liquid biofuels are not reported to the activity categories corresponding with the Stationary Combustion).

The EUROSTAT format of the Energy Balance made possible the achievement of the transparency and accuracy in usage of the Activity Data, linking in the worksheets all the available data and avoiding the occurrence of the transcription mistakes. Also, the definitions of the fuels are the same with UNFCCC, CRT.

Accuracy

The accuracy of the emissions estimation results from usage of the data at the most possible detailed level and from automatic character of the calculation.

Completeness

All occurring sources of emissions from 1.A Fuel stationary combustion are estimated for solid, liquid, gaseous fuels, biomass and other fuels (industrial waste). All emissions from CO_2, CH_4 and N_2O were accounted. Also, there are accounted emissions resulted from indirect GHG gases, NO_x, CO, NMVOC and SO_2.

Consistency

The methods used for estimation of the emissions are in accordance with the IPCC regulations on the entire-time series.

3.2.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

For the current submission the following sectoral emissions recalculations were performed:

1. Activity data

Due to the methodological provisions and compliance with the reporting rules and to avoid double accounting of data from the inventory, recalculations were made for the activity data of natural gas and refinery gas fuels as described below:

Recalculations were made for *Refinery gas*, due to the decrease in energy consumption from the *Energy sector - Stationary combustion - 1.A.1.b Petroleum Refining category - liquid fuels* for the period 2014-2022, consumption that was added to the IPPU sector; in this case the CO_2, CH_4 and N_2O emissions are updated;

Recalculations were made for *Natural gas*, due to the decrease in energy consumption from the *Energy sector - Stationary combustion - 1.A.1.b Petroleum Refining category - gaseous fuels* for the period 1989-2022, consumption that was added to the IPPU sector; in this case the CO_2, CH_4 and N_2O emissions are updated;

Recalculations were made for *Natural gas*, due to the decrease in energy consumption from the *Energy sector - Stationary combustion - 1.A.2.c Chemicals category - gaseous fuels* for the period 2014-2022, consumption that was added to the IPPU sector; in this case the CO_2, CH_4 and N_2O emissions are updated;

In addition to the elements provided initially, the fact that the changes are related to the decrease in energy emissions associated with hydrogen production from the emissions associated with the Energy Sector, and with their reallocation in the IPPU Sector.

Solid fuels

- ✓ In *1.A.2.d Pulp, Paper and Print category* for the 2013 year for the *coke_oven_coke* was identified a transcription error in the Common Reporting Tables (CRT) of the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.

Liquid fuels

- ✓ In *1.A.1.a Public Electricity and Heat Production category* for the 2007-2022 period for the *Residual fuel oil, Transport diesel and Refinery gas* was identified a transcription error in the Common Reporting Tables (CRT) of the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.
- ✓ In *1.A.2.e Food Processing, Beverages and Tobacco category* for 2022 year for the *Residual fuel oil* was identified a transcription error in the Common Reporting Tables (CRT) of the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.
- ✓ In *1.A.2.g Other category* for 2014-2022 period for the *Refinery gas* was updated the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.

2. Net Calorific Value

- ✓ For categories 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction and 1.A.4 Other Sectors for liquid fuels (Refinery Gas, Gas diesel oil, Residual fuel oil, Petroleum coke, Heating and other gasoil) and Natural gas the period 1990–2022, have been updated the Net Calorific Value; this has been resulted in the update of CO_2, CH_4 and N_2O emissions.

3. CO_2 emission factors

For categories 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction and 1.A.4 Other Sectors for liquid fuels (Refinery Gas, Residual fuel oil) and Natural gas the period 1990–2022, have been updated the CO_2 emission factors; this has been resulted in the update of CO_2, CH_4 and N_2O emissions.

Share ETS–CO_2 on 1A1a	**2014**	BE	15,414.22	13,327.24	86.5%
Share ETS–CO_2 on 1A1a	**2014**	GB	123,083.98	121,009.22	98.3%
Share ETS–CO_2 on 1A1a	**2014**	PL	152,593.99	145,144.52	95.1%
Share ETS–CO_2 on 1A1a	**2014**	SK	4,632.41	3,983.50	86.0%
Share ETS–CO_2 on 1A1a	**2014**	HU	11,354.44	11,031.62	97.2%
Share ETS–CO_2 on 1A1a	**2014**	AT	8,090.83	6,363.25	78.6%
Share ETS–CO_2 on 1A1a	**2014**	**weighted avg.**	315,169.88	300,859.36	95.45%

The differences in 1.A.1.a between the RO Energy Balance and the ETS data are showed in the bellow table:

Fuel/ year/ ktonnes/ Natural gas [TJ/ Nm3]	Solid fuels						Liquid fuels										Gaseous fuel	
	Other bituminuous coal		Sub–bituminous coal		Lignite		Refinery gas		Residual Fuel Oil		Transport diesel		Heating and other gas oil		Petroleum coke		Natural gas [TJ]	
	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB
2007	162	0	2313	952	32115	31957	0	56	254	445	0	30	0	22	0	0	139090	178767
2008	380	0	3020	500	33220	33146	0	63	197	415	0	20	0	20	0	0	122442	157850
2009	158	0	2243	371	29071	30161	0	51	331	435	0	8	3	27	0	0	106475	123965
2010	109	0	1860	330	28109	28145	99	138	159	291	0	12	3	17	0	0	87758	117649
2011	251	0	2400	358	34859	34318	104	168	192	247	0	13	0	20	63	0	107942	123952
2012	265	0	2062	667	31815	30360	76	163	136	257	0	46	0	13	123	0	102174	107941
2013	216	0	2013	316	22731	23179	52	116	43	136	0	15	0	9	111	0	100379	86015
2014	149	0	1831	241	23577	23427	64	114	34	131	0	59	0	3	114	0	93218	79892
2015	147	0	1290	192	25018	25144	53	90	47	169	0	9	0	3	103	0	101365	75813
2016	148	0	997	151	22230	22943	67	230	70	68	0	9	0	3	100	100	99793	77239
2017	154	0	818	222	24474	25167	66	218	114	33	0	6	0	2	111	111	102504	85809
2018	142	0	669	231	23565	24183	60	213	31	60	0	3	0	2	108	108	103343	82095
2019	123	0	567	273	20988	21404	49	331	13	45	0	3	1	1	27	140	93148	77323
2020	107	0	599	167	14844	15277	45	215	19	47	0	4	0	1	0	88	97763	73336
2021	96	0	362	99	16458	17557	38	229	20	42	0	2	0	3	0	69	99686	74831
2022	104	0	320	134	16699	18111	27	222	34	47	0	3	0	4	0	105	93816	60629
2023	69	0	198	70	14188	14296	45	169	17	52	0	2	0	2	0	64	87388	60341

Table 3.9 The impact of recalculations on GHG emission estimates in the sub–sector 1.A.1 – Energy Industry

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	1,058,268.86	1,058,268.86	0.000	78,885.00	78,885.00	0.000	1.43	1.43	0.000	0.78	0.78	0.000
1990	985,402.41	985,402.41	0.000	71,447.82	71,447.82	0.000	1.53	1.53	0.000	0.62	0.62	0.000
1991	903,259.82	903,259.82	0.000	65,927.69	65,927.69	0.000	1.31	1.31	0.000	0.60	0.60	0.000
1992	789,397.96	788,426.06	-0.123	59,360.13	59,290.88	-0.117	1.06	1.06	-0.092	0.60	0.60	-0.016
1993	771,254.69	770,512.33	-0.096	57,975.36	57,922.80	-0.091	1.06	1.06	-0.070	0.58	0.57	-0.013
1994	783,015.32	781,637.44	-0.176	58,957.01	58,859.07	-0.166	1.08	1.08	-0.127	0.58	0.58	-0.024
1995	813,134.42	811,938.04	-0.147	61,321.90	61,236.42	-0.139	1.21	1.21	-0.099	0.61	0.61	-0.020
1996	845,152.86	844,114.30	-0.123	63,428.92	63,355.32	-0.116	1.22	1.22	-0.085	0.61	0.61	-0.017
1997	766,386.40	765,376.17	-0.132	56,986.41	56,915.39	-0.125	1.17	1.17	-0.086	0.53	0.53	-0.019
1998	661,866.51	660,208.24	-0.251	48,364.55	48,247.51	-0.242	0.93	0.93	-0.178	0.42	0.42	-0.039
1999	552,143.96	550,187.08	-0.354	40,522.51	40,382.43	-0.346	0.79	0.79	-0.248	0.37	0.37	-0.053
2000	573,381.90	571,219.96	-0.377	43,002.57	42,848.41	-0.358	0.81	0.81	-0.266	0.42	0.42	-0.052
2001	591,696.41	590,529.55	-0.197	45,374.35	45,292.23	-0.181	1.01	1.01	-0.116	0.47	0.47	-0.025
2002	571,704.86	568,551.15	-0.552	42,980.13	42,753.68	-0.527	0.80	0.80	-0.393	0.42	0.42	-0.075
2003	612,226.31	612,254.19	0.005	46,132.76	46,105.08	-0.060	0.83	0.83	0.003	0.46	0.46	0.001
2004	543,916.98	549,611.68	1.047	40,824.06	41,116.05	0.715	0.72	0.73	0.790	0.41	0.41	0.139
2005	536,596.56	543,737.77	1.331	40,512.70	40,892.30	0.937	0.71	0.72	1.001	0.42	0.42	0.172
2006	551,232.48	559,518.87	1.503	42,457.72	42,899.64	1.041	0.73	0.74	1.137	0.47	0.47	0.178
2007	579,636.66	579,776.45	0.024	45,449.04	45,456.05	0.015	0.68	0.68	0.104	0.49	0.49	0.032
2008	563,154.10	561,776.75	-0.245	44,003.46	43,990.23	-0.030	0.66	0.66	-0.208	0.51	0.51	-0.027
2009	477,366.40	477,055.04	-0.065	36,959.10	36,936.38	-0.061	0.56	0.56	-0.056	0.44	0.44	-0.007
2010	441,692.68	442,275.03	0.132	33,229.53	33,306.93	0.233	0.53	0.53	0.519	0.40	0.40	0.149
2011	498,656.00	499,537.96	0.177	37,659.86	37,740.50	0.214	0.60	0.60	0.445	0.49	0.49	0.109
2012	457,229.94	457,576.55	0.076	34,702.30	34,738.72	0.105	0.54	0.55	0.343	0.44	0.44	0.093
2013	376,018.00	376,445.92	0.114	28,358.82	28,366.92	0.029	0.49	0.49	0.087	0.35	0.35	0.012

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
2014	373,106.67	373,333.65	0.061	28,356.06	28,367.76	0.041	0.55	0.55	0.070	0.36	0.36	0.018
2015	372,506.58	372,655.83	0.040	28,154.42	28,159.41	0.018	0.54	0.54	0.028	0.36	0.36	0.004
2016	346,461.17	346,641.25	0.052	25,667.35	25,672.99	0.022	0.51	0.51	0.035	0.32	0.32	0.006
2017	358,398.35	358,595.53	0.055	26,484.18	26,493.05	0.033	0.54	0.55	0.036	0.33	0.33	0.006
2018	343,223.71	343,403.37	0.052	24,895.03	24,901.09	0.024	0.49	0.49	0.037	0.31	0.31	0.006
2019	307,275.97	307,475.58	0.065	21,611.57	21,616.84	0.024	0.47	0.47	0.042	0.28	0.28	0.007
2020	267,837.55	268,005.50	0.063	18,104.35	18,108.78	0.024	0.46	0.46	0.037	0.22	0.22	0.008
2021	278,154.11	278,556.33	0.145	18,488.39	18,488.88	0.003	0.51	0.51	0.079	0.23	0.23	0.017
2022	271,099.89	270,245.23	-0.315	17,996.69	17,929.47	-0.373	0.50	0.50	-0.171	0.23	0.23	-0.037
2023		232,542.19			15,475.45			0.37			0.17	

Table 3.10 The impact of recalculations on the GHG emission estimates in the sub–sector 1.A.2 – Manufacturing Industries and Constructions

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	1,065,975.47	1,065,975.47	0.000	65,801.50	65,778.29	-0.035	2.40	2.40	0.000	0.34	0.34	0.000
1990	882,723.88	882,740.66	0.002	53,958.96	53,941.92	-0.032	2.14	2.14	0.001	0.29	0.29	0.001
1991	591,804.98	591,816.80	0.002	34,734.08	34,724.06	-0.029	1.13	1.13	0.001	0.16	0.16	0.001
1992	568,547.32	568,561.33	0.002	35,007.73	35,007.76	0.000	1.71	1.71	0.001	0.24	0.24	0.001
1993	518,644.72	518,658.46	0.003	31,567.23	31,566.89	-0.001	1.53	1.53	0.001	0.22	0.22	0.001
1994	489,446.38	489,459.12	0.003	29,227.32	29,223.59	-0.013	1.24	1.24	0.001	0.18	0.18	0.001
1995	490,015.16	490,030.68	0.003	28,820.62	28,815.45	-0.018	1.44	1.44	0.001	0.20	0.20	0.001
1996	473,542.62	473,556.93	0.003	28,242.39	28,237.95	-0.016	1.23	1.23	0.001	0.18	0.18	0.001
1997	378,950.10	378,957.16	0.002	22,433.51	22,431.02	-0.011	1.07	1.07	0.001	0.15	0.15	0.000

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1998	308,339.42	308,342.81	0.001	18,416.74	18,415.42	-0.007	0.86	0.86	0.000	0.12	0.12	0.000
1999	281,868.39	281,875.55	0.003	16,922.00	16,920.94	-0.006	0.84	0.84	0.001	0.12	0.12	0.001
2000	291,661.02	291,671.51	0.004	17,619.38	17,617.64	-0.010	0.98	0.98	0.001	0.14	0.14	0.001
2001	307,871.26	307,881.53	0.003	18,984.04	18,981.80	-0.012	1.03	1.03	0.001	0.15	0.15	0.001
2002	327,046.54	327,056.23	0.003	19,706.10	19,703.30	-0.014	1.29	1.29	0.001	0.18	0.18	0.001
2003	302,184.26	302,196.49	0.004	17,678.19	17,674.61	-0.020	1.30	1.30	0.001	0.18	0.18	0.001
2004	287,809.01	287,820.89	0.004	18,126.61	18,124.41	-0.012	1.25	1.25	0.001	0.18	0.18	0.001
2005	268,452.28	268,465.19	0.005	16,882.27	16,880.26	-0.012	1.10	1.10	0.001	0.16	0.16	0.001
2006	259,657.72	259,668.87	0.004	16,017.46	16,015.81	-0.010	1.17	1.17	0.001	0.17	0.17	0.001
2007	292,014.37	292,014.37	0.000	18,877.85	18,877.22	-0.003	1.27	1.27	0.000	0.18	0.18	0.000
2008	305,096.53	305,096.53	0.000	20,396.16	20,391.57	-0.023	1.23	1.23	0.000	0.17	0.17	0.000
2009	223,864.94	223,864.94	0.000	14,603.94	14,602.24	-0.012	0.97	0.97	0.000	0.14	0.14	0.000
2010	239,042.36	239,042.36	0.000	14,619.63	14,620.58	0.006	1.09	1.09	0.000	0.15	0.15	0.000
2011	261,436.18	261,436.18	0.000	17,390.03	17,387.68	-0.014	1.19	1.19	0.000	0.17	0.17	0.000
2012	269,325.08	269,316.42	-0.003	17,692.83	17,692.83	0.000	1.27	1.27	-0.001	0.18	0.18	0.000
2013	236,294.54	234,281.54	-0.852	14,963.25	14,963.64	0.003	1.11	1.09	-1.808	0.15	0.15	-1.965
2014	234,097.65	234,097.37	0.000	14,621.99	14,621.50	-0.003	1.05	1.05	0.000	0.14	0.14	0.000
2015	234,019.45	234,003.61	-0.007	13,123.74	13,120.93	-0.021	0.99	0.99	-0.002	0.14	0.14	-0.001
2016	217,317.91	217,316.87	0.000	12,875.21	12,870.52	-0.036	0.95	0.95	0.000	0.13	0.13	0.000
2017	223,359.87	223,360.02	0.000	13,039.68	13,034.60	-0.039	0.93	0.93	0.000	0.12	0.12	0.000
2018	231,552.71	231,628.20	0.033	13,700.09	13,699.91	-0.001	0.94	0.94	0.008	0.13	0.13	0.006
2019	222,370.22	222,447.91	0.035	13,312.61	13,312.48	-0.001	0.92	0.92	0.008	0.12	0.12	0.006
2020	227,639.28	227,712.96	0.032	14,410.43	14,410.28	-0.001	1.01	1.01	0.007	0.14	0.14	0.005
2021	240,583.48	240,578.37	-0.002	14,750.04	14,746.37	-0.025	1.12	1.12	0.000	0.15	0.15	0.000
2022	400,299.47	219,200.60	-45.241	13,088.61	13,081.57	-0.054	1.62	1.07	-33.602	0.25	0.15	-42.813
2023		193,878.04			11,408.25			0.97			0.13	

Table 3.11 The impact of recalculations on GHG emission estimates in the sub–sector 1.A.4 – Other Sectors

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	241,759.41	241,759.41	0.000	14,081.34	14,067.47	-0.099	17.42	17.42	0.000	1.56	1.56	0.000
1990	196,746.11	196,746.11	0.000	10,877.29	10,863.12	-0.130	16.71	16.71	0.000	0.16	0.16	0.000
1991	198,856.64	198,856.64	0.000	10,734.18	10,717.95	-0.151	12.03	12.03	0.000	0.12	0.12	0.000
1992	172,316.96	172,316.96	0.000	9,876.73	9,867.93	-0.089	12.44	12.44	0.000	1.16	1.16	0.000
1993	164,349.78	164,349.78	0.000	8,401.70	8,392.84	-0.105	13.31	13.31	0.000	0.96	0.96	0.000
1994	151,565.48	151,565.48	0.000	6,850.44	6,841.21	-0.135	12.84	12.84	0.000	0.73	0.73	0.000
1995	173,325.45	173,325.45	0.000	7,878.25	7,867.96	-0.131	14.28	14.28	0.000	0.88	0.88	0.000
1996	214,931.27	214,931.27	0.000	7,526.39	7,516.62	-0.130	29.78	29.78	0.000	0.92	0.92	0.000
1997	272,243.44	272,243.44	0.000	9,111.64	9,100.62	-0.121	39.32	39.32	0.000	1.27	1.27	0.000
1998	271,400.80	271,400.80	0.000	9,428.50	9,415.97	-0.133	35.24	35.24	0.000	1.15	1.15	0.000
1999	240,664.81	240,664.81	0.000	7,962.77	7,951.48	-0.142	33.04	33.04	0.000	0.85	0.85	0.000
2000	241,653.42	241,653.42	0.000	8,226.56	8,215.21	-0.138	32.18	32.18	0.000	0.88	0.88	0.000
2001	207,555.57	207,555.57	0.000	7,802.98	7,791.38	-0.149	22.88	22.88	0.000	0.56	0.56	0.000
2002	208,736.88	208,736.88	0.000	7,865.02	7,853.65	-0.145	23.44	23.44	0.000	0.50	0.50	0.000
2003	252,009.34	252,009.34	0.000	9,297.36	9,283.38	-0.150	28.74	28.74	0.000	0.59	0.59	0.000
2004	282,000.06	282,000.06	0.000	9,902.38	9,887.45	-0.151	34.85	34.85	0.000	0.63	0.63	0.000
2005	289,363.00	289,363.00	0.000	10,228.22	10,213.90	-0.140	35.56	35.56	0.000	0.62	0.62	0.000
2006	315,938.91	315,938.91	0.000	11,992.22	11,973.06	-0.160	33.77	33.77	0.000	0.64	0.64	0.000
2007	287,645.26	287,645.26	0.000	10,098.31	10,081.10	-0.170	35.36	35.36	0.000	0.62	0.62	0.000
2008	297,007.60	297,007.60	0.000	8,924.59	8,905.87	-0.210	44.78	44.78	0.000	0.73	0.73	0.000
2009	300,952.03	300,952.03	0.000	9,139.76	9,123.41	-0.179	43.99	43.99	0.000	0.82	0.82	0.000
2010	305,961.22	305,961.22	0.000	9,093.67	9,093.69	0.000	45.54	45.54	0.000	0.84	0.84	0.000
2011	290,716.15	290,716.15	0.000	9,220.91	9,220.04	-0.009	40.89	40.89	0.000	0.84	0.84	0.000
2012	305,194.55	305,194.55	0.000	9,697.55	9,697.25	-0.003	42.53	42.53	0.000	0.94	0.94	0.000
2013	294,072.21	294,072.21	0.000	9,361.38	9,359.33	-0.022	40.88	40.88	0.000	0.84	0.84	0.000
2014	283,407.86	283,407.86	0.000	8,929.65	8,927.39	-0.025	41.12	41.12	0.000	0.84	0.84	0.000

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
2015	281,637.61	281,637.61	0.000	9,236.17	9,234.78	-0.015	39.15	39.15	0.000	0.83	0.83	0.000
2016	285,181.11	285,181.11	0.000	9,419.93	9,418.64	-0.014	39.30	39.30	0.000	0.85	0.85	0.000
2017	298,247.03	298,247.03	0.000	9,950.61	9,949.71	-0.009	40.08	40.08	0.000	0.87	0.87	0.000
2018	309,732.94	309,732.94	0.000	10,475.71	10,474.69	-0.010	41.11	41.11	0.000	0.96	0.96	0.000
2019	310,669.21	310,669.21	0.000	10,496.75	10,493.99	-0.026	41.43	41.43	0.000	0.96	0.96	0.000
2020	315,049.36	315,049.36	0.000	10,710.53	10,708.20	-0.022	41.57	41.57	0.000	0.95	0.95	0.000
2021	344,808.73	344,808.73	0.000	11,901.39	11,898.80	-0.022	44.22	44.22	0.000	1.02	1.02	0.000
2022	316,919.08	316,919.08	0.000	10,847.76	10,845.27	-0.023	41.76	41.76	0.000	1.01	1.01	0.000
2023		308,393.14			10,677.43			39.93			1.01	

3.2.4.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

Activity Data

The co–operation with Romanian authorities administrating the EU–ETS and National Institute for Statistics will be maintained in order to have a fully correspondence concerning the definitions (fuel's calorific power) and quantities of the fuels, between the declarations of the operators under EU–ETS and, respectively, to NIS. A further analysis, in co–operation with the National Institute for Statistics, on the EU–ETS reporting will be conducted in order to take into consideration these emissions data, in the context of Tier 3 approach, on the activity category where these operators have to report. Annualy analysis on the EU–ETS reporting in comparison with Large Combustion Plants reporting, in order to check the concistency of the reported data, will be performed. For the current submission it was the resources is available only for these activities from 1.A.1.a, 1.A.1.b, 1.A.1.c, 1.A.2.a, 1.A.2.b, 1.A.2.c, 1.A.2.d, 1.A.2.e, 1.A.2.f and 1.A.2.g categories. Regarding the recommendation of ERT about that the endeavour to facilitate effective access to, and the sharing of, relevant energy data between all relevant actors involved in data collection and processing, Romania implemented the specific elements:

- discussions between the competent authority for the National Greenhouse Gas Inventory administration and the representatives of the National Institute for Statistics (NIS) begun;

- discussions inside the National Environmental Protection Agency, related to the possibility to share the EU–ETS data with the NIS in order to find the reason for discrepancies between EU–ETS and Energy Balance related data are continuing.

Emission Factors

Following the same procedure used until now, based on EU–ETS operators reporting, the country–specific CO_2 emission factors will be calculated and included in the next inventory submission. In response of ERT recommendation, “Romania further investigate and elaborate on the non–energy use of fuels reported in the energy balance, which is not reported in the energy sector, and assess whether the country specific carbon storage factors are appropriate”, Romania analysed the non–energy use of the fuels as activity data provided through the energy balances and used national values for net calorific power and country specific emission factors for the fuels reported under the EU–ETS. It is planned, in continuing, to take into consideration the emissions from the operators reporting on EU–ETS (having their reports verified by accredited verifiers) in order to achieve a hire tier approach in the estimation of the CO_2 emissions.

3.2.5 Fuel combustion, Energy Industry (CRT 1.A.1)

The following activity categories are included in this sub–sector:

- ❖ Conventional electricity, CHP and heat producer plants;
- ❖ Petroleum refining plants;
- ❖ Solid fuel transformation plants;
- ❖ Oil and gas extraction and coal mining;
- ❖ Own consumption of the energy sector.

Figure 3.18 Total GHG emissions trend for the subsector 1.A.1 Energy industries by category

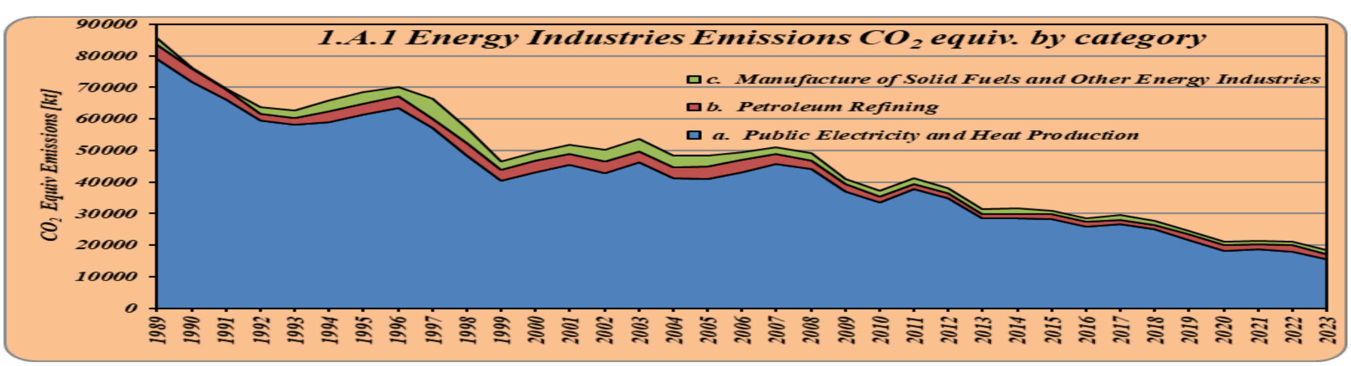
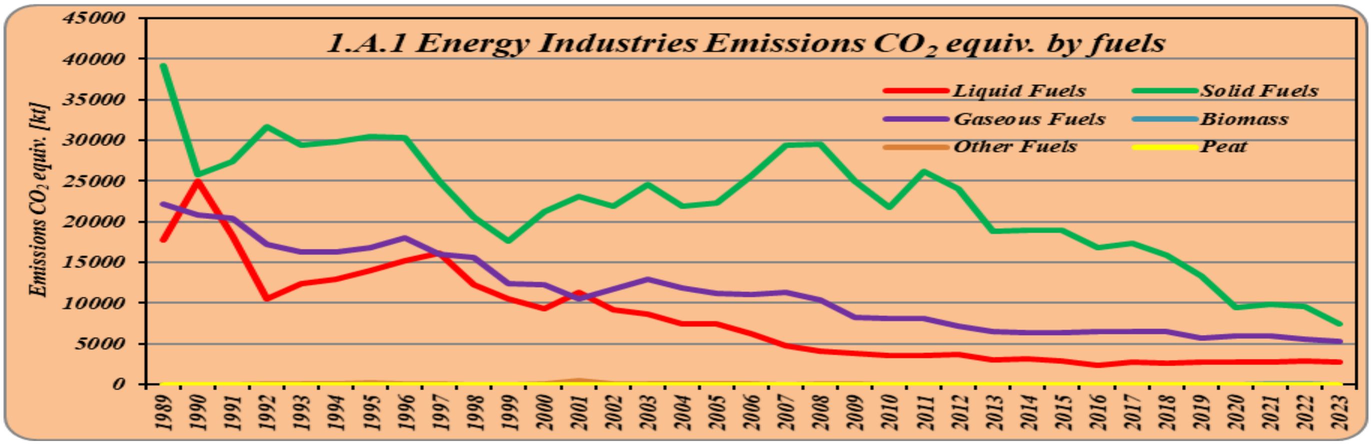


Figure 3.19 GHG emissions trend for the subsector 1.A.1 Energy industries by type of fuels



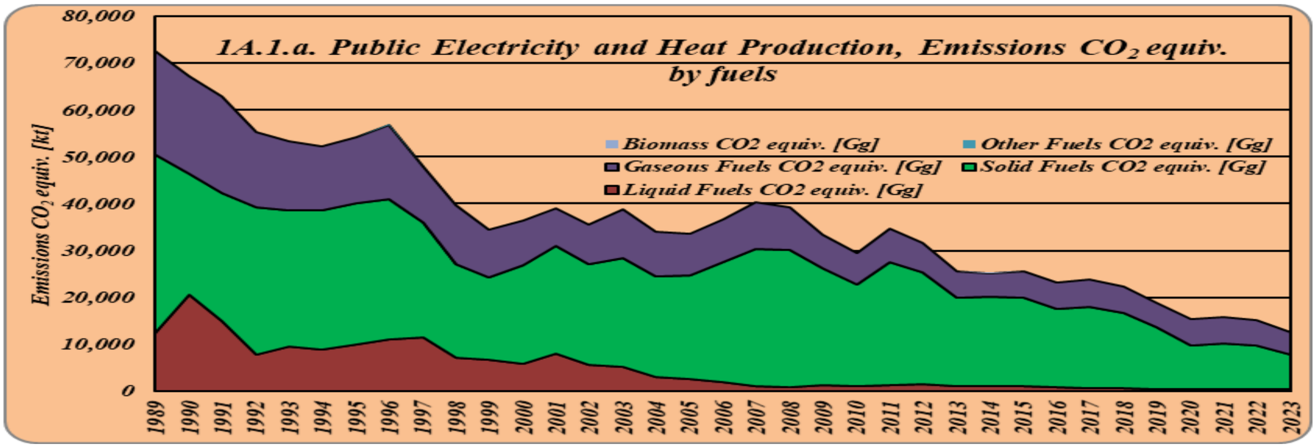
Energy Industries, CRT – 1.A.1 is a CO_2 key category by liquid, solid and gaseous fuels, level and trend, excluding and including LULUCF, as result of T1 approach. The general trend in CRT category 1.A.1 is a decrease in the emissions, but having a constant contribution to the total of 1A Fuel combustion emissions: 45.58% in the base year and a 24.90% in 2023. For the last years of the time–series, 2016, 2017, 2018, 2019, 2020, 2021 and 2022 the share of the Energy Industries in the total Energy sector encountered a decreasing, having a share of 38.64% in 2016 in year, of 38.22% in 2017 year, of 35.86% in 2018 year, 32.62% in 2019 year, 28.51% in 2020 year, 27.52% in 2021 year and 27.38% in 2022 year. The contribution of this sub–sector to the 1.A. – Fuel combustion is, for the year 2023, about 15,332.07 kt CO_2 equiv. having the main contributor the activity category 1.A.1.a – Electricity and Heat Production with 12,636.24 kt CO_2 equiv.

3.2.5.1 Public Electricity and Heat Production (CRT 1.A.1.a)

3.2.5.1.1 Category description

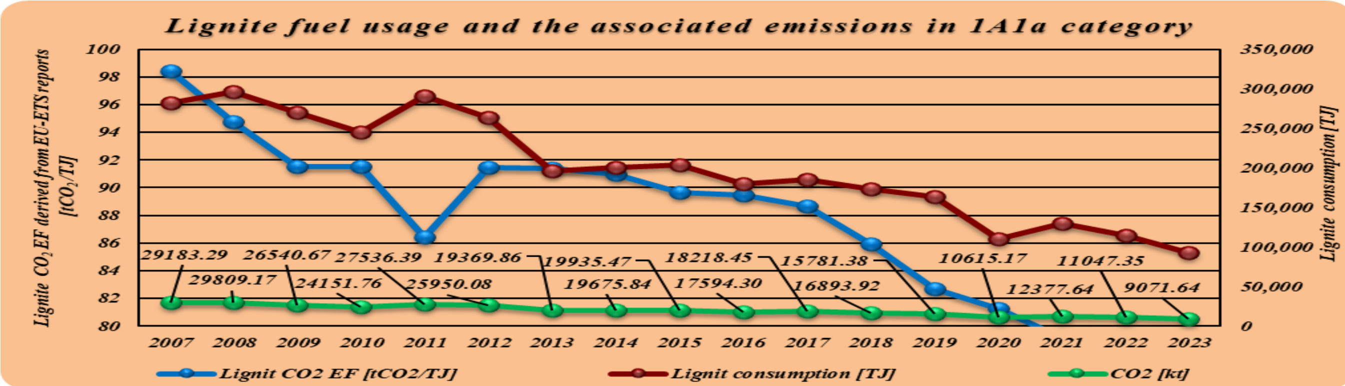
The 1.A.1.a. – Electricity and Heat Production activity category covers emissions from fuel combustion in Main Activity Producer Electricity Plants, Main Activity Producer CHP Plants, Main Activity Producer Heat Plants and Own Use in Electricity, CHP and Heat Plants. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.20 GHG emissions from 1.A.1.a Public Electricity and Heat Production



The share to the total of GHG emissions 1A – Fuel Combustion, for CRT category 1.A.1.a is 41.82% in the base year and 20.26% for the year 2023 (about 12,636.24 kt CO_2 equiv.). The share of this activity category to the 1.A.1. – Energy Industry is 45.58% for the base year and 24.90% for the year 2023 (about 15,532.07 kt CO_2 equiv.). The most quantity of combusted fuel in this activity is from solid fuel (aprox. 62.93%), for the entire time–series, being supplied mostly from national resources. The usage of the liquid fuels drastically decreased in the last years of the analyzed period, to 10.26% in total fuels used. Small quantities of GHG emissions are from the combustion of biomass and other fuels (6.56 kt CO_2 equiv. for the 2023 year). The decreasing trend is observed for the all burned fuels, due to the fact that the demand of the energy slightly decreased in the 2013 and for the fact that the supply from non fossil resources has an ascendant trend (hydro, wind, solar and nuclear resources). Particularly, the case of the lignite usage in the 1.A.1.a category, the descent trend of the country specific CO_2 lignite emission factor derived from the EU–ETS reporting period and including the oxidation factor (as is explained in the 3.2.4.4. chapter – "*Source-specific QA/QC and verification*"), has an influence in the variation of the associated CO_2 emissions, the main cause being the variation of the consumption – see the below figure.

Figure 3.21 CO_2 emissions variation associated with the lignite usage in the 1.A.1.a – Public Electricity and Heat Production



3.2.5.1.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels without analyze on EU–ETS reporting, or large combustion plants, are used. For the fuels reported in this activity category and having determined Country Specific Emission Factors (CS EFs) and Plant Specific Emission Factors (PS EFs) Tier 2 and Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. See the Chapter 3.2.4.2 for more details.

3.2.5.1.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.5.1.4 Uncertainty assessment and time-series consistency

The activity data, EFs and methodology used in estimating GHG emissions are consistent for the entire period. See the chapter 3.2.4.3 for more details.

3.2.5.1.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were

implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.5.1.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.5.1.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

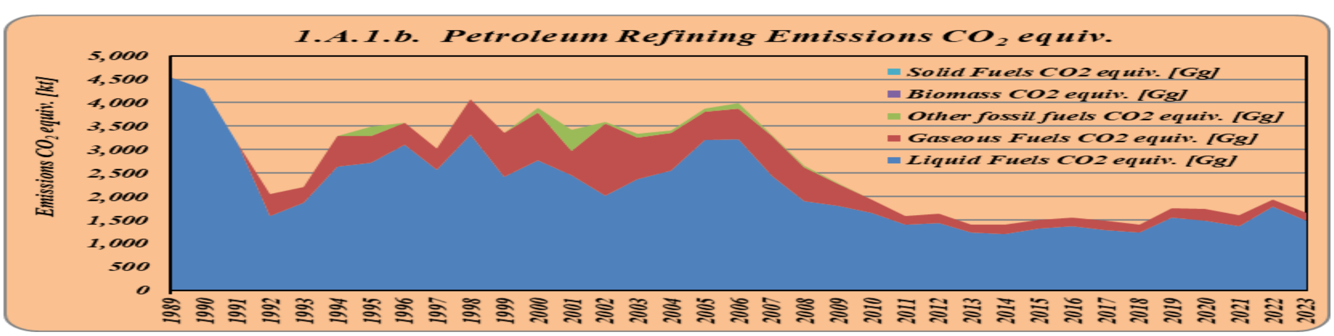
No improvements are planned for the next submission.

3.2.5.2 Petroleum Refining (CRT 1.A.1.b)

3.2.5.2.1 Category description

The share in total GHG emissions 1.A – fuel Combustion of this activity is 2.62% for the year 1989 and 2.66% for the year 2023. The main fuels reported are liquids which are: Refinery gas, Transport diesel and Residual fuel oil, together with natural gas having a contribution about 1,661.05 kt CO_2 equiv. in 2023. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT Sector 1.A.).

Figure 3.22 GHG emissions from CRT 1.A.1.b Petroleum refining



3.2.5.2.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels without analyze on EU–ETS reporting are used. For the fuels reported in this activity category and having determined Country Specific Emission Factors (CS EFs) and Plant Specific Emission Factors (PS EFs) Tier 2 and Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. See the Chapter 3.2.4.2 for more details.

3.2.5.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.5.2.4 Uncertainty assessment and time-series consistency

The activity data, EFs and methodology used in estimating GHG emissions are consistent for the entire period. See the chapter 3.2.4.3 for more details.

3.2.5.2.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.5.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.5.2.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

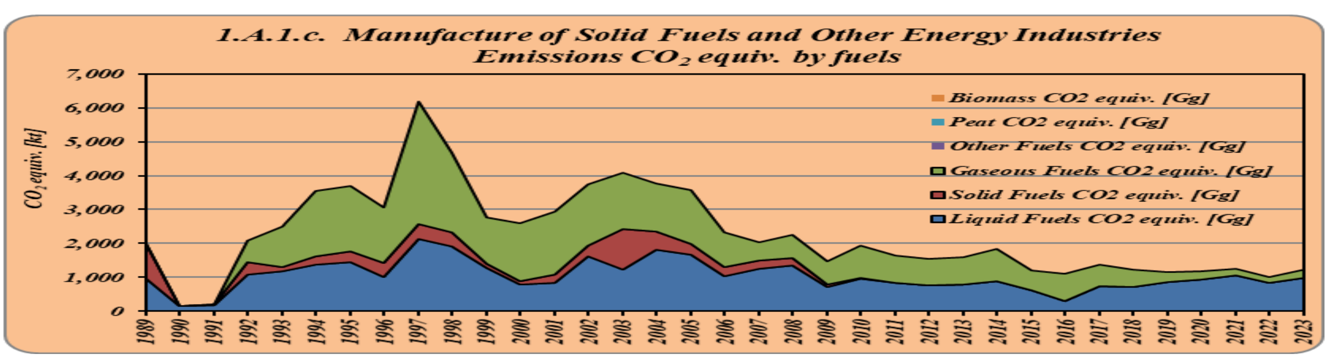
No improvements are planned for the next submission.

3.2.5.3 Manufacture of Solid Fuels and Other Energy Industries (CRT 1.A.1.c)

3.2.5.3.1 Category description

Category 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries covers emissions from fuel combustion in Coal Mines, Patent Fuel Plants (Energy), Coke Ovens (Energy) and BKB Plants (Energy). See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.). The share in total GHG emissions – sector 1A, is 1.98% for the year 2023, starting to a share of 1.14% in the base year, 1989. The emissions from this activity decreased with 37.53% compared to base year. This category having a contribution about 1,234.78 kt CO_2 equiv. in 2023. This is also a result in the change in the fuel mix used in this activity category, which, from mostly solid and liquid used in the first years, has now shifted and mixed, being predominant liquid and natural gas. The fluctuation of the fuels consumption level, especially for liquids fuels, could be explained by the fact that, when the economy is down like the Romanian economy (2010, 2011, being a deep crisis years), the internal and less expensive resources are preffered. The first which are not used anymore are the liquid fuels. In addition, the alternative sources of energy (renewable) are used. Therefore, in 2010 the economy was supported by the hydro energy production (being a good year from the hydrological point of view), in contrast with 2011 when a dry year imposed the usage of the fossil fuels. In 2012, the descendant trend is maintained, starting to increase in the last years.

Figure 3.23 GHG emissions from 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries



3.2.5.3.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels without analyze on EU–ETS reporting are used. For the fuels reported in this activity category and having determined Country Specific Emission Factors (CS EFs) and Plant Specific Emission Factors (PS EFs) Tier 2 and Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. See the Chapter 3.2.4.2 for more details.

3.2.5.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.5.3.4 Uncertainty assessment and time-series consistency

The activity data, EFs and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.5.3.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.5.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.5.3.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

No improvements are planned for the next submission.

3.2.6 Fuel combustion, Manufacturing Industries and Construction (CRT 1.A.2)

CRT 1.A.2. Manufacturing Industries and Construction is a CO_2 key category by, liquid, solid, gaseous and other fossil fuels, level and trend, excluding and including LULUCF as result of T1 approach. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.). The share of this activity category to the 1.A.2 – Manufacturing Industries and Construction is 37.98% for the base year and 18.39% for the year 2023 (about 11,470.65 kt CO_2 equiv.).

Figure 3.24 Total GHG emissions trend for the subsector 1.A.2 Manufacturing Industries and Constructions by category

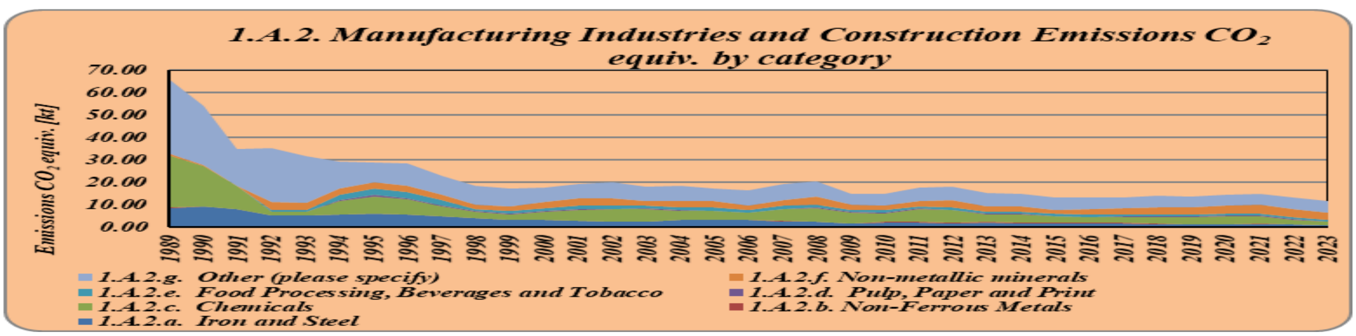
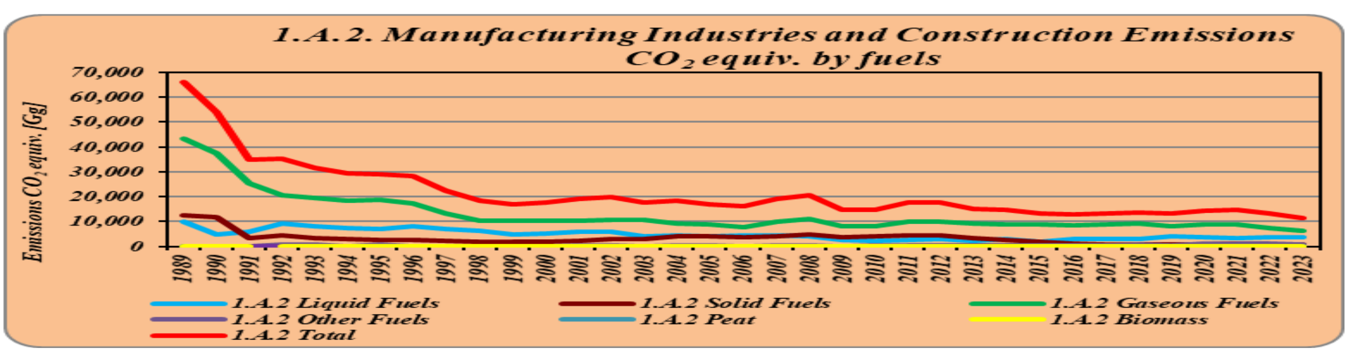


Figure 3.25 GHG emissions trend for the subsector 1.A.2 Manufacturing Industries and Constructions by fuels



The industries included in this sub-sector are the following:

❖ ***Energy Use in the Petrochemical Sector***

❖ ***Energy Use in Transformation Sector*, *autoproducers:***

- Auto producer Electricity Plants
- Auto producer CHP Plants
- Auto producer Heat Plants.

❖ ***Energy Sector – Blast Furnaces (Energy)***

❖ ***Industry Sector:***

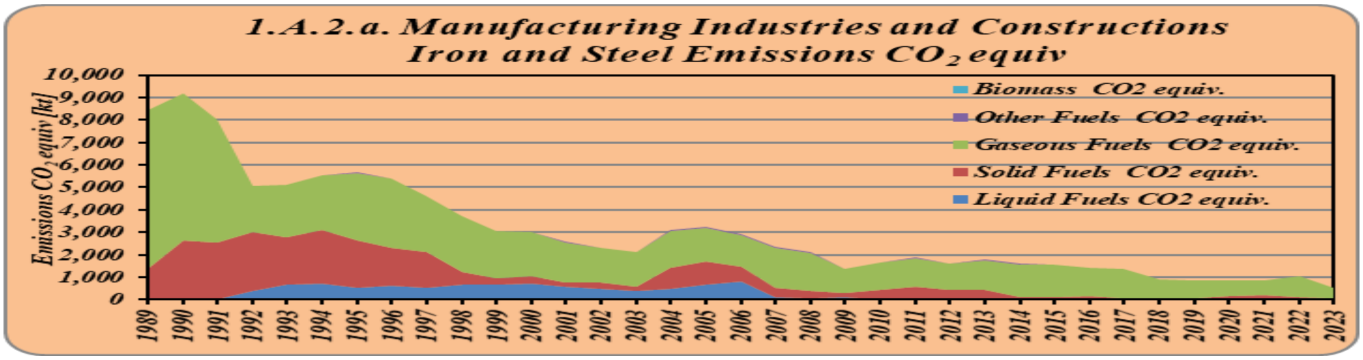
- Iron and Steel;
- Chemical (including Petrochemical);
- Non–Ferrous Metals;
- Non–Metallic Minerals;
- Transport Equipment;
- Machinery;
- Mining and Quarrying;
- Food, Beverages and Tobacco;
- Paper, Pulp and Printing;
- Wood and Wood Products;
- Construction;
- Textiles and Leather.
- Non–specified (Industry).

3.2.6.1 Iron and Steel (CRT 1.A.2.a)

3.2.6.1.1 Category description

The share of the total CO_2 equiv. emissions of the 1.A.2.a category to the 1.A.2 sub–sector, is 12.78% from the base year, 1989, to 4.79% – current year, 2023. The contribution of this category is about 548.87 kt CO_2 equiv., in 2023. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.26 GHG emissions from 1.A.2.a – Iron and Steel, by fuels



3.2.6.1.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels without analyze on EU–ETS reporting are used. For the fuels reported in this activity category and having determined Country Specific Emission Factors (CS EFs) and Plant Specific Emission Factors (PS EFs) Tier 2 and Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. The NCVs used are those corresponding with that used in industry. See the Chapter 3.2.4.2 for more details.

3.2.6.1.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.6.1.4 Uncertainty assessment and time-series consistency

The activity data, EFs and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.6.1.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport* *(excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.6.1.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.6.1.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

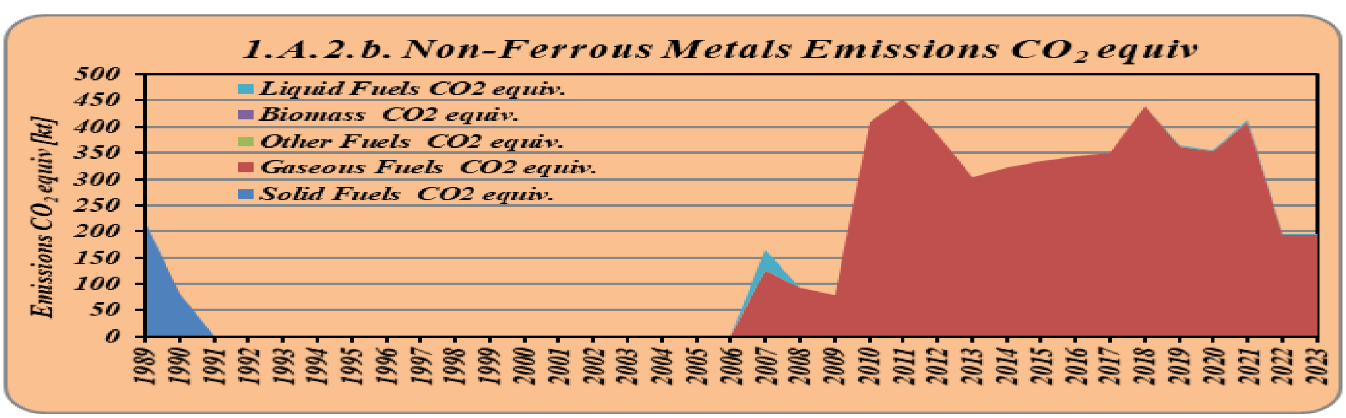
No improvements are planned for the next submission.

3.2.6.2 Fuel combustion, Manufacturing Industries and Construction, Non–Ferrous metals (CRT 1.A.2.b)

3.2.6.2.1 Category description

The share of the total CO_2 equiv. emissions of the 1.A.2.b category to the 1.A.2 sub–sector, is 0.33% from the base year, 1989, to 1.70% – current year, 2023. The contribution of this category is about 195.27 kt CO_2 equiv., in 2023. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.27 GHG emissions from 1.A.2.b – Non-Ferrous Metals, by fuels



3.2.6.2.2 Methodological issues

The activity data from this category for the 1991–2006 period is included in the 1.A.1.a Iron and steel reporting. The Energy Balance provided fuel consumption only on 1989 and 1990 years. For the 1991–2006 period the notation key is IE – included elsewhere. The Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU–ETS, are used and for the fuels having determined Country Specific Emission Factors, Tier 2 methodology is used. For the 2007–2023 period for the fuels having the emission factors by fuel and tehnology type and the Plant Specific Emission Factors (PS EFs), the Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. The NCVs used are those corresponding with that used in industry. See the Chapter 3.2.4.2 for more details.

3.2.6.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.6.2.4 Uncertainty assessment and time-series consistency

The activity data, EFs and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.6.2.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.6.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.6.2.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

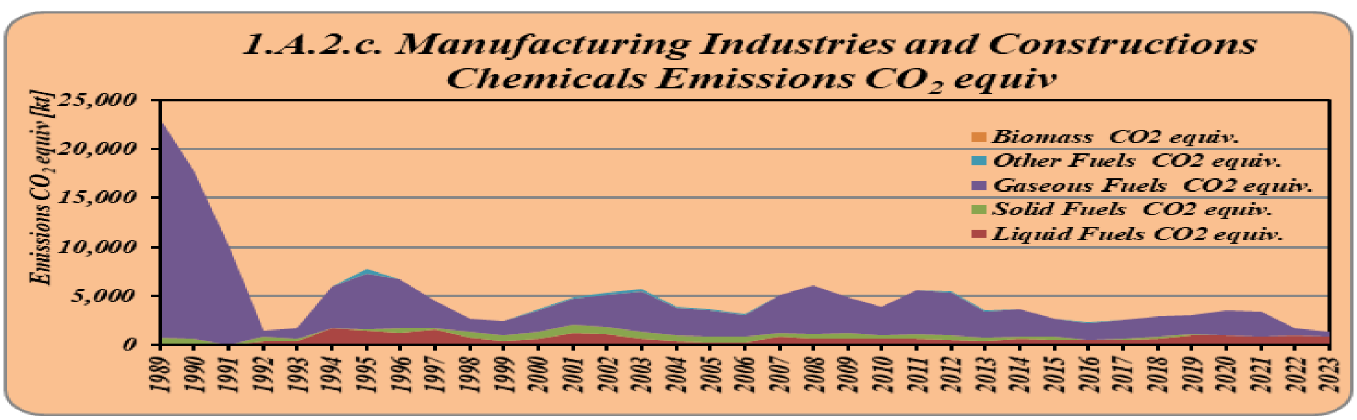
No improvements are planned for the next submission.

3.2.6.3 Category Fuel combustion, Manufacturing Industries and Construction, Chemicals (CRT 1.A.2.c)

3.2.6.3.1 Category description

The share of the total GHG emissions of the 1.A.2.c category to the 1.A.2 sub-sector vary from the base year, 1989 – 35.00% to 12.40% - current year, 2023. The contribution of this category is about 1,422.81 kt CO_2 equiv., in 2023. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.). Due to the coronavirus pandemic, the consumption and industrial activity for other fossil fuels in 2021 year cannot be compared to the previous years.

Figure 3.28 GHG emissions from 1.A.2.c – Chemicals, by fuels



3.2.6.3.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU–ETS, are used. For the fuels reported in this activity category having determined Country Specific Emission Factors, Tier 2 methodology is used and for the fuels having the emission factors by fuel and tehnology type and the Plant Specific Emission Factors (PS EFs), the Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. The NCVs used are those corresponding with that used in industry. See the Chapter 3.2.4.2 for more details.

3.2.6.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.6.3.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.6.3.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.6.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.6.3.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

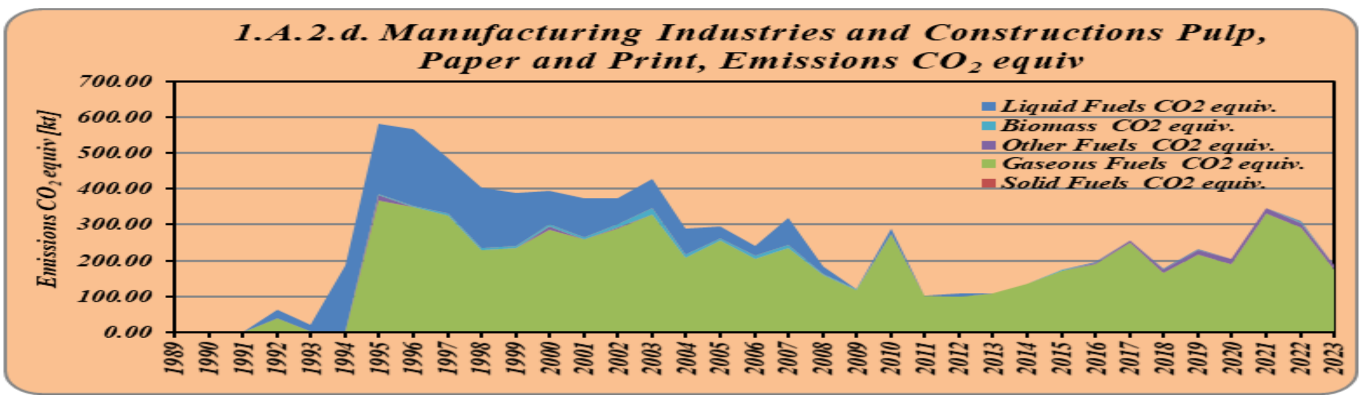
No improvements are planned for the next submission.

3.2.6.4 Fuel combustion, Manufacturing Industries and Construction, Pulp, Paper and Print (CRT 1.A.2.d)

3.2.6.4.1 Category description

The activity data start to be recorded in this category with 1992 year. The share of the total GHG emissions of the 1.A.2.d category to the 1.A.2 sub–sector is about 1.64% – in the current year, 2023. The contribution of this category is about 188.36 kt CO_2 equiv., in 2023. See more details about trends in the Chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.29 GHG emissions from 1.A.2.d – Pulp, Paper and Print, by fuels



3.2.6.4.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU–ETS, are used. For the fuels reported in this activity category having determined Country Specific Emission Factors, Tier 2 methodology is used and for the fuels having the emission factors by fuel and tehnology type and the Plant Specific Emission Factors (PS EFs), the Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. The NCVs used are those corresponding with that used in industry. See the Chapter 3.2.4.2 for more details.

3.2.6.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.6.4.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.6.4.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.6.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.6.4.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

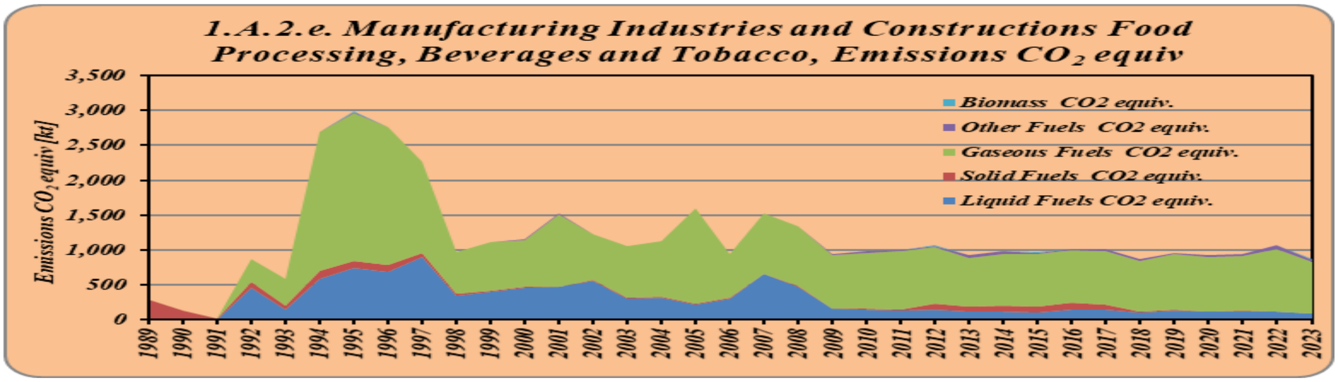
No improvements are planned for the next submission.

3.2.6.5 Fuel combustion, Manufacturing Industries and Construction, Food Processing, Beverages and Tobacco (CRT 1.A.2.e)

3.2.6.5.1 Category description

The share of the total GHG emissions of the 1.A.2.e category to 1.A.2 sub–sector is about 0.44% – base year to the 7.52%, current year, 2023. The contribution of this category is about 863.13 kt CO_2 equiv., in 2023. It is observed a rising of the natural gas usage as fuel in this activity category, mostly on the period 1993–1995. Also, starting to 1992 the biomass is used as combusted fuel for energy purposes. Secondly, the liquid fuels are burned in this category, together with the natural gas. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.30 GHG emissions 1.A.2.e – Food Processing, Beverages and Tobacco, by fuels



3.2.6.5.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU–ETS, are used. For the fuels reported in this activity category having determined Country Specific Emission Factors, Tier 2 methodology is used and for the fuels having the emission factors by fuel and tehnology type and the Plant Specific Emission Factors (PS EFs), the Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. The NCVs used are those corresponding with that used in industry. See the Chapter 3.2.4.2 for more details.

3.2.6.5.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.6.5.4 Uncertainty assessment and time-series consistency

The activity data, EFs and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.6.5.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.6.5.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.6.5.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

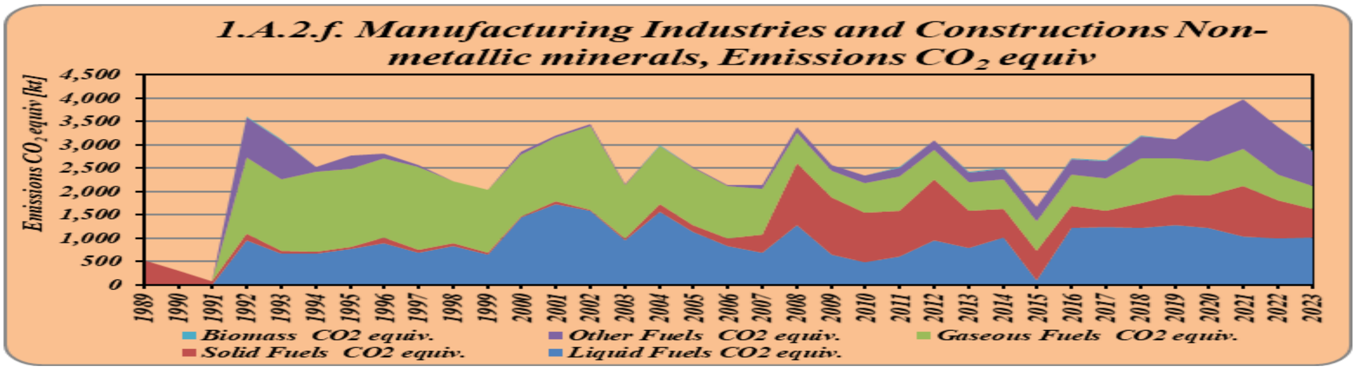
No improvements are planned for the next submission.

3.2.6.6 Fuel combustion, Manufacturing Industries and Construction, Other (please specify) (CRT 1.A.2.f)

3.2.6.6.1 Category description

In this new activity category, all type of fuels are consumed in a different proportion. Predominant is the usage of the liquid and other fuels. It is observed a main contribution of the natural gas usage as fuel in this activity category, mostly on the period 1992–2002. The share of the total GHG emissions of the 1.A.2.f category to the 1.A.2 sub–sector is about 0.79% – base year to the 24.92%, current year, 2023. The contribution of this category is about 2,858.81 kt CO_2 equiv., in 2023. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.31 GHG emissions from 1.A.2.f – Other, by fuels



3.2.6.6.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU–ETS, are used. For the fuels reported in this activity category having determined Country Specific Emission Factors, Tier 2 methodology is used and for the fuels having the emission factors by fuel and tehnology type and the Plant Specific Emission Factors (PS EFs), the Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. The NCVs used are those corresponding with that used in industry. See the Chapter 3.2.4.2 for more details.

3.2.6.6.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.6.6.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.6.6.5 Category-specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were

implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.6.6.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.6.6.7 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

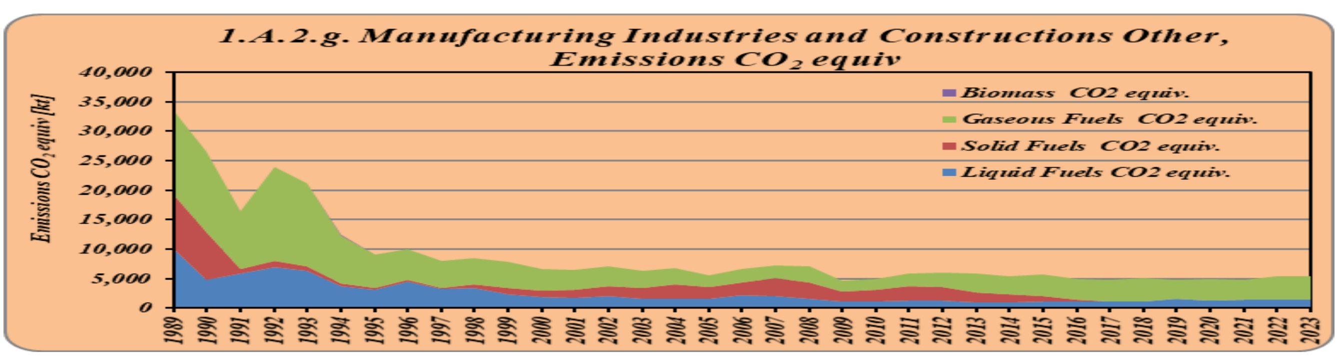
No improvements are planned for the next submission.

3.2.6.7 Fuel combustion, Manufacturing Industries and Construction, Other (please specify) (CRT 1.A.2.g)

3.2.6.7.1 Category description

The usage of the liquid, solid and gaseous fuels is balanced in this category. Small quantities of biomass are used on the period 2000–2010. The share of the total GHG emissions of the 1.A.2.g category to the 1.A.2 sub–sector is about 50.67% – base year to the 47.02, in 2023, the contribution of this category being about 5,393.40 kt CO_2 equiv. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.32 GHG emissions from 1.A.2.g – Other, by fuels



3.2.6.7.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU–ETS, are used. For the fuels reported in this activity category having determined Country Specific Emission Factors, Tier 2 methodology is used and for the fuels having the emission factors by fuel and tehnology type and the Plant Specific Emission Factors (PS EFs), the Tier 3 methodology is used. The activity data are provided by Romanian Energy Balance sent by NIS to IEA/EUROSTAT and monitoring reports provided by economic operators under EU–ETS. The NCVs used are those corresponding with that used in industry. See the Chapter 3.2.4.2 for more details.

3.2.6.7.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.6.7.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period. See the Chapter 3.2.4.3 for more details.

3.2.6.7.5 Category–specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.6.7.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.6.7.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No improvements are planned for the next submission.

3.2.7 Transport (CRT 1.A.3.)

3.2.7.1 Category description

The IPCC source category for transport covers all types of mobile sources including also the range of characteristics that affect the emission factors and consequently the emissions. Those are compiled in five categories, according to the source. The direct GHG emissions originating from transport are carbon dioxide, methane and nitrous oxide; for the estimation of each gas the most appropriate method has been chosen based on the type of emission, transport category and data availability. Emission trends over the years depend significantly on the amount of fuel consumed. In 2023 year, the emissions from transport categories accounted for 22,124.76 kt CO_2 equiv. The GHG characterized are: CO_2, CH_4, N_2O, NO_x, NMVOC, CO and SO_2. Within the Energy Sector total emissions, 31.06% represents transport emissions. This sector includes emissions from road transportation, domestic aviation, railways, domestic navigation and other transportation.

Figure 3.33 Contribution of each category to total fuel consumption in Transport Subsector

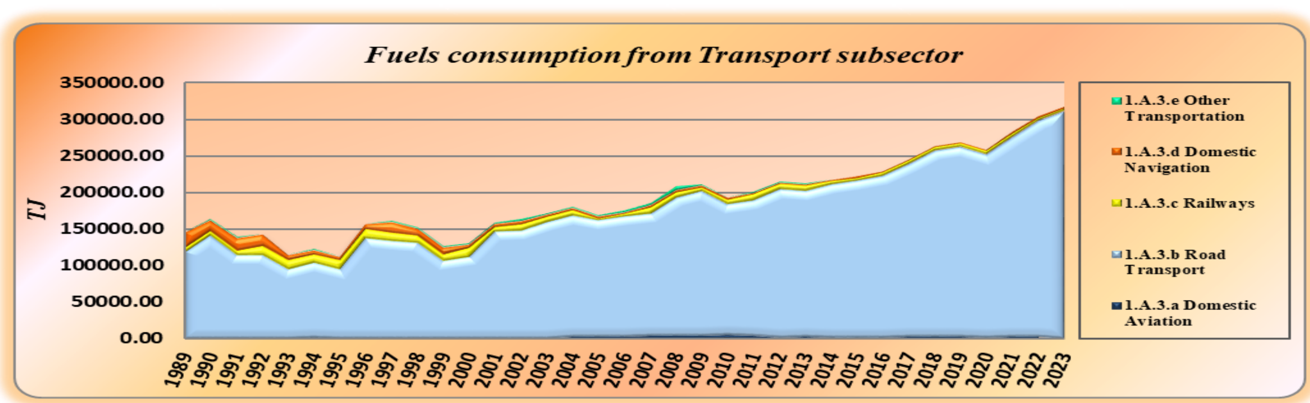
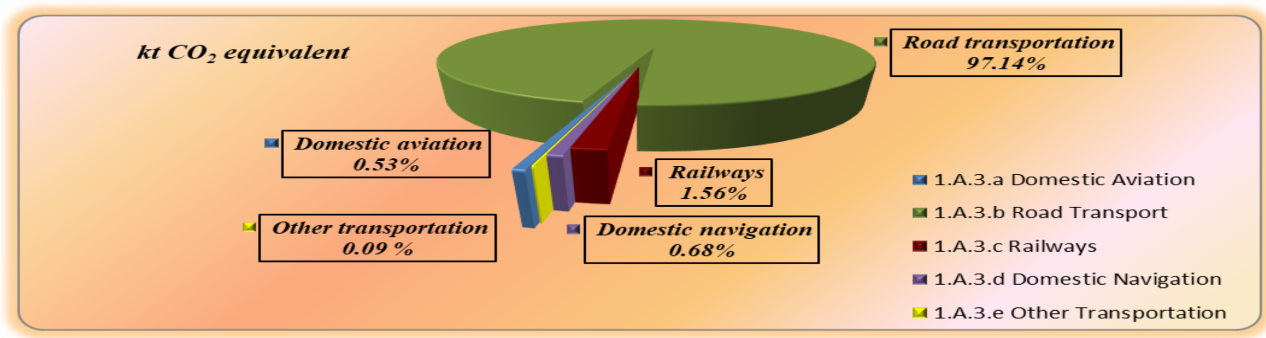


Figure 3.34 The contribution of the emissions from different categories of Transport Subsector in 2023

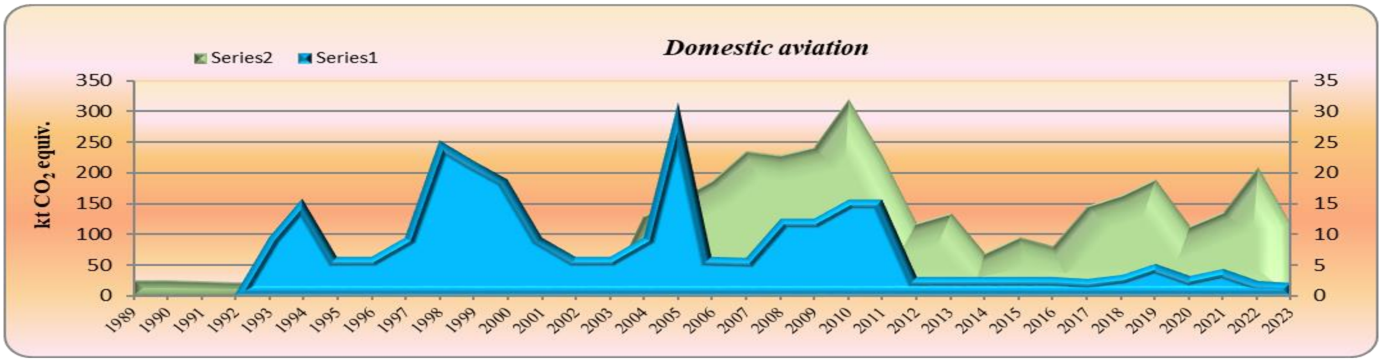


3.2.7.2 Domestic Aviation (CRT 1.A.3.a)

3.2.7.2.1 Category description

The emissions from the Domestic Aviation category come from combustion of fuels of jet kerosene and aviation gasoline. Aircraft emit carbon dioxide, methane and nitrous oxide, as well as carbon monoxide, non-methane volatile organic compounds, sulphur dioxide, and nitrogen oxides. In 2023 year, the Domestic Aviation related emissions represents 0.53% of total emissions from the Transport sector (22,124.76 kt CO_2 equiv.). In the 1989–1991 period emissions remains broadly constant, the fuel consumption being constant. Starting with 1992 year emissions have been increased in Domestic Aviation category due to the economic country development and intern and international tourism. Between 1993–2023 increases and decreases of emissions due to fluctuations in the number of flights operated took place, as well as fluctuating fuel consumption. Referring to the military transport related emissions from fuel use in Romania, these are accounted in the CRT category 1.A.5.a Other (Not elsewhere specified) – Stationary, according to the data provided through the IEA/Eurostat – Oil Annual Questionnaire and elaborated based on the Commission Regulation (EU) No 147/2013 of 13 February 2013 amending Regulation (EC) No 1099/2008 of the European Parliament and of the Council on energy statistics regarding the implementation of updates for the monthly and annual energy statistics; according to the provisions specified previously, the fuel consumption is allocated under “Other Sector – Not Elsewhere Specified” category. The methodological note associated with the previously mentioned category is “Report activities not included elsewhere. This category includes military fuel use for all mobile and stationary consumption (e.g. ships, aircraft, road and energy used in living quarters), regardless of whether the fuel delivered is for the military of that country or for the military of another country”.

Figure 3.35 GHG emissions Trend from Domestic Aviation category



3.2.7.2.2 Methodological issues

Methodology

The GHG emissions from Domestic Aviation category are calculated according to the 2006 IPCC provision. For the 1989–2003 period a Tier 1 method was applied as (no LTO data were available); for 2004–2023, a Tier 2 method has been used.

Tier 1 method

The Tier 1 method is based on an aggregate quantity of fuel consumption data for aviation (LTO and cruise) multiplied by average emission factors.The direct greenhouse gas emissions are calculated according to Equation 3.6.1 in the 2006 IPCC -Volume 2, chapter 3.6.1.1, page 3.59.

Tier 2 method

The Tier 2 method is applicable for jet kerosene. Tier 2 method splits the calculation of emissions from aviation into the following steps:

1. Estimate the domestic and international fuel consumption totals for aviation.
2. Estimate LTO fuel consumption for domestic and international operations.
3. Estimate the cruise fuel consumption for domestic and international aviation.
4. Estimate emissions from LTO and cruise phases for domestic and international aviation.

Tier 2 approach uses Equations 3.6.2 to 3.6.5 (page 3.59, Chapter 3.6.1.1, vol.2, 2006 IPCC GL) to estimate emissions.

Emission factors

Default values of CO_2 emissions factor, according to the 2006 IPCC (vol.2, chapter 3.6.1.2, table 3.6.4, page 3.64.) for Tier 1 and Tier 2 methods, have been used.

CO_2 emission factor	
Fuel	**Default (kg/TJ)**
Aviation Gasoline	70,000
Jet Kerosene	71,500

For Tier 1 the values of CH_4 and N_2O emissions factor for Domestic and International Aviation are default according to the 2006 IPCC methodology, Table 3.6.5, chapter 3, vol 2, page 3.64.

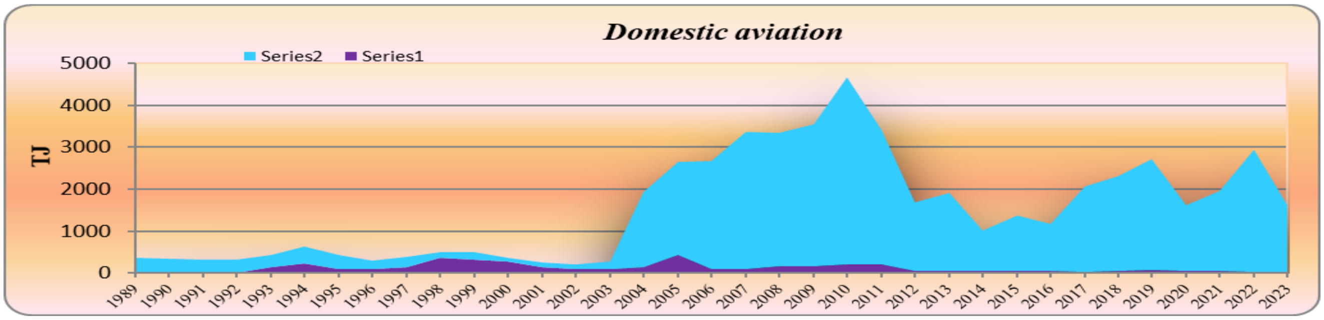
Default emission factor (kg/TJ) for all fuels	
CH_4	**N_2O**
0.5	2

For Tier 2 the values of CH_4 and N_2O emissions factor for Domestic and International Aviation are default according to the 2006 IPCC methodology, Table 3.6.9, page 3.70, Chapter 3, vol. 2. (see Annex V.3). The values of CH_4 and N_2O emissions for Domestic and International Aviation were calculated for each cycle type of aircraft flight (kg fuel/ LTO) using the 2006 IPCC methodology vol. 2, Chapter 3 Table 3.6.9, page 3.70 (see Annex V.3). The values of NO_x emission factors are default and in accordance with the 2006 IPCC Guidelines. The values of CO, NMVOC emission factors are default and in accordance with the 1996 IPCC Guidelines. For the estimation of the SO_2 emissions were used the values of the Sulphur content provided by the site EMEP/EEA Air Pollutant Emission Inventory Guidebook – 2019 and according to the 1996 IPCC Guidelines. The values of emission factors and the values of estimate emissions have been determined according to the 1996 IPCC Guidelines.

Activity Data

Fuel consumption data are provided through the Romanian Civil Aeronautical Authority and IEA/Eurostat Questionnaire, elaborated by NIS. In respect to aviation gasoline data, for 1989–2023 period IEA/Eurostat Questionnaire data have been used. For the 2004–2006 period, fuel consumption data were not available, they being estimated through extrapolation based on 2007 year fuel consumption data and LTO data on 2004–2007 period; for 2007–2023 period IEA/ Eurostat Questionnaire have been used. The fuels consumption for Domestic Aviation were calculated for the cycles of the fly LTO (landing/take off)/Cruise. The fuel consumption/ LTO is provided through the Eurostat website/ Aircraft traffic data by reporting country [avia_tf_acc] (see Annex V.3).

Figure 3.36 Contribution of fuels consumption from Domestic Aviation category



3.2.7.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.7.2.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

CO_2

❖ ***activity data:***

- aviation gasoline: 5 %;
- jet kerosene: 5 %.

❖ ***emision factors:***

- Aviation gasoline: 5 %;
- Jet Kerosene: 5 %.
- 7.07 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

CH_4

❖ ***activity data:***

- aviation gasoline: 5 %;
- jet kerosene: 5 %.

❖ ***emision factors:***

- Aviation gasoline: 150 %
- Jet Kerosene: 150 %

- 150 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

N_2O

❖ ***activity data:***

- aviation gasoline: 5 %;
- jet kerosene: 5 %.

❖ ***emision factors:***

- Aviation gasoline: 150 %
- Jet Kerosene: 150 %
- 150 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency-University of Graz consortium; additional information are included in Annex V.10.

3.2.7.2.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.
No recalculations were implemented following the QA activities mentioned in the previous two paragraphs. The activity data series were also compared to those on Eurostat, the data being reported at the same level of aggregation and the figures comparable; additionally, national emission factors values were compared witht national emission factors values specific to Bulgaria, considering that similar energy activities are implemented. Further elements are presented within Annex V.11.

3.2.7.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

For CO_2, CH_4 and N_2O emissions have been performed recalculation for 2022 year due to the updated value of Jet kerosene fuel consumption, data provided by NIS.

3.2.7.2.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

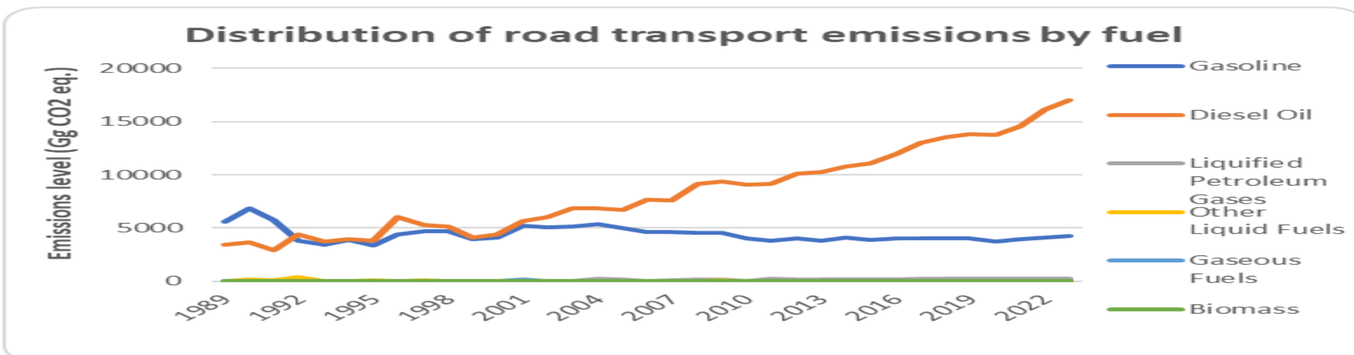
Implementation requirements and future recommendations consistent with the 2006 IPCC.

3.2.7.3 Road Transport (CRT 1.A.3.b)

3.2.7.3.1 Category description

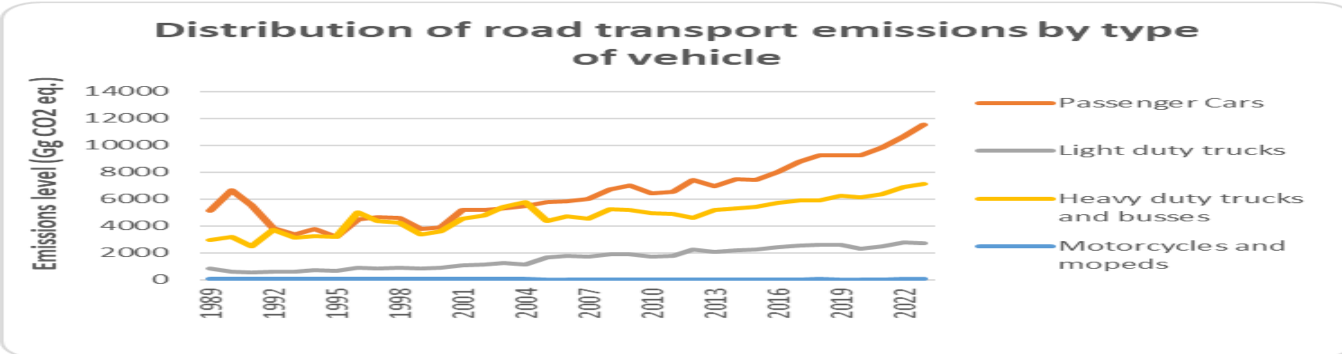
CO_2 emissions from Road Transportation category, is a key category, by level, trend, including LULUCF and excluding LULUCF criteria. Road Transportation category includes emissions from all types of vehicles, light–duty vehicles such as automobiles and light trucks, and heavy–duty vehicles such as tractor trailers and buses; on-road motorcycles (including mopeds, scooters, and three-wheelers) related emissions are also included. Mobile sources produce direct greenhouse gas emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from the combustion of various fuel types, as well as several other pollutants such as carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO_2), particulate matter (PM) and oxides of nitrate (NOx), which cause or contribute to local or regional air pollution. Exhaust emissions from road transport arise from the engines internal combustion of fuels such as gasoline, diesel, liquefied petroleum gas, other kerosene and natural gas.

Figure 3.37 Distribution of Road transportation emissions by fuel (Gg CO_2 equiv.)



In Road Transport Subsector the emissions trend reflects the changes in period 1989–1999 characterized by a process of transition to a market economy. Roads in Romania had a low level of modernization. Massive development of trade and the industrial revolution led to improving the roads and to achieve efficient vehicles; therefore, the goods road transport services have experienced a considerable increase after 1989. In 1994 was launched the Logan brand Romania has contributed to a rise in the number of passenger cars, and in 2005 entered the diesel version, one of the factors that led to increased diesel consumption and CO_2 emissions. A distinct uptrend of GHGs emissions could be noticed since 2000 to present. On the whole, increasing emissions trend from the Road Transport Sub–sector is due to the increasing trend of the number of vehicles and volume of goods transported, especially starting with 2000; with the reviving economy CO_2 emissions grew constantly to 2019. Due to the COVID-19 pandemy, the mobility level decreased in 2020, determining a decrease in the GHG emissions level. The emissions level increase again in 2021, 2022 and 2023, due to an increased mobility level.

Figure 3.38 Distribution of Road transportation emissions by type of vehicle (Gg CO_2 equiv.)



Overall, the GHG emissions from road transport increased by 139.14% compared to base year levels being 8998,90 kt CO_2 equiv in 1989 and reached levels of 21,490.97 kt CO_2 equiv. in 2023. The most important contributor to GHG emissions is represented by passenger cars, followed by heavy duty trucks and buses, light duty trucks and motorcycles and mopeds; in 2023, emissions from passenger cars contributed to 53.8% in total Road transportation emissions and heavy duty trucks and buses with 33.29%.

Figure 3.39 Distribution of Road transportation emissions by type of vehicle (%)

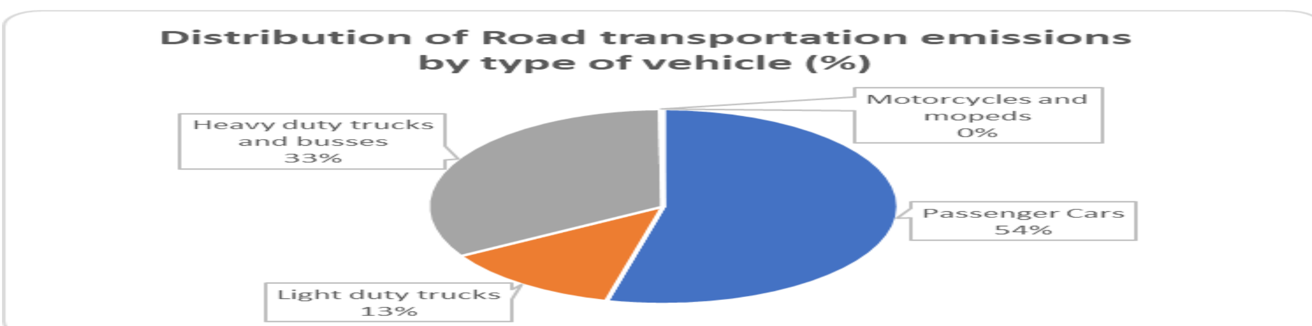
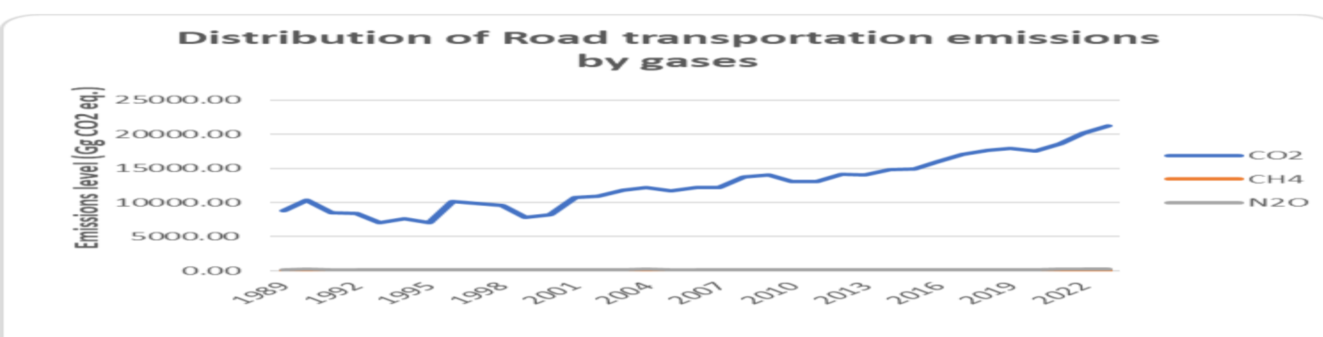


Figure 3.40 Distribution of Road transportation emissions by gases (Gg CO_2 equivalent)



Whereas CO_2 emissions are closely linked to fuel consumption, CH_4 and N_2O emissions are impacted also by the technology. N_2O emissions have a higher warming potential compared to CH_4, hence, a slight increase in their release in the environment leads to a greater impact. As it can be observed, CO_2, CH_4 and N_2O emissions tend to fluctuate for the full period of the inventory. By far the most important gas emitted from the sector road transport is CO_2. It accounts for 98.8% of the total greenhouse gas emissions of the sector, in 2023. CH_4 emissions contributed with 0.17% to the total emissions of the road transport .The decreasing trend after 1991 is the result of improved transmission network resulting in substantially lower and reduced emissions from gasoline passenger cars due to catalytic converters. In 2023, N_2O emissions contributed with 1.03% to the total emissions of this sector. The changes in N_2O emissions may mainly be explained by the changes in EFs for diesel and gasoline combustion. The first generation of catalytic converters generates N_2O as undesirable by-product in the exhaust gases, leading to an increase of N_2O emissions until 2004. With new converter materials being used, the emission factors are decreasing after 2005. There is also an increasing to the years 2000–2005, which is closely linked to the introduction of Euro 1 vehicles. This category it is known for higher N_2O emissions. CH_4 and N_2O emissions peak growth in 1990-1991 respectively and after the fuel consumption which is also the peak on the 1989–2000 period. Compliance with emission standards grew raised significantly influence, CH_4 and N_2O thereby leading to low levels of methane and nitrous oxide. As the technology improves over time, there is a noticeable decrease in the passage from Euro 1 to Euro 3, which could be detected clearly after 2005.

3.2.7.3.2 Methodological issues

Methodology

In the development of estimates, it was primarily utilized default EFs available in the IPCC 2006 and, in some cases (where the previous documents do not comprise values) from EMEP/EEA air pollutant emission inventory guidebook 2013. Model Copert 4, Tier 1 was used in the absence of more detailed fleet data (for the period 1989–2004).

<u>For the 1989–2004 period</u>

A) Tier 1 methodology

Tier 1 methods apply simple linear relation between activity data and emission factors. The activity data is derived from readily available statistical information (consumption energy statistics, fleet data, data on traffic counts etc). The most common estimation approach is to combine information on the extent to which a activity takes place (called activity data or AD) with coefficients that quantify the emissions or removals per unit activity, called emission factors (EF), the default Tier 1 emission factors are chosen in way that they represent 'typical' or 'averaged' process conditions - they tend to be technology independent. For this time period 1989–2004, was used default emission factors of EMEP/EEA emission inventory guidebook 2013, Tier 1. Emissions of CO_2, CH_4 and N_2O are calculated based on the amount and type of fuel combusted and its carbon content (for CO_2 gas). The vehicle categories that have been considered are passenger cars, light commercial vehicles, heavy-duty vehicles, and two–wheel vehicles. The fuels that have been considered include gasoline, diesel and LPG. This equation requires the fuel consumption of vehicle category, and national statistics do not provide vehicle category details.

Emission factors

CO_2, CH_4, N_2O and for the indirect greenhouse gases

For the period 1989–2004 Tier 1 emission factors (EFs) were used, so as to be applicable to countries with older vehicle fleets. The emission factors are provided in Table 3–5 to Table 3–11 of EMEP/EEA emission inventory guidebook 2013. However, a consequence of this approach, in the context of the legislative emission requirements for more modern vehicles, is that the Tier 1 emission factors will give somewhat higher emission values than a Tier 2 or 3 methodology for countries whose fleet comprises vehicles which comply with more recent (i.e. Euro 2 / Euro II and later) emission standards. In Table 3–5 to Table 3–9, the maximum values correspond to uncontrolled vehicle technology, and the minimum values correspond to a European average in 2005 (before the introduction of Euro 4). For the estimation of the CO_2, CH_4, N_2O, CO, NOx and NMVOC emissions were used the values provided by the site EMEP/EEA Air Pollutant Emission Inventory Guidebook 2013 and according to IPCC 2006 Guidelines. (CO_2 ch. Road transport GB 2013, table 3–11 pag.27; CH_4 ch. Road transport GB 2013, table 3–70 pag.82; N_2O ch. Road transport GB 2013, table 3–7 pag.26; CO, NOx, ch. Road transport GB 2013, table 3–5 and table 3–6 pags.25–26; NMVOC ch. Gasoline evaporation GB 2013, pag.8–9; SO_2 IPCC 1996, Vol.III, pag.1.44 Guidelines table 1–12 Default Values of Sulphur Content in gasoline (road), diesel(road) and jet kerosene).

Activity data

Liquid and gaseous fuels

The energy balances prepared by the Romanian National Institute for Statistics in the Eurostat format (Eurostat Questionnaire), were used for estimating the emissions for the years in 1990–2004 period. NIS did not prepared balances in the Eurostat format for the years before 1990; therefore, the IEA Energy Balance (IEA Questionnaire) was used for the year 1989. The other data, necessary for implementation of model COPERT–Tier 1, have been provided by national institutions: fleet data provided by Romanian National Institute for Statistics (NIS), were processed and completed by the Romanian Automobile

Registry (RAR).

Biomass

In order to estimate the emissions from biomass combustion activities in road transport, data on energetic quantities provided through the Energy Balance were used. Liquid biomass used comprise biogasoline, biodiesel and other bioliquids. All these types are combusted to produce heat and/or power. However, CO_2 emissions released from these processes are reported as an information item, as the CO_2 is naturally captured from the air. That is not applicable for the CH_4 and N_2O emissions, being reported and accounted for, in the total inventory emissions. The national energy balance is provided by NIS. From biomass, the net calorific values (NCVs) used for converting mass or volume units of the fuel quantities into energy units [TJ] are provided by NIS.

Choice of NCV

For liquid fuels country specific NCVs values, derived for the corresponding liquid fuels from the EU-ETS reporting, are used.

For gaseous fuels was used directly the amount in TJ as reported by the energy balances. Since the reported values are Gross Calorific Values, all numbers were multiplied by 90% in order to compute the NCV.

For the 2005–2023 period

Methodology

Model Copert 4, Tier 3 was used for the period 2005–2023, detailed statistics necessary to use higher level methods have allowed. For the period 2005–2023 the emission calculations of road transport have been performed with the use of the version 11 of the European COPERT 4 software, model methodology corresponding to Tier 3, according to the IPCC 2006. In the Tier 3 method, exhaust emissions are calculated using a combination of firm technical data (emission factors) and activity data (total vehicle km). In the model emissions were calculated through the input of detailed data on average daily trip distance, the relative humidity per month, minimum and maximum temperatures per month, consumption and fuel specifications, vehicle fleet categorized in sectors, subsectors and technology (standard), vehicle stock and annual mileage, speed and driving shares.

Emission Factors

For period 2005–2023, emissions have been calculated based on the Tier 3 method (actually Copert 4).

In the Tier 3 approach, total exhaust emissions from road transport are calculated as the sum of hot emissions (when the engine is at its normal operating temperature) and emissions during transient thermal engine operation (termed cold-start emissions). The distinction between emissions during the hot stabilised phase and the transient warming-up phase is necessary because of the substantial difference in vehicle emission performance during these two conditions. Concentrations of some pollutants during the warming-up period are many times higher than during hot operation, and a different methodological approach is required to estimate the additional emissions during this period. Vehicle emissions are heavily dependent on the engine operation conditions. Different driving situations impose different engine operation conditions, and therefore a distinct emission performance. In this respect, a distinction is made between urban, rural and highway driving. As will be demonstrated later, different activity data and emission factors are attributed to each driving situation. Cold–start emissions are attributed mainly to urban driving (and secondarily to rural driving), as it is expected that a limited number of trips start at highway conditions. Total emissions are calculated by combining activity data for each vehicle category with appropriate emission factors. The emission factors vary according to the input data (driving situations, climatic conditions). Also, information on fuel consumption and fuel specification is required to maintain a fuel balance between the figures provided by the user and the calculation.

Activity data

Fuel consumption (liquid, gaseous and biofuels) is obtained from Romanian Energy Balance IEA/ Eurostat/UNECE format data and converted into energy units using the NCV. According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the net (or lower) calorific value (NCV) should be used as the conversion factor for each fuel. The other data, necessary for implementation of model COPERT have been provided by national institutions: Romanian National Institute for Statistics (NIS), Romanian Automobile Registry (RAR), General Directorate for Driving Licenses and Registrations (GDDLR) and National Institute of Meteorology (NIM). A degree of expert judgment was necessitating as well. The following input data is compiled for the emission calculations with the use of COPERT 4–Tier 3.

Activity data: fleet data, circulation data

Input data for Population, Annual Mileage (km/year), Mean fleet mileage (km), Speed (Km/h) and the mileage percentage driven by each vehicle technology per driving mode (urban, rural, highway), data collected by monitoring traffic systems (video cameras located on the public roads from the endowment Romanian Police) and through field surveys (made by partners from RAR) (see Annex V.2). The number of vehicles is used in each category and an average mileage for each category based on some average values. The COPERT software then is run twice – once with the original data to compare the calculated fuel consumption for each fuel with the actual fuel consumption reported by the national statistics. On the second run, the mileage adjustment for the fuel difference, the reason have to do this adjustment several times in order to obtain 0% of the difference calculated and statistics by the fuel. The data on the number of vehicles were obtained from NIS until 2004 and from the Romanian Automotive Register since 2005. The data for the period 1989–2004 were primarily collected by the Ministry of Internal Affairs (Directorate for Driving Licenses and Vehicles Registration) on the basis of data and information in existing vehicle registration documents submitted to NIS, who compiled a database on the type of use of vehicles that was then processed by the Romanian Automotive Register. The Romanian Automotive Register, given its expertise with road vehicles and previous research data, considered that the data fully reflected the national circumstances in the sense that the data captured all available information and data. All available information and data is used to ensure time-series consistency of the data between the data sets, and particularly between 2004 and 2005.

Minimum and maximum temperatures and relative humidity

National Institute of Meteorology provided us data on maximum and minimum temperatures and relative humidity for each month of the period 2005–2023 in the 41 regions of Romania. These data used in Copert are calculated as an arithmetic average of the 41 regions of the country.

Fuel specifications

Fuel quality specification from liquid fuels, gasoline and diesel oil is regulated by the Government Decision no. 15/2006 and subsequent decisions:

Table 3.12 Country specific characteristics for gasoline and diesel oil according Decision no 689/ 2004, update by Decision no. 15/2006

	Sulfur (% m/m)		**Hidrocarbons**		**Benzene (% v/v)**	**E100 (% v/v)**	**E150 (% v/v)**	**Oxygen Content (%m/m)**
			aromatics (% v/v)	**olefins (% v/v)**				
				< 1 january 2005				
Leaded gasoline	-	0.08	42	-	3	-	-	-
Unleaded gasoline	**Sulfur (mg/kg)**							
	min	max						
	-	150	42	-	3	-	-	-
				Unleaded Gasoline				
≥ 1 january 2005	-	150	42	18	1	46	75	2.7
≥ 1 january 2007	-	50	35	18	1	46	75	2.7
≥ 1 january 2009	-	10	35	18	1	46	75	2.7
				Diesel oil				

	Sulfur (% m/m)		Hidrocarbons		Benzene (% v/v)	E100 (% v/v)	E150 (% v/v)	Oxygen Content (%m/m)
			aromatics (% v/v)	olefins (% v/v)				
	Sulfur (mg/kg)		PAH (% m/m)		Density (kg/m^3)	T95% C^0	Cetane number	
			max.				min.	
< 1 january 2007	-	350	11		845	360	51	
≥ 1 january 2007	-	50	11		845	360	51	
≥ 1 january 2009	-	10	11		845	360	51	

Vehicle fleet

The data on fleet detailed on technology, necessary for implementation of model COPERT 4 have been provided by Romanian Auto Register. RAR is the technical body appointed by the Ministry of Transport as the competent authority in the field of road vehicles, road safety and environmental protection. Individual approval is a legal requirement for vehicle registration and the procedure where by RAR shows that a vehicle meets individual constructive conditions and technical state under the regulations. Successful completion of individual approval procedure is materialized by issuing Identity Card Vehicle (CIV) that are registered on the technical data and vehicle identification. Database on registered fleet, detailed technical categories is thus achieved. Data on fleet in circulation is provided by General Directorate for Driving Licenses and Registrations (GDDLR) data compiled and processed by registered fleet RAR (see Annex V.2).

3.2.7.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.7.3.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are:

Table 3.13 Uncertainties for road transport

Road Transport 1.A.3.b.	Uncertainty				Combined uncertainty		
	AD	EF CO_2	EF N_2O	EF CH_4	EF CO_2	EF N_2O	EF CH_4
Motor Gasoline	3	5	108	48	0.0583	1.0804	0.4809
Gas Diesel Oil	3	4	50	50	0.0500	0.5009	0.5009
Liquefied Petroleum Gases (LPG)	3	4	50	50	0.0500	0.5009	0.5009
Other Liquid Fuels (Other Kerosene)	3	4	50	50	0.0500	0.5009	0.5009
Gaseous Fuels	3	4	50	50	0.0500	0.5009	0.5009
Biomass	3	20	50	50	0.2022	0.5009	0.5009

Combined uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

3.2.7.3.5 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Industrial Processes and Product Use Sector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020, 2023 and 2025, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

For the calculation of the emissions from CRT category 1.A.3.b, it was developed an Excel spreadsheet model, which was linked directly to the Eurostat format energy balances provided by the NIS. Wherever it was possible, automated data validation was implemented within the model, but many manual checks were performed, too.

Furthermore the background data for the emission factors calculations under the ETS, were used for further QA/QC checks.

The methods used for estimation of the emissions are in accordance with the IPCC regulations on the entire-time series.

3.2.7.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were performed.

3.2.7.3.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

The planned improvemnets comprise:

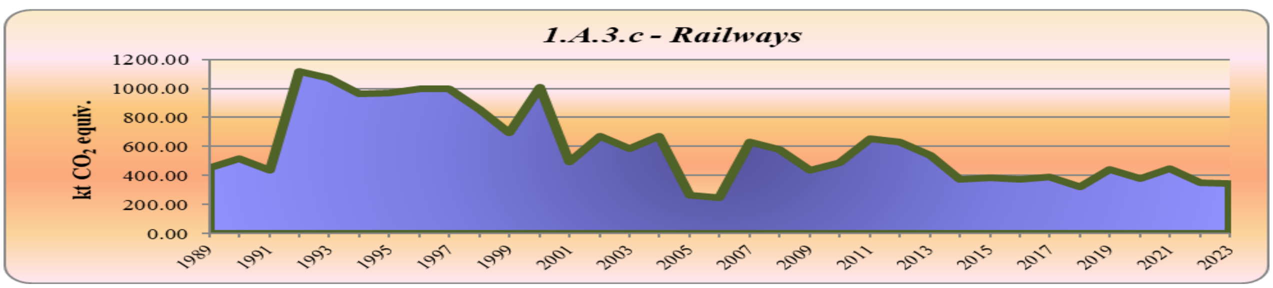
- further analyzing the issue of estimating CO_2 emissions from fossil carbon in biofuels separately, with the aim to update the approach used, as needed, as part of the next inventory submissions;
- further analyzing the approach used to characterize the emissions from lubricants combusted in two–stroke engines in road vehicles, aiming to report them under the Road transportation Subsector.

3.2.7.4 Railways (CRT 1.A.3.c)

3.2.7.4.1 Category description

The Railways category includes emissions from following fuels: Diesel Oil, Gasoline, Residual Fuel Oil, Lignite – Brown coal, Sub–bitouminous Coal, Other bitouminous Coal, Coking Coal, Other Kerosene. In the 2023 year the emissions from Railways category represents 1.56% of total emissions from the Transport sector (22,124.76kt CO_2 equiv.). In Railways category, the emissions trend reflects the changes in this period characterized by a process of transition to a market economy. In the time period, increases and decreases of emissions are due to fluctuations of fuel consumption and number of domestic trips. In 2005 a decrease of the fuels consumption took place due to the decline of the economic and industrial activities. Starting with 2007 year until 2011 year the emissions increased due to the fuel consumption growth; for the 2012–2018 time period, the trend of fuel consumption was decreasing. Starting with 2019, an oscilated trend has been observed, due to increasing and decreasing of the fuel consumption and domestic trips number. In 2023 year, fuel consumption decreased by 0.89% compared to 2022.

Figure 3.41 GHG emissions Trend from Railways category for 1989–2023 time period



3.2.7.4.2 Methodological issues

Methodology

The GHG emissions from Railways category are calculated according to the 2006 IPCC and IPCC GPG 2000. The activity data are provided by IEA/Eurostat Questionnaire and values for emissions factors used are provided by the 2006 IPCC Guidelines.

Tier 1 method

The direct GHG emissions are calculated according to the 2006 IPCC and calculation formula is presented in vol. 2, Section 3.4.1.1. The indirect GHG emissions are calculated according to the 1996

IPCC and EMEP/EEA Air Pollutant Emission Inventory Guidebook – 2019.

Tier 2 method

The CO_2 emissions, are estimated using country–specific and fuel–specific emission factors. The IPCC Tier 2 approach is used to calculate the CO_2 emissions from fuel combustion in the sectors and are calculated according to the 2006 IPCC Guidelines vol. 2 (page 3.41, section 3.4.1.1).

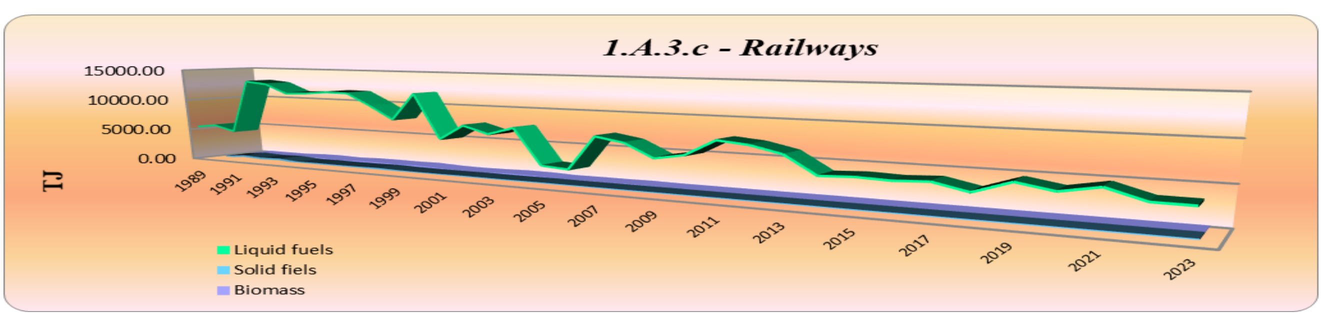
Emission factors

The values of CO_2 Emissions Factor is *country specific*. The values of CH_4 and N_2O emission factors are *default*, according to the 2006 IPCC Guidelines. In the development of estimates, there were primarily utilized default EFs, obtained from the 2006 IPCC Guidelines. To achieve the estimations of the CO_2 emissions on the national circumstances, a study, "Elaboration/documentation of national emission factors/other parameters relevant to National Greenhouse Gas Inventory (NGHGI) Sectors Energy, Industrial Processes, Agriculture and Waste, values to allow for the higher tier calculation methods implementation", has determined the national emission factors based on EU–ETS operators reporting on the of 2007–2010 time period. For the time period 2007–2022 the estimations for the CO_2 emissions were determined using the national emission factors, these values being achieved by using the methodology provided through the same study. For the 2007–2022 time period the country specific emission factors determined from the EU–ETS operator reports, were used. The country specific emission factors and country specific net caloric values are obtained through procedures of calculation described above (detailed in the 3.2.4.2. Stationary Combustion section) and are used at the national level for all fuels associated to the estimation of the CO_2 emissions from the Energy sector (including the Transport subsector). The obtained emission factors are considered to be relevant, as they refer to the same fuel in the context of estimating the CO_2 emissions.

Activity data

The activity data for Railways category are provided by IEA/Eurostat Questionnaire.

Figure 3.42 Contribution of fuel consumption from Railways category



The solid fuels were used in small quantities until 2004, after which were used liquid fuels and electricity.

3.2.7.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.7.4.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

CO_2

❖ ***activity data:***

- Liquid: 5 %
- Solid: 3 %
- Gaseous: 3 %
- Biomass: 2%

❖ ***emision factors:***

- Liquid: 3 %
- Solid: 2 %
- Gaseous: 1%
- Biomass: 20%
- 5.83 % liquid and 3.60 % solid and 20.21% for biomass associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

CH_4

❖ ***activity data:***

- Liquid: 5 %
- Solid: 3 %
- Gaseous: 3%
- Biomass: 3 %

❖ ***emision factors:***

- Liquid: 50 %

- Solid: 50 %
- Gaseous: 50%
- Biomass: 50 %
- 50.25 % for liquid, 50.09 % for solid and biomass associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

N_2O

❖ ***activity data:***

- Liquid: 5 %
- Solid: 3 %
- Gaseous: 3%
- Biomass: 3 %

❖ ***emision factors:***

- Liquid: 50 %
- Solid: 50 %
- Gaseous: 50%
- Biomass: 50 %
- 50.25 % for liquid, 50.09 % for solid and biomass associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

3.2.7.4.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union

GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020, 2023 and 2024, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs. The activity data series were also compared to those on Eurostat, the data being reported at the same level of aggregation and the figures comparable; additionally, national emission factors values were compared with national emission factors values specific to Bulgaria, considering that similar energy activities are implemented. Further elements are presented within Annex V.11.

3.2.7.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the emissions estimates quality some important recalculations were made:

- ***activity data:*** Recalculations have been made for the 1989–2022 period due to the apdated values of consumptions.
- ***net calorific value:*** For 1989–2022 period, NCVs have been updated based on the data provided by the economic operators.
- ***emissions* factors:** Recalculations have been made for 1989–2013 period, because the country specific

emissions factors for CO_2 have been updated.

❖ **emissions**: Recalculations have been made due to the updates of Activity Data, Net Calorific Values and National Emission Factors.

Table 3.14 The impact of recalculations on GHG emission estimates in the Railways category (CRT 1.A.3.c)

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	5,564.07	5,564.69	0.01	409.44	409.49	0.01	0.02	0.02	0.01	0.16	0.16	0.00
1990	6,327.61	6,327.61	0.00	473.14	473.14	0.00	0.03	0.03	0.00	0.17	0.17	0.00
1995	12,134.22	12,126.95	-0.06	879.42	878.67	-0.09	0.06	0.06	-0.03	0.34	0.34	0.00
2000	12,473.41	12,473.41	0.00	917.54	917.54	0.00	0.05	0.05	0.00	0.35	0.35	0.00
2005	3,332.67	3,332.67	0.00	243.52	243.52	0.00	0.01	0.01	0.00	0.09	0.09	0.00
2010	6,032.34	6,033.77	0.02	442.08	442.19	0.02	0.03	0.03	0.02	0.17	0.17	0.00
2015	4,765.62	4,769.83	0.09	349.20	349.50	0.09	0.02	0.02	0.06	0.13	0.13	0.00
2016	4,634.29	4,638.82	0.10	339.29	339.62	0.10	0.02	0.02	0.07	0.13	0.13	0.00
2017	4,837.28	4,837.28	0.00	354.30	354.30	0.00	0.02	0.02	0.00	0.14	0.14	0.00
2018	3,954.05	3,956.69	0.07	289.76	289.95	0.07	0.02	0.02	0.05	0.11	0.11	0.00
2019	5,431.39	5,434.13	0.05	398.11	398.31	0.05	0.02	0.02	0.04	0.15	0.15	0.00
2020	4,714.13	4,718.61	0.10	345.49	345.81	0.09	0.02	0.02	0.07	0.13	0.13	0.00
2021	5,516.92	5,523.13	0.11	404.37	404.82	0.11	0.02	0.02	0.08	0.16	0.16	0.00
2022	4,303.74	4,307.99	0.10	315.40	315.70	0.10	0.02	0.02	0.07	0.12	0.12	0.00

3.2.7.4.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

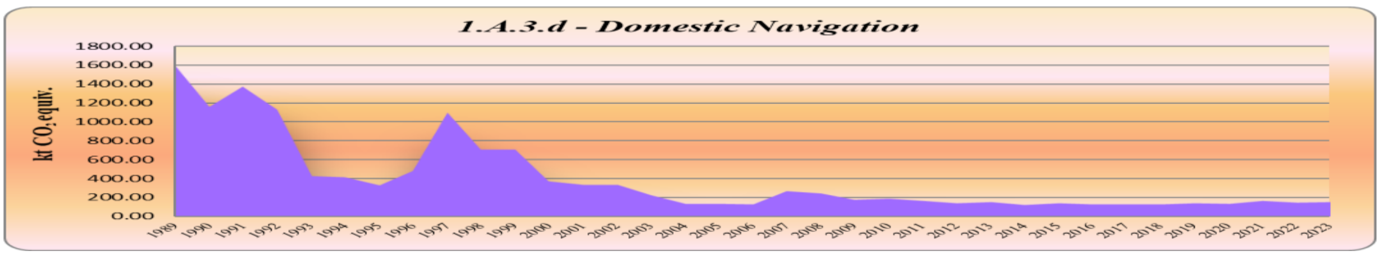
3.2.7.5 Domestic Navigation(CRT 1.A.3.d)

3.2.7.5.1 Category description

The Navigation sub-sector includes emissions from following fuels: Diesel Oil, Gasoline, Residual Fuel Oil, Other Liquid Fuels (LPG, Heating and other gasoil). In the current submission, the emissions from Domestic

Navigation category associated to 2023 year represents 0.68 % from total emissions accounted by Transport sector (22,124.76 kt CO_2 equiv.). In the Domestic Navigation category, the impact of economic and industrial activities and number of maritime races affects the level of GHG emissions and fuel consumption. GHGs emissions from Domestic Navigation subcategory are insignificant, their values meeting both criteria defined in the IPCC (<0.05% and <500 kt CO_2 eq).

Figure 3.43 GHG emissions trend from Domestic Navigation category for 1989–2023 period



3.2.7.5.2 Methodological issues

The GHG emissions from Domestic Navigation category are calculated according to the IPCC 2006 methodology also by Tier 1 and Tier 2, depending on data and information used for estimation of emissions, by gas and by type of fuel. The Tier1 and Tier 2 methods used are presented in section 3.2.7.4.2 of the NID.

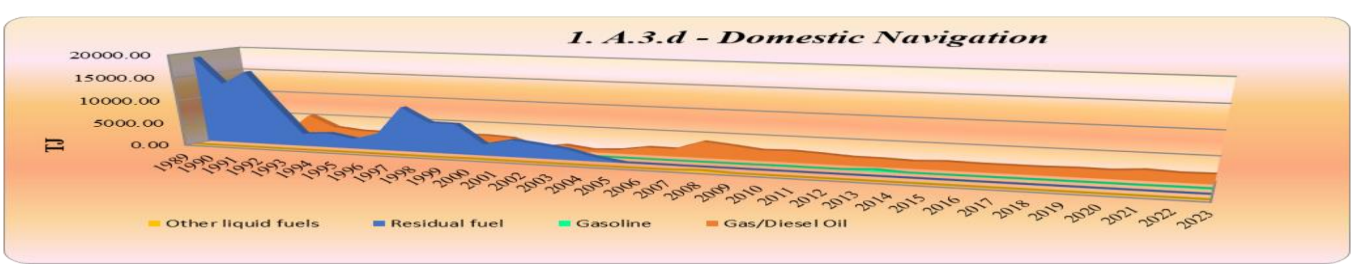
Emission Factors

The values of CO_2 Emissions Factor are country specific for all the fuels used, excepting the LPG for which was used the default EF from IPCC 2006. The values of CH_4 and N_2O emission factors are default according to the 2006 IPCC Guidelines.

Activity Data

The activity data for Domestic Navigation category are provided by IEA/Eurostat Questionnaire.

Figure 3.44 Contribution of fuels consumption from Domestic Navigation category for 1989–2023 period



3.2.7.5.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.7.5.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

CO_2

❖ ***activity data:***

- Residual Fuel Oil: 5 %
- Diesel oil: 5 %
- Gasoline: 3 %

❖ ***emision factors:***

- Residual Fuel Oil: 3 %
- Diesel oil: 3 %
- Gasoline: 1 %
- 5.83 % residual fuel oil and diesel oil and 3.10 % gasoline associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

CH_4

❖ ***activity data:***

- Residual Fuel Oil: 5 %
- Diesel oil: 5 %
- Gasoline: 3 %
- Biomass: 3 %

❖ ***emision factors:***

- Residual Fuel Oil: 50 %
- Diesel oil: 50 %
- Gasoline: 50 %
- Biomass: 50 %
- 50.25 % for residual fuel oil and gas/diesel oil, 50.09 % for gasoline and biomass, associated with the

overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

N_2O

- ***activity data:***
- Residual Fuel Oil: 5 %
- Diesel oil: 5 %
- Gasoline: 3 %
- Biomass: 3 %
- ***emision factors:***
- Residual Fuel Oil: 50 %
- Diesel oil: 50 %
- Gasoline: 50 %
- Biomass: 50 %
- 50.25 % for residual fuel oil and gas/diesel oil, 50.09 % for gasoline and biomass, associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

The values were collected/ elaborated/ selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency-University of Graz consortium; additional information are included in Annex V.10.

3.2.7.5.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach, the results of these activities being mentioned at the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament

and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020, 2023 and 2024, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs. The activity data series were also compared to those on Eurostat, the data being reported at the same level of aggregation and the figures comparable; additionally, national emission factors values were compared witht national emission factors values specific to Bulgaria, considering that similar energy activities are implemented. Further elements are presented within Annex V.11.

3.2.7.5.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the quality of emissions estimates were made the following specific recalculations:

- ***Emissions factors***: For 1989 year, because the country specific emissions factors for CO_2 have been updated.
- ***Emissions***: Recalculations of the CO_2, CH_4 and N_2O emissions have been made due to updates of the Activity Data, Net Calorific Values and National Emission Factors.
- **Net calorific value**:
  - For 1989 year, NCVs have been updated based on the data provided by the economic operators.

The impact of recalculations made on emission estimates are described in the Tables below:

Table 3.15 The impact of recalculations on GHG emission estimates in the Domestic Navigation category (CRT 1.A.3.d)

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]	Effects of changes on emission estimates for N_2O [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	20,309.27	20,306.72	-0.01	1,580.69	1,578.68	-0.13	0.14	0.14	-0.01	0.04	0.04	-0.01
1990	14,719.94	14,719.94	0.00	1,143.39	1,142.12	-0.11	0.10	0.10	0.00	0.03	0.03	0.00
1995	4,299.69	4,299.69	0.00	326.36	326.15	-0.06	0.03	0.03	0.00	0.01	0.01	0.00
2000	4,808.90	4,808.90	0.00	365.15	364.91	-0.06	0.03	0.03	0.00	0.01	0.01	0.00
2005	1,738.79	1,738.79	0.00	128.15	128.14	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2010	2,496.66	2,496.66	0.00	182.89	182.89	0.00	0.02	0.02	0.00	0.00	0.00	0.00
2015	1,830.95	1,830.95	0.00	134.24	134.24	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2016	1,712.86	1,712.86	0.00	125.57	125.57	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2017	1,715.07	1,715.07	0.00	125.72	125.72	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2018	1,725.59	1,725.59	0.00	126.47	126.47	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2019	1,862.40	1,862.40	0.00	136.50	136.50	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2020	1,786.89	1,786.89	0.00	130.96	130.96	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2021	2,188.29	2,188.29	0.00	160.41	160.41	0.00	0.02	0.02	0.00	0.00	0.00	0.00
2022	1,960.33	1,960.33	0.00	143.62	143.62	0.00	0.01	0.01	0.00	0.00	0.00	0.00

3.2.7.5.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

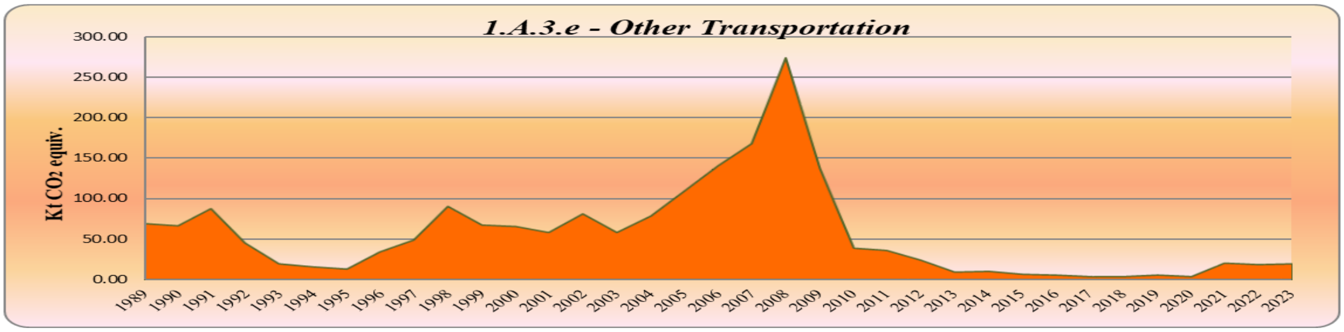
No improvements are planned for the next submission.

3.2.7.6 Other transportation- (CRT 1.A.3.e)

3.2.7.6.1 Category description

This category includes Pipeline Transport (1A.3.e.i) and Other (1.A.3.e.ii). This category includes combustion emissions from all remaining transport activities including pipeline transportation (the operation of pump stations and maintenance of pipelines), ground activities in airports (off – road activities). In the 2023 year the emissions from Other Transportation category represents 0.09% of total emissions from the Transport sector (22,124.76 kt CO_2 equivalent).

Figure 3.45 The GHG emissions from Other Transportation category for 1989–2023 period



3.2.7.6.2 Methodological issues

The GHG emissions from the Other Transportation category are calculated according to the 2006 IPCC Guidelines and the 2000 IPCC GPG. The Tier 1 and Tier 2 methods were used and are presented in the section 3.2.7.4.2.

Emission Factors

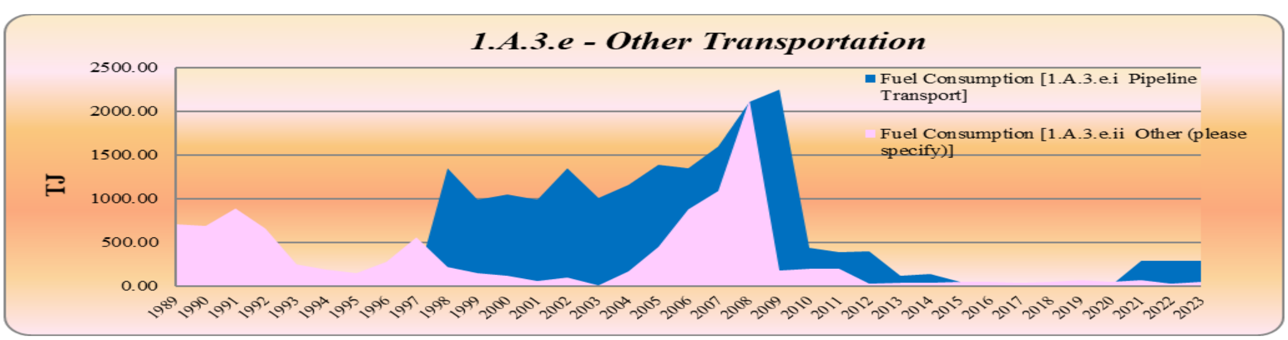
The CO_2 emission factor is country specific and is presented in section 3.2.7.4.2.

The values of CH_4, N_2O and NOx emission factors are default according to the 2006 IPCC Guidelines. The values of CO, NMVOC, SO_2 emission factors are default according to the 2006 IPCC Guidelines, the 1996 IPCC Guidelines and EMEP/EEA Air Pollutant Emission Inventory Guidebook - 2019.

Activity Data

The activity data for Other Transportation category are provided by IEA/Eurostat Questionnaire.

Figure 3.46 Contribution of fuel consumption from Other Transportation category for 1989–2023 period



3.2.7.6.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.7.6.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

CO_2

- ***activity data:***
  - Liquid: 3 %
  - Solid: 3 %
  - Gaseous: 3 %
  - Biomass: 3 %
- ***emision factors:***
  - Liquid: 3 %
  - Solid: 4 %
  - Gaseous: 2 %
  - Biomass: 20 %
  - 4.24 % liquid, 5 % solid, 3.61 % gaseous and 20.22 % biomass associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

CH_4

- ***activity data:***
  - Liquid: 3 %
  - Solid: 3 %
  - Gaseous: 3 %
  - Biomass: 3 %
- ***emision factors:***
  - Liquid: 50 %
  - Solid: 50 %
  - Gaseous: 50 %

- Biomass: 50 %
- 50.09 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

N_2O

- ***activity data*:**
  - Liquid: 3 %
  - Solid: 3 %
  - Gaseous: 3 %
  - Biomass: 3 %
- ***emision factors:***
  - Liquid: 50 %
  - Solid: 50 %
  - Gaseous: 50 %
  - Biomass: 50 %
  - 50.09 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

3.2.7.6.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament

and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs. The activity data series were also compared to those on Eurostat, the data being reported at the same level of aggregation and the figures comparable; additionally, national emission factors values were compared with national emission factors values specific to Bulgaria, considering that similar energy activities are implemented. Further elements are presented within Annex V.11.

3.2.7.6.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the emissions estimates quality, some important recalculations were made:

❖ ***Emissions:***

- Recalculations of the CO_2 emissions for the 1992 – 2022 period have been made due to updates of the National Emission Factors.

Table 3.16 The impact of recalculations on GHG emission estimates in the Other Transportation category (CRT 1.A.3.e)

Year	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]
	NIR 2024	NIR 2025	
1992	67.5078	67.5078	-0.10
1993	65.3956	65.3956	-0.09
1994	86.1550	86.1550	-0.09
1995	44.3666	44.3202	-0.10
1996	19.0384	19.0215	-0.05
1997	15.8461	15.8326	-0.02
1998	13.0787	13.0660	-0.16
1999	33.9833	33.9672	-0.15
2000	48.1060	48.0959	-0.19
2001	90.0903	89.9435	-0.18
2002	67.1679	67.0689	-0.18
2003	65.2339	65.1111	-0.17
2004	58.3297	58.2223	-0.14
2005	81.3343	81.1872	-0.14
2006	58.2091	58.1080	-0.10
2007	77.8979	77.7851	-0.13
2008	109.3474	109.1946	-0.11
2009	138.3726	138.2300	-0.20
2010	165.6618	165.4544	0.00
2011	269.9519	269.6427	-0.01
2012	136.9331	136.6529	0.00
2013	38.1166	38.1167	-0.02
2014	35.6908	35.6882	-0.02
2015	24.1318	24.1310	-0.01
2016	9.3828	9.3811	-0.01
2017	10.3394	10.3369	-0.002
2018	5.8611	5.8606	-0.002
2019	5.6964	5.6961	-0.001
2020	3.1416	3.1415	-0.005
2021	3.8269	3.8268	-0.02
2022	5.2043	5.2042	-0.03
2023		19.1013	

3.2.7.6.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No source–specific planned improvements are envisaged.

3.2.8 Fuel combustion, Other Sectors (CRT 1.A.4)

3.2.8.1 Category description

CRT category 1.A.4. Other sectors, as result of T1 approach is a CO_2 key category by liquid and gaseous fuel – level and trend, excluding and including LULUCF, CO_2 key category by solid fuel – trend, excluding LULUCF and is a CH_4 key category by biomass – level and trend, excluding and including LULUCF. The fuel consumption in the following subcategories is included in this category:

- ❖ Commercial/Institutional;
- ❖ Residential;
- ❖ Agriculture/Forestry/Fisheries.

The commercial/institutional category includes fuel consumptions declared by the economic agents in various activities, including: commerce, financial activities, banking and insurance, hotels and restaurants, real-estate transactions, rentals and services, public administration and defense, education, health and social assistance, other collective, social and personal services. The residential category includes the quantities: the deliveries for open flame consumption for heating and cooking purposes, including energy consumption for residential space by the owners and the administration of the economic agents; the deliveries to population to produce heat and hot water in central heating and quantities of coal received by the miners as direct allowances (payment) from the mining companies; the heat delivered to the population for heating and hot water, both from the public and from auto producer sectors. The agriculture/forestry/fishing category includes consumptions recorded in the following activity fields: agriculture, forestry, logging, hunting, fishing, and fuel consumption of the fishing ships. The share to the total of GHG emissions 1A – Fuel Combustion, for CRT category 1.A.4 Other is 8.62% in the base year and 19.34% for the year 2023 (about 12,061.98 kt CO_2 equiv.).

Figure 3.47 GHG emissions from 1.A.4 – Other, by category

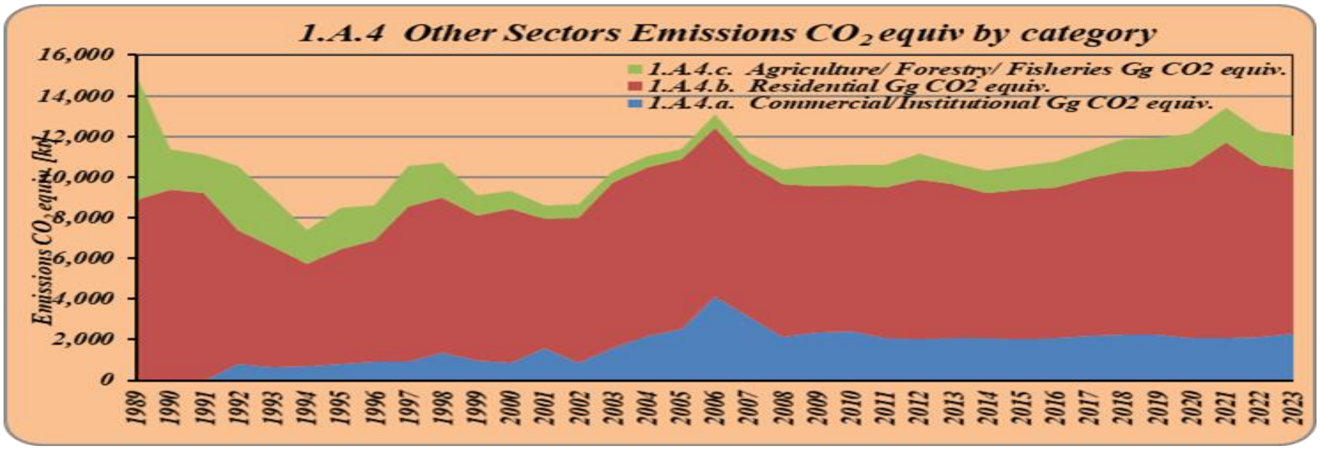
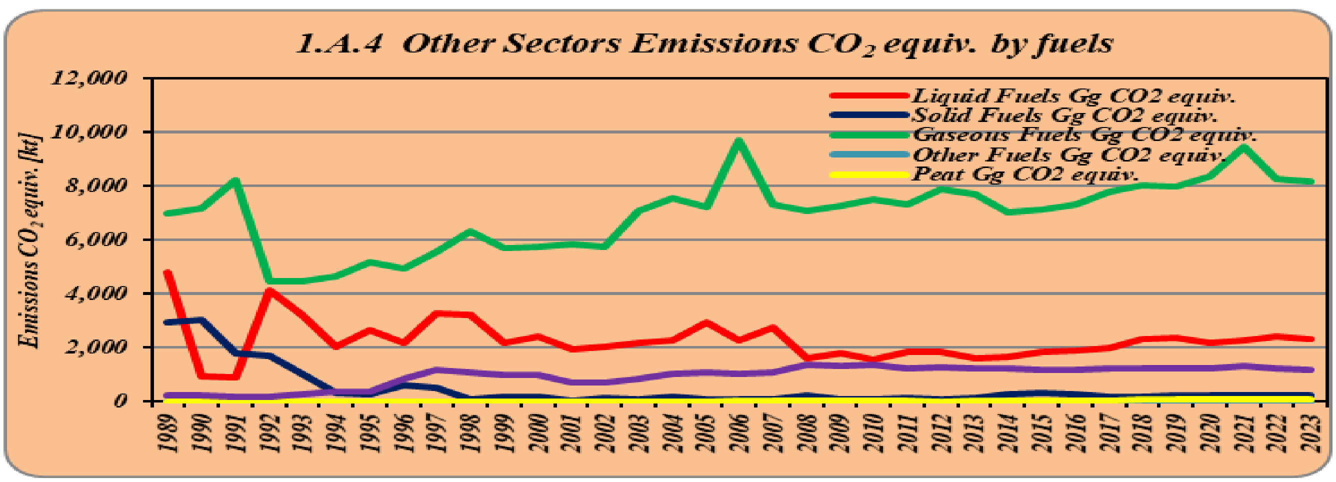


Figure 3.48 GHG emissions from 1.A.4 – Other, by fuels

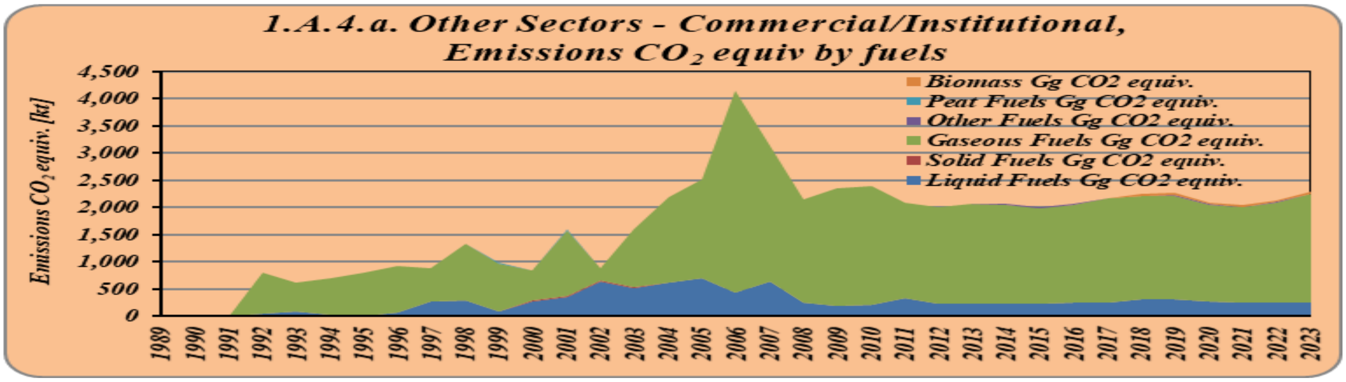


3.2.8.2 Fuel combustion, Other Sectors – Commercial/Institutional (CRT 1.A.4.a)

3.2.8.2.1 Category description

The reporting of combustion on this category started with the 1992 year. The share of the total GHG emissions from the 1.A.4.a category to the 1.A.4 sub-sector is about 18.97%, current year, 2023. The contribution of this category is about 2,288.47 kt CO_2 equiv., in 2023. It is observed a main contribution of the natural gas usage as fuel in this activity category, mostly on the period 2003–2023. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.49 GHG emissions from 1.A.4.a – Commercial/ Institutional, by fuels



3.2.8.2.2 Methodological issues

Since the resources for solid fuels in the Romanian economy are mainly from the internal exploitations, the weighted arithmetic averages for the emission factors calculated based on all the EU–ETS activities reporting, are used in the 1.A.4 – Other Sectors. For the liquid and gaseous fuels, being a mix between import and exports supply, result the same quality of this kind of fuels in the entire economy. Based on the recommendation of the ISPE Study, have been used the weighted arithmetic averages for the Emission Factors calculated based on the all the EU–ETS activities reporting. Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU–ETS, are used. For the fuels reported in this activity category having determined Country Specific Emission Factors on EU–ETS reporting, Tier 2 methodology is used. The activity data are provided through the Romanian Energy Balance, sent by NIS to IEA/EUROSTAT. The NCVs used are those provided in correspondence with this activity in the Energy Balance, and for the concerned fuels, the national weighted averages values derived from the EU–ETS reports, are used. See the Chapter 3.2.4.2 for more details.

3.2.8.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.8.2.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period.

See the Chapter 3.2.4.3 for more details.

3.2.8.2.5 Category–specific QA/QC and verification, if applicable

A cross-checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.8.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.8.2.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

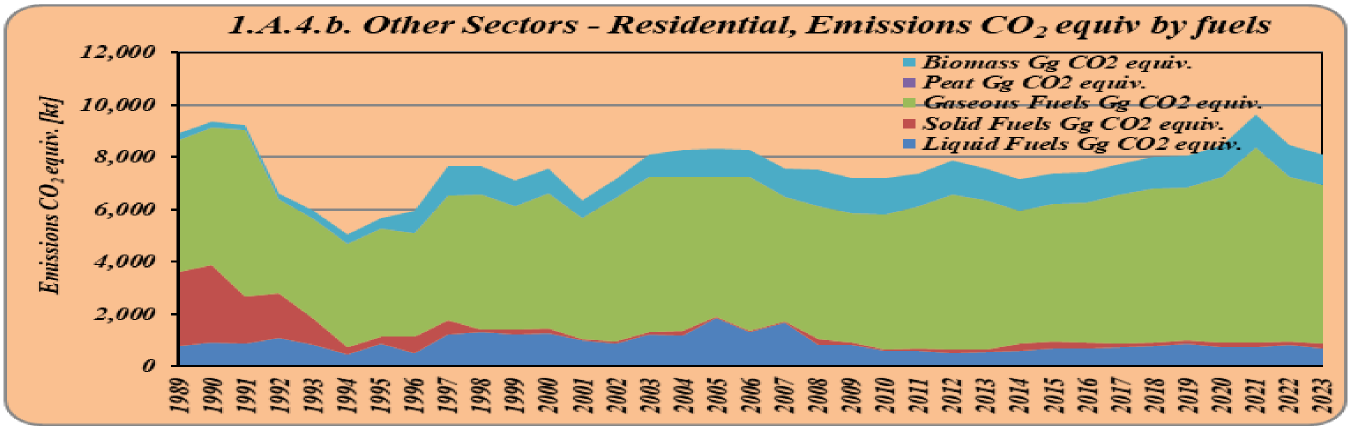
We have done an analysis and we have not identified other ways to improve the quality of the estimates of emissions. In accordance with the 2006 IPCC methodology, we are using the Tier 2 approach in estimation of CO_2 emissions.

3.2.8.3 Fuel combustion, Other Sectors – Residential (CRT 1.A.4.b)

3.2.8.3.1 Category description

The share of the total GHG emissions of the 1.A.4.b category to the 1.A.4 sub–sector is about 59.46% – base year to the 67.18%, current year, 2023. The contribution of this category is about 8,103.55 kt CO_2 equiv., in 2023. It is observed a main contribution of the natural gas usage as fuel in this activity category, on the entire time-series. Also, the biomass has a significant ascendant contribution to the emissions. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.).

Figure 3.50 GHG emissions from 1.A.4.b – Residential, by fuels



3.2.8.3.2 Methodological issues

Tier 1 Methodology and default emission factors for the fuels without analyze on EU–ETS reporting are used. For the fuels reported in this activity category having determined Country Specific Emission Factors on EU–ETS analyze, Tier 2 methodology is used. he activity data are provided on Romanian Energy Balance sent by NIS to IEA/ EUROSTAT. The NCVs used are those provided in correspondence with this activity in the Energy Balance, and for the concerned fuels, the national weighted averages values derived from the EU–ETS reports, are used. See the chapter 3.2.4.2 for more details.

3.2.8.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.8.3.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period. See the chapter 3.2.4.3 for more details.

3.2.8.3.5 Category–specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were

implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.8.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.8.3.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

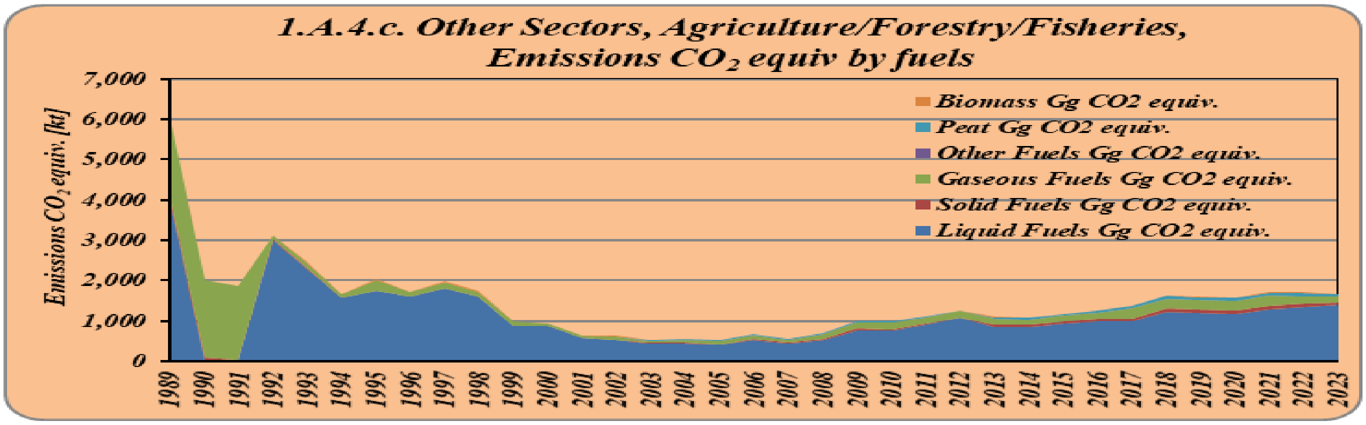
We have done an analysis and we have not identified other ways to improve the quality of the estimates of emissions. In accordance with the 2006 IPCC methodology, we are using the Tier 2 approach in estimation of CO_2 emissions.

3.2.8.4 Fuel combustion, Other Sectors – Agriculture/ Forestry/ Fisheries (CRT 1.A.4.c)

3.2.8.4.1 Category description

The information provided by the National Institute for Statistics related to the agriculture category was that no available collected data exist to report stationary data separated from mobile. Also, the consumption data, associated to the fishing activity will be reported starting with the reference year 2013 – this is the first year for which the number of the reporting units is representative for the fishing activity. Data or estimation methodology are not available for the previous years. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.). The share of the total GHG emissions of the 1.A.4.c category to the 1.A.4 sub-sector is about 40.54% – base year to the 13.84%, current year, 2023. The contribution of this category is about 1,669.96 kt CO_2 equiv., in 2023. It is observed a main contribution of the liquid fuel combustion in this activity category, on the entire time–series.

Figure 3.51 GHG emissions from 1.A.4.c – Agriculture/Forestry/Fisheries, by fuels



3.2.8.4.2 Methodological issues

Tier 1 Methodology and default emission factors for the fuels which are not reported under EU–ETS, are used. For the fuels reported in this activity category having determined Country Specific Emission Factors on EU–ETS analyze, Tier 2 methodology is used. The activity data are provided on Romanian Energy Balance sent by NIS to IEA/EUROSTAT. The NCVs used are those provided in correspondence with this activity in the Energy Balance, and for the concerned fuels, the national weighted averages values derived from the EU–ETS reports, are used. See the chapter 3.2.4.2 for more details.

3.2.8.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.8.4.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period. See the chapter 3.2.4.3 for more details.

3.2.8.4.5 Category–specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were

implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.8.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.8.4.7 Category–specific planned imporvments, if applicable, including tracking of those identified in the review process

We have done an analysis and we have not identified other ways to improve the quality of the estimates of emissions. In accordance with the 2006 IPCC methodology, we are using the Tier 2 approach in estimation of CO_2 emissions.

3.2.9 Fuel combustion, Other Sectors (Not specified elsewhere) – (CRT 1.A.5)

CRT category 1.A.5. Other sectors (Not specified elsewhere), as result of T1 approach is a CO_2 key category by liquid – level and trend, excluding and including LULUCF. The fuel consumption in the following subcategories is included in this category:

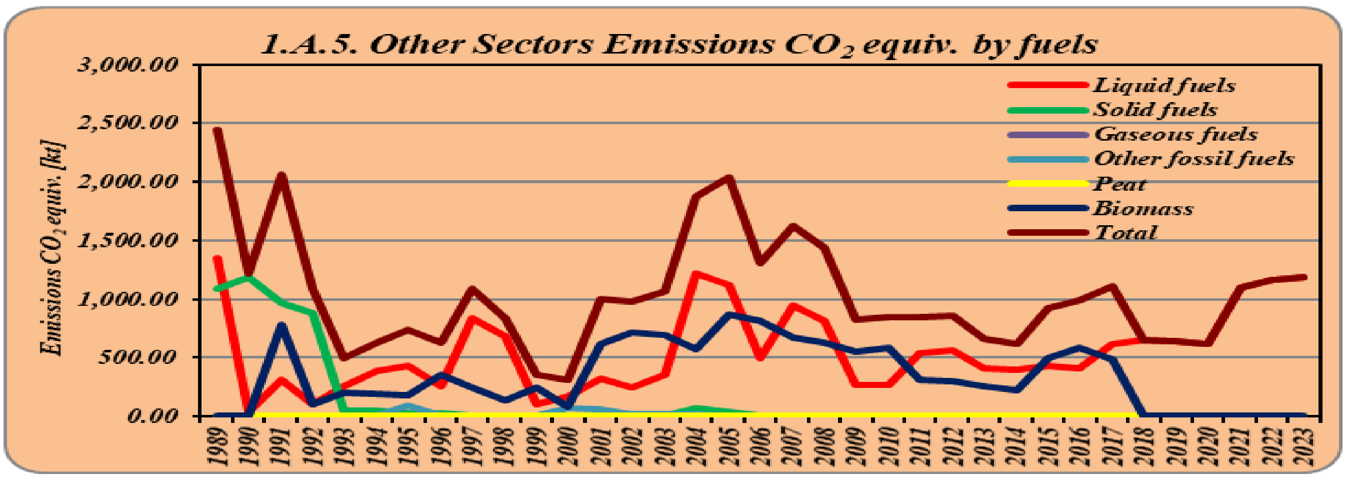
- Stationary;
- Mobile.

3.2.9.1 Other Sectors (Not specified elsewhere) – Stationary (CRT 1.A.5.a)

3.2.9.1.1 Category description

This category accounts the fuel consumption reported through the Energy Balances in the category "Other sectors – Not elsewhere specified (Other)", EUROSTAT/IEA/UNECE questionnaires format. According to the Energy Balances IEA Statistics manual, in the above Energy Balances category the military consumption shall be reported. The National Institute for Statistics clarified that the fuel consumptions reported by military and internal affaires institutions are collected and associated to the NACE Rev. 2 corresponding activities. This activity category analyzes the fuels burned in the stationary installations not specified to the above sub-sectors. Mainly are combusted liquid fuels and secondly some solid fuels. See more details about trends and key categories in the chapters 3.1 – Overview of the sector and 3.2.4 Source category – Fuel combustion (CRT sector 1.A.). The share of the total GHG emissions from the 1.A.5.a Stationary category to the 1.A.5 sub–sector is about 1.41% in the base year, 1989, and 1.90%, current year, 2023. The contribution of this category is about 1,187.08 kt CO_2 equiv., in 2023. It is observed a main contribution of the liquid usage as fuel in this activity category.

Figure 3.52 GHG emissions from 1.A.5 – Other Sectors, by fuels



3.2.9.1.2 Methodological issues

Since the resources for solid fuels in the Romanian economy are mainly from the internal exploitations, the weighted arithmetic averages for the emission factors calculated based on all the EU–ETS activities reporting, are used in the 1.A.5 – Other Sectors. For the liquid and gaseous fuels, being a mix between import and exports supply, result the same quality of this kind of fuels in the entire economy. Based on the recommendation of the ISPE Study, have been used the weighted arithmetic averages for the Emission Factors calculated based on the all the EU–ETS activities reporting. Tier 1 Methodology and Default emission factors for the fuels without analyze on EU–ETS reporting are used. For the fuels reported in this activity category having determined Country Specific Emission Factors on EU–ETS reporting, Tier 2 methodology is used. The activity data are provided on Romanian Energy Balance sent by NIS to IEA/EUROSTAT. The NCVs used are those provided in correspondence with this activity in the Energy

Balance, and for the concerned fuels, the national weighted averages values derived from the EU–ETS reports, are used. See the chapter 3.2.4.2 for more details.

3.2.9.1.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.2.9.1.4 Uncertainty assessment and time-series consistency

The activity data, EF and methodology used in estimating GHG emissions are consistent for the entire period. See the chapter 3.2.4.3 for more details.

3.2.9.1.5 Category–specific QA/QC and verification, if applicable

A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*. See the chapter 3.2.4.4 for more details.

3.2.9.1.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The recalculations were performed due to the activity data changes in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

3.2.9.1.7 Category–specific planned imporvments, if applicable, including tracking of those identified in the review process

We have done an analysis and we have not identified other ways to improve the quality of the estimates of emissions. In accordance with the 2006 IPCC methodology, we are using the Tier 2 approach in estimation of CO_2 emissions.

3.2.9.2 Other Sectors (Not specified elsewhere) – Mobile (CRT 1.A.5.b)

This activity category mostly is included in the 1.A.5.a Stationary reporting. For this category the notation key is IE – included elsewhere for the entire time series.

3.3 Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production (CRT 1.B)

3.3.1 Overview of the subsector

This chapter provides information on the estimation of the greenhouse gas emissions associated with the Fugitive Emissions from Fuels Subsector. The following direct GHG emissions and source categories are quantified and reported:

❖ CH_4 emissions from Solid Fuels;

❖ CH_4, CO_2 and N_2O emissions from Oil and Natural Gas.

In 2023 GHG emissions from the Fugitive Emissions from Fuels Subsector accounted for 8,855.98 kt CO_2 equivalent, which represent 8.53% of the total national GHG emissions in this year. In the base year, the total GHG emissions from the Fugitive Emissions from Fuels Subsector amounted to 46,876.46 kt CO_2 equivalent, which represent 15.14% of the total national GHG emissions in this year (see in the table below).

Table 3.17 The contribution of Fugitive Emissions from Fuels Subsector emissions to the total GHG in Romania, for 1989–2023 period

Year	Total GHG emissions (excl. LULUCF) [kt CO_2 equiv.]	GHG emissions from Fugitive Emissions [kt CO_2 equiv.]	Contribution of Fugitive Emissions in total GHG emissions [%]
1989	309,563.96	46,876.46	15.14
1990	256,636.86	34,189.60	13.32
1995	188,315.16	27,475.34	14.59
2000	141,841.50	17,986.32	12.68
2005	150,375.83	18,237.31	12.13
2007	154,891.56	15,751.95	10.17
2008	151,566.48	15,342.59	10.12
2009	130,229.60	13,947.80	10.71
2010	124,812.87	13,341.02	10.69
2011	132,250.56	12,932.54	9.78
2012	129,239.42	12,406.97	9.60

Year	Total GHG emissions (excl. LULUCF) [kt CO_2 equiv.]	GHG emissions from Fugitive Emissions [kt CO_2 equiv.]	Contribution of Fugitive Emissions in total GHG emissions [%]
2013	117,865.19	11,732.48	9.95
2014	118,110.56	11,305.60	9.57
2015	116,802.10	11,025.31	9.44
2016	114,839.10	10,531.03	9.17
2017	117,804.06	10,295.70	8.74
2018	118,545.09	10,102.26	8.52
2019	115,311.93	10,298.93	8.93
2020	111,521.22	9,613.64	8.62
2021	115,375.00	9,413.05	8.16
2022	109,667.26	9,175.95	8.37
2023	103,862.45	8,855.98	8.53

The GHG emissions from Oil and Natural Gas category, are responsible for 36.55% of total GHG emissions from Fugitive Emissions subsector, the Solid Fuels category contributes with 63.45%.

Figure 3.53 Total GHG emissions from Fugitive Emissions from Fuels Subsector for 1989–2023 period

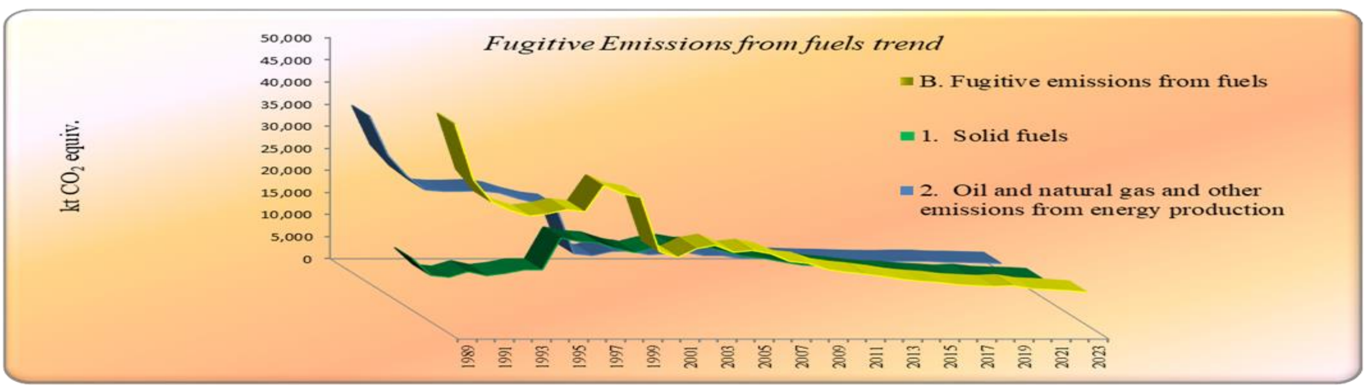


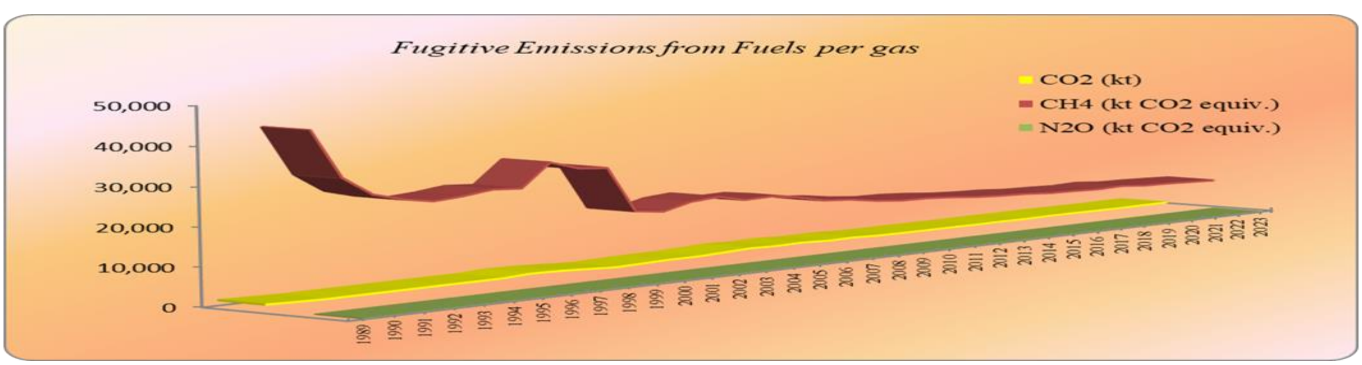
Table 3.18 The contribution, per gas, in total GHG emissions from Fugitive Emissions from Fuels Subsector, for the 1989–2023 period

Year	Total emissions from Fugitive Emissions from Fuels Subsector [kt CO_2 equiv.]	CO_2 emissions		CH_4 emissions		N_2O emissions	
		kt CO_2	%	kt CO_2 equiv.	%	kt CO_2 equiv.	%
1989	46,876.46	1,377.54	2.94	45,495.26	97.05	3.66	0.008
1990	34,189.60	1,176.62	3.44	33,009.87	96.55	3.11	0.009
1995	27,475.34	1,084.47	3.95	26,388.12	96.04	2.75	0.010
2000	17,986.32	953.98	5.30	17,031.07	94.69	1.26	0.007

Year	Total emissions from Fugitive Emissions from Fuels Subsector [kt CO_2 equiv.]	CO_2 emissions		CH_4 emissions		N_2O emissions	
		kt CO_2	%	kt CO_2 equiv.	%	kt CO_2 equiv.	%
2005	18,237.31	1,151.26	6.31	17,084.87	93.68	1.18	0.006
2007	15,751.95	1,260.40	8.00	14,490.54	91.99	1.01	0.006
2008	15,342.59	1,384.76	9.03	13,956.87	90.97	0.95	0.006
2009	13,947.80	1,076.90	7.72	12,870.00	92.27	0.90	0.006
2010	13,341.02	1,159.37	8.69	12,180.78	91.30	0.86	0.006
2011	12,932.54	879.83	6.80	12,051.85	93.19	0.86	0.007
2012	12,406.97	838.54	6.76	11,567.62	93.23	0.81	0.007
2013	11,732.48	840.73	7.17	10,890.93	92.83	0.83	0.007
2014	11,305.60	824.54	7.29	10,480.24	92.70	0.82	0.007
2015	11,025.31	784.92	7.12	10,239.58	92.87	0.81	0.007
2016	10,531.03	835.27	7.93	9,695.00	92.06	0.77	0.007
2017	10,295.70	776.17	7.54	9,518.79	92.45	0.74	0.007
2018	10,102.26	860.99	8.52	9,240.54	91.47	0.73	0.007
2019	10,298.93	862.14	8.37	9,436.07	91.62	0.73	0.007
2020	9,613.64	794.37	8.26	8,818.57	91.73	0.70	0.007
2021	9,413.05	753.03	8.00	8,659.34	91.99	0.68	0.007
2022	9,175.95	807.69	8.80	8,367.62	91.19	0.64	0.007
2023	8,855.98	795.92	8.99	8,059.45	91.01	0.61	0.007

The inventory preparation, including identification of key categories, preparation of uncertainty estimates and implementation of QA/QC procedures, have been performed according to IPCC 2006 Guidelines.

Figure 3.54 GHG emissions from Fugitive Emissions from Fuels Subsector, per gas



3.3.2 Solid Fuels (CRT 1.B.1)

3.3.2.1 Category description

The 1.B.1. – Solid Fuels are key category from both level and trend point of view (Tier 1, excluding and including LULUCF) for CH_4 emissions. The source category "Solid Fuels" consists of three sub–source categories:

- "Coal Mining and Handling" *(CRT 1.B.1.a*);
- "Solid Fuel Transformation" (*CRT 1.B.1.b*), and
- "Other" (*CRT 1.B.1.c*).

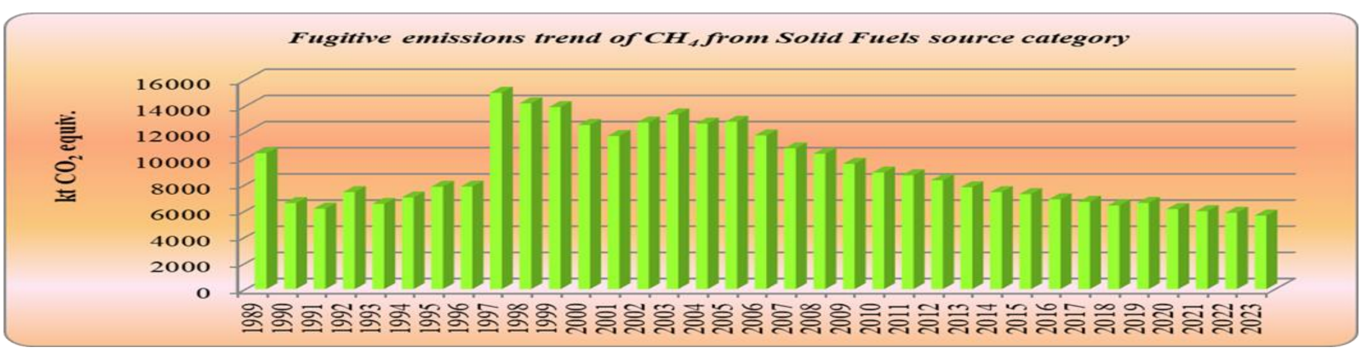
3.3.2.1.1 Coal mining and handling (CRT 1.B.1.a)

- Emission: CH_4;
- Key source: Yes.

This sub-source category includes all fugitive emissions from coal. Romania has superior coal (anthracite and coal) and lowers (brown coal and lignite). Besides these, there are peat coal and shale as well as coal in the form of coking coal used in power plants. After 1989 the extraction of coal was in a continuous process of restructuring in connection with the requirements of the electricity sector and thermal and other industries. Since 1998, started a process of conservation and closing of unprofitable mines and quarries. By the end of 2006 mining activities were carried out in 12 mines (7 for coal and 5 for lignite) and in 24 quarries (1 for lignite and 23 for coal). Closing inefficient mines, led to a situation where only about 30% of the total geological reserves of coal is also found in the activity. According to Domestic Energy Balance, in Romania only hard coal, lignite and brown coal are extracting. Activity data used to estimate 1.B.1 category related emissions were provided by NIS in the form Eurostat Questionnaire for 1989 and International Energy Agency (IEA)/Eurostat Questionnaire for every year in the 1990–2021 period. The emissions of methane are the most important in respect to the solid fuels fugitive emissions. The emissions trend reflects the changes in this period characterized by a process of transition to a market economy; the trend can be split in three parts: the period 1989–1999, the period 2000–2010 and the period 2011–2022. CH_4 emissions suddenly increase in 1997 as a result of the closure of a large number of mines (42), which led to an increase in CH_4 emissions from abandoned underground mines, then recording a decrease in these emissions until 2001. Emissions have started to increase starting with 2002, because of the economic revitalization. In 2006, a reduction of primary energy production was registered, except for lignite/brown coal, where it increased

(+19.7% compared to 2005). In the 2007–2010 period the emissions started to decrease again after the begining of global financial crisis which conducted to economic contraction. In 2017 there were increases of 104.9% of the coal production (excluding coke) and at the import of coke (+ 94.1%) compared to 2016. In 2020, primary energy production decreased compared to 2019, mainly due to the significant decrease in coal production by 34% compared to the previous year; also, thermoelectric energy production decreased by 10% compared to the previous year, due to the decrease of coal-based electricity production by 31.3%. In 2021, the share of coal consumption, in the total consumption for the production of thermoelectric energy, was 37.7%, increasing compared to 2020 when it was 34.3%. The production of primary energy in 2021 increased compared to 2020, against the background of the increase in the production of coal and electricity from renewable sourses. In 2022, the share of coal consumption, in the total consumption for the production of thermoelectric energy, was 36.1%, decreasing compared to 2021 when it was 37.7%. The production of primary energy in 2022 decreased compared to 2021, against the background of the decrease in the production of coal, electricity from renewable sourses and crude oil. In 2023, the share of coal consumption, in the total consumption for the production of thermoelectric energy was 30.8%, decreasing compared to 2022 when it was 36.1%. The production of primary energy in 2023 decreased compared to 2022, against the background of the decrease in the production of coal and crude oil (Source – Romanian National Institute for Statistics). The trend of the CH_4 emissions from Solid Fuels category is shown in the figure below:

Figure 3.55 Fugitive Emissions of CH_4 from Solid Fuels



3.3.2.2 Methodological issues

3.3.2.2.1 Coal mining and handling (CRT 1.B.1.a)

- ❖ Emission: CH_4;
- ❖ Key source: Yes.

Underground mines *(CRT 1.B.1.a.1.)*

- ❖ *Mining activities (CRT 1.B.1.a.1.i);*
- ❖ *Post mining activities (CRT 1.B.1.a.1.ii.)*
- ❖ *Abandoned Underground Mines (CRT 1.B.1.a.1.iii.).*

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors for the solid fuels reporting are used. The formula used in the calculations is *Equation 4.1.1* from 2006 IPCC GL, volume 2, chapter 4.1.3, page 4.9.

Activity Data

Consequence of the fact that values of the lignite production from surface mines (including the brown coal) for the period 1990–1999 are not available in the Eurostat/IEA data and, starting with 2000, in the IEA/Eurostat Questionnaire, lignite production it divided into underground and surface mines are led to and, that the values for 2000–2023 period are observed data, an estimation for the 1990–1999 period has been conducted. Based on activity data assumptions (including the closure of more underground and surface mines (quarries) in the period 1997–1999) it was considered that the ratio between the underground and the surface mines could be constant. Therefore, for the 1989–1999 historical period the ratio afferent of 2000 year, i.e. 74% lignite extracted from surface mines and 26% lignite extracted from underground mines, has been considered applicable. For the 1989–1999 period: *Lignite Underground Coal Production (Mt):* IEA/Eurostat Questionnaire 2023 – Indigenous Production (Lignite/Brown Coal – 26%). For the 2000–2023 period: *Lignite Undergound Coal Production (Mt):* IEA/Eurostat Questionnaire 2023 – Indigenous Production (Lignite/Brown Coal – 100%). The activity data include:

1989_BAL_Romania have been used for 1989 and IEA/ Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used.

- ❖ *Underground Coal Production (Mt):* IEA/Eurostat Questionnaire 2023 – Indigenous Production (Anthracite – 100%, Coking Coal – 100%, Other Bituminous Coal – 100%, Sub-bituminous Coal – 100%, Peat – 100%, Lignite/Brown Coal – 26% for 1989–1999 time series and Lignite/Brown Coal – 100% for 2000–2023 time series).

Emission factor

- ❖ *Default Emission Factor*: from 2006 IPCC GL, volume 2, chapter 4.1.3.2, page 4.12;
- ❖ *The default value of 18 m^3/t* (average CH_4 Emission Factor) according to the 2006 IPCC GL for "Mining Underground Coal Production" has been used.
- ❖ *The default value of 2.5 m^3/t* (average CH_4 Emission Factor) according to the 2006 IPCC GL for "Post Mining Underground Coal Production" has been used;

- *Conversion Factor*: this is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20°C and 1 atmosphere pressure and has a value of 0.67 Gg/10^6 m^3 (0.00000067 Gg/m^3).

Figure 3.56 Lignite – Brown Coal Production trend

Abandoned Underground Mines *(CRT 1.B.1.a.1.iii)*

The emissions from Abandoned Underground mines were estimated according to the Mining Industry Strategy data. The data used for estimation of emissions were provided by National Hard Coal Company (CNH Petrosani), lignite mines administrated by Oltenia National Lignite Society (S.N.L.O. Tg. Jiu) and coal mines administrated by National Coal Society (S.N.C. Ploiesti).

Methodology

Tier 2 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Parameters for the *Abandoned Underground Mines* reporting are used. The formula used in the calculations is *Equation 4.1.11* from the 2006 IPCC GL, volume 2, chapter 4.1.5.2., page 4.26 and *Equation 4.1.12* from the 2006 IPCC GL, volume 2, chapter 4.1.5.2, page 4.27.

Activity Data

Emissions from abandoned mines were approximated based on the data in table on page 15 of the Mining Industry Strategy 2012–2035: https://cupdf.com/document/strategia-industriei-miniere-pentru-perioada-2012.html?page=15. According with this table the data used to calculate emissions of abandoned mines are those associated with the activity of the CNH Petrosani, S.N.L.O. Tg. Jiu and S.N.C. Ploiesti companies. In respect to the CH_4 emissions in the underground abandoned mines, the calculation took into account all data and information provided by the national legislation referred to in the Mining Industry Strategy. Thus, a number of 171 underground mines were identified that closed/abandoned between 1935 and 2015. Most mines were closed, especially between 1997 and 1999. Activity data used to estimation of CH_4 emissions consist in the number of 171 underground mines closed/abandoned for 1901–2018 period. Because hard coal mining in Romania faces complex geological conditions, making profitable mining difficult, besides Petrila mine which has been closed in 2015, the Paroşeni and Uricani mines were closed in 2019, all these mines from National Society for Jiu Valley Closure Mine . The total number of closed underground mines reached 173. Of the seven underground mines on the Jiului Valley existing in Romania in 2013, there are still four mines of the National Coal Company (CNH Petroșani) that are still operating: Lonea, Lupeni, Livezeni and Vulcan.

Time Interval	Nr. closed/abandoned mines
1900-1925	NE
1926-1950	6
1950-1976	3
1976-2000	114
2001-Present	50

Emission factor

❖ *Default values – percentage of coal mines that are gassy* from the 2006 IPCC GL, volume 2, chapter 4.1.5.2, page 4.24, Table 4.1.5 have been used:

Time Interval	Low	High	average
1900-1925	0%	10%	5%
1926-1950	3%	50%	27%
1950-1976	5%	75%	40%
1976-2000	8%	100%	54%
2001-Present	9%	100%	55%

❖ *Average emissions rate for each time interval* from the 2006 IPCC GL, volume 2, chapter 4.1.5.2, page 4.26, Table 4.1.8 has been used:

Parameter	Emissions, million m^3/year
Low	1.3
High	38.8
average	20.05

❖ *Default Emission Factor*: for emissions factor according to *Equation 4.1.12* from the 2006 IPCC GL, volume 2, chapter 4.1.5.2, page 4.27, Table 4.1.9 has been used:

Coal Rank	a	b
Anthracite	1.72	-0.58
Bituminous	3.72	-0.42
Sub-bituminous	0.27	-1
Bituminous	3.72	-0.42

Methane for energy recovery from underground mines

According to the information supplied by the Ministry of Economy (MC), the National Coal Company and National Institute for Research and Development in Mine Safety (INSEMEX), there are provided values regarding the recovery of the methane in the mining activities. The recovered methane is reported in the Petrosani Mining Basin, the mines named Lupeni and Vulcan (see the Figure and the Table below).

Figure 3.57 Underground Mines category and Solid Fuel Transformation category emissions trend

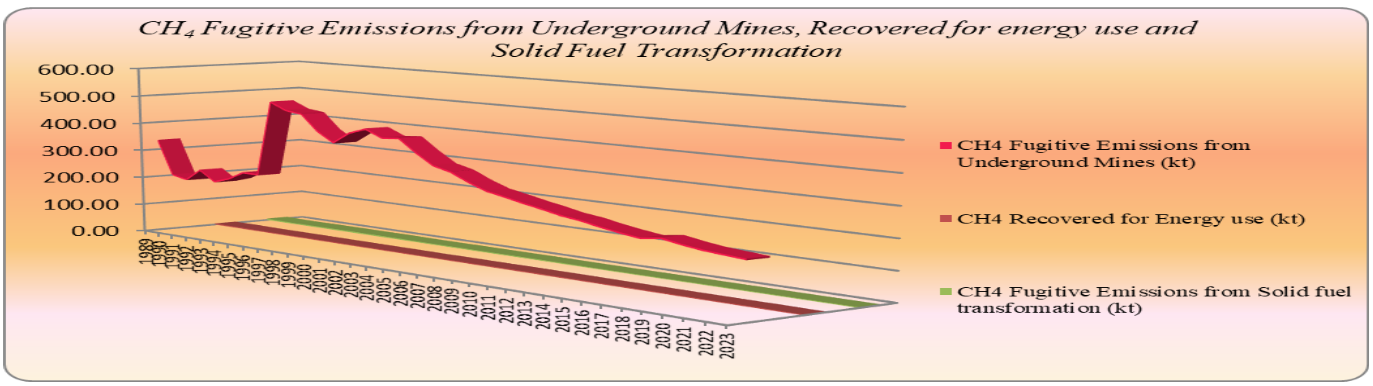


Table 3.19 Fugitive Emissions of CH_4 from Underground Mines and CH_4 Recovered for energy use

Year	**Underground mines**	
	CH_4 fugitive emissions (kt)	**CH_4 Recovered for energy use (kt)**
1989	334.03	1.36
1990	211.26	1.25
1995	251.98	0.58
2000	428.63	0.45
2005	433.48	0.59
2007	356.06	0.58

Year	Underground mines	
	CH_4 fugitive emissions (kt)	CH_4 Recovered for energy use (kt)
2008	341.47	0.91
2009	315.12	0.95
2010	293.65	1.02
2011	282.32	0.93
2012	269.57	0.76
2013	258.43	0.37
2014	245.84	0.49
2015	238.23	0.55
2016	226.06	0.51
2017	216.49	0.38
2018	208.19	0.46
2019	216.70	0.45
2020	205.76	0.41
2021	197.47	0.73
2022	192.63	0.32
2023	187.97	0.28

Surface mines (1.B.1.a.2)

❈ *Mining activities (1.B.1.a.2.i.);*

❈ *Post mining activities (1.B.1.a.2.ii).*

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors for the solid fuels reporting are used. The formula used in the calculations is *Equation 4.1.7*. from the 2006 IPCC GL, volume 2, chapter 4.1.4.2, page 4.18.

Activity Data

for the period 1990–1999 are not available in the Eurostat/IEA data and, starting with 2000, in the IEA/Eurostat Questionnaire, lignite production it divided into underground and surface mines are led to and, that the values for 2000–2023 period are observed data, an estimation for the 1990–1999 period has been conducted. Based on activity data assumptions (including the closure of more underground and surface mines – quarries – in the period 1997–1999) it was considered that the ratio between the underground and the surface mines could be constant. Therefore, for the 1989–1999 historical period the ratio afferent of 2000 year, i.e. 74% lignite extracted from surface mines and 26% lignite extracted from underground mines, has been considered applicable. For the 1989–1999 period: *Surface Coal Production (Mt):* IEA/Eurostat Questionnaire 2023 – Indigenous Production (Lignite/Brown Coal – 74%). For the 2000–2023 period: *Surface Coal Production (Mt):* IEA/Eurostat Questionnaire 2023 – Indigenous Production (Lignite/Brown Coal – 100%).

Emissions Factor

- *Default Emission Factor*: from the 2006 IPCC GL, volume 2, chapter 4.1.3.2, page 4.18;
- *The default value of 1.2 m^3/t* (average CH_4 Emission Factor) according to the 2006 IPCC GL for "Surface Coal Production" has been used;
- *The default value of 0.1 m^3/t* (average CH_4 Emission Factor) according to the 2006 IPCC GL for "Post mining Surface Coal Production" has been used;
- *Conversion Factor*: this is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20°C and 1 atmosphere pressure and has a value of 0.67 $Gg/10^6\ m^3$ (0.00000067 Gg/m^3).

3.3.2.2.2 Solid Fuel Transformation (CRT 1.B.1.b)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission.

Activity Data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used.

- *Coking Coal Production (Mt):* IEA/Eurostat Questionnaire 2023 – Transformation Sector (Coking Coal – 100 %).

Emission Factor

Emission Factors for the Solid Fuels transformation reporting are used.

- *The default value of 0.35 kg CH_4/t* according to EFDB of IPCC - Database on Greenhouse Gas Emission Factors of IPCC has been used.

3.3.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.3.2.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

❖ ***Coal Mining and Handling sub-source category*** *(CRT 1.B.1.a)*

- AD: 5 %;
- EF:
  - CO_2: 200 %;
  - CH_4: 200 %;
  - 200.06 % for CO_2 and 200.06 % for CH_4 associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

❖ ***Solid Fuel Transformation sub-source category*** *(CRT 1.B.1.b)*

- AD: 1 %;
- EF:
  - CO_2: 200 %;
  - CH_4: 200 %;
  - 200 % for CO_2 and 200 % for CH_4 associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the 2006 IPCC.

The values were selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. Due to the fact that all activity data were provided through the IEA/Eurostat Questionnaire 2023 and were obtained using the same method, that default emission factors were used for the whole time-series and the same estimating method was used for the whole period, the data series 1989–2023 is consistent.

3.3.2.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

3.3.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

3.3.2.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

3.3.3 Oil and natural gas and other emissions from energy production(CRT 1.B.2)

3.3.3.1 Category description

This source category comprises fugitive emissions from all oil and gas activities. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, and venting, flaring and accidental releases. The current structure of the Romanian natural gas market, currently includes: an operator of the National Transport System – S.N.T.G.N. Transgaz S.A., 9 manufacturers, 3 operators for underground storage, 31 companies supplying and distributing natural gas to captive consumers, 85 suppliers on the wholesale market. The National Society for Natural Gas Transportation TRANSGAZ S.A is made up of two national companies – "TRANSGAZ" S.A. Medias (for the transport of natural gas) and "DEPOGAZ" S.A. Ploiesti (for the storage of natural gas), two natural gas distribution companies – "DISTRIGAZ NORD" S.A. Tg. Mureş and "DISTRIGAZ SUD" S.A. Bucharest and a trading company for exploitation – production – "EXPROGAZ" S.A. Medias. The oil and gas pipelines had, at the end of 2018, a length of 16,601 kilometers, according to the data centralized by the National Institute of Statistics. The National Society for Natural Gas Transportation TRANSGAZ S.A. has technical infrastructure so that it allows to ensure the transportation of the natural gas to the consumming areas. Also, the pipelines for the transport of crude oil had a length of 2,776 kilometers, those for gasoline transport 336 kilometers and those for ethane transport, 139 kilometers. In 2020, the National Society for Natural Gas Transportation TRANSGAZ S.A. has technical infrastructure so that it allows to ensure the transportation of the natural gas to the consumming areas of the 13,430 km of the transporting pipelines plus over 369 km of pipelines for the international transit. The emissions trend for the entire period is characterized by a continuos decrease, which is due to a number of factors:

- the decline of economic activities and energy consumption;
- the economy being in transition, some energy intensive industries reduced their activities, this being reflected in the GHG emissions reduction especialy during 1989–1999 period;
- the decrease of the natural gas national reserves;
- in 2006, the available energy resources rised over the level in the previous year. The increase was based mainly on the increased import of energy carriers, offsetting the small decrease of the primary energy production due to diminished crude oil;
- in 2017 the most significant increase was production of usable natural gas (+746 thousand toe), representing + 9.5% over the previous year and a decrease in the production of crude oil (-166 thousand toe, representing -4.5%);
- on types of energy carriers in 2018, crude oil and petroleum products increased and electricity

consumption, increased usable natural gas and coal (including coke) decreased-compared to the previous year;

- in 2020, primary energy production decreased compared to 2019, because the production of usable natural gas has decreased by 10.7% compared to the previous year; also, regarding the use of energy on the main activities of the national economy, in 2020 the transport sector registered a decrease of 3% compared to 2019;
- in 2021, the production of thermoelectric energy increased compared to the previous year, due to the increase in the production of electricity based on coal, representing +14.2% and the production based on gaseous hydrocarbons representing +4.9%; compared with 2020, the crude oil production decreased by 95.6%, the utilisable natural gas production increased by 100.5%, and the production of coal (exclusive coke) increased by 116%; by types of energy carriers, the main increases in gross domestic consumption were to crude oil and petroleum products, coal (including coke) and natural gas;
- in 2022, the production of thermoelectric energy decreased compared to the previous year, due to the decrease in the production of electricity based on coal (-3.0%) and the production based on gaseous hydrocarbons (-5.9%); compared with 2021, the crude oil production decreased by 94.3%, the utilisable natural gas production increased with 101.3%, and the production of coal (exclusive coke) decreased by 92.3%, (Source – Romanian National Institute for Statistics);
- in 2023, the production of thermoelectric energy decreased compared to the previous year, due to the decrease in the production of electricity based on coal (-22.2%) and the production based on gaseous hydrocarbons (-2.0%); compared with 2022, the crude oil production decreased by 95.4%, the utilisable natural gas production increased with 101.7%, and the production of coal (exclusive coke) decreased by 80.9% (Source – Romanian National Institute for Statistics).

Figure 3.58 Total GHG Oil and Natural Gas source category emissions trend

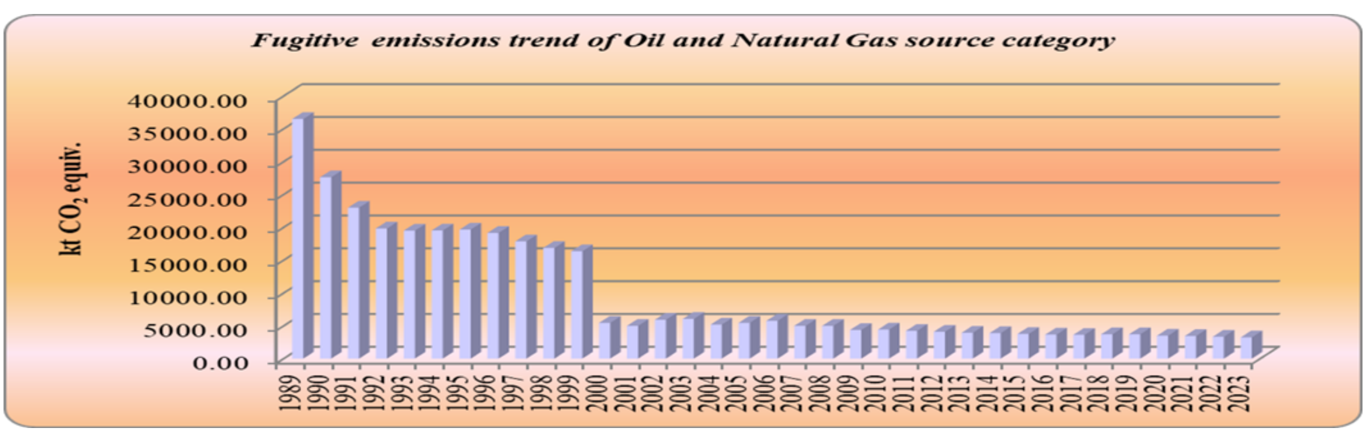
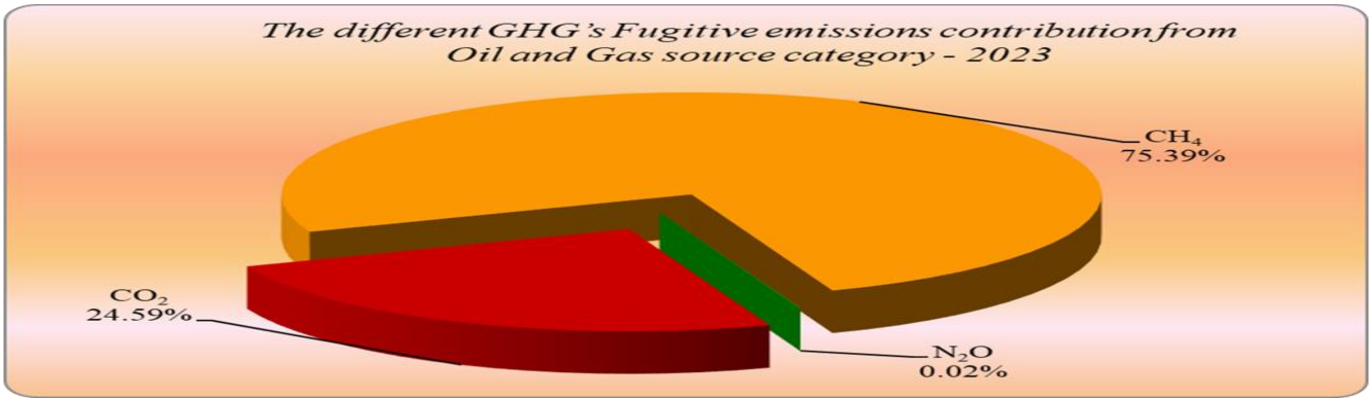


Figure 3.59 The contribution of GHGs Fugitive emission per gas from Oil and Natural Gas source category



3.3.3.2 Methodological issues

3.3.3.2.1 Oil (CRT 1.B.2.a)

- Emission: CH_4, CO_2, N_2O
- Key source: Yes

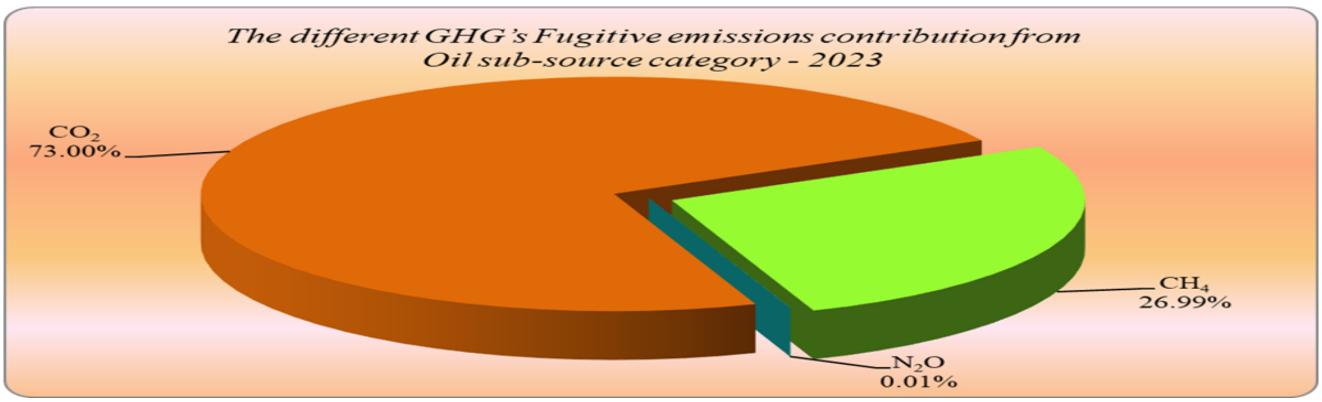
This *sub–source category* comprises emissions from venting, flaring and all other fugitive sources associated with *exploration, production, transmission, upgrading, and refining of crude oil and distribution* of crude oil products. The 1.B.2.a. – Oil and Natural Gas – Oil source category are key category from both level and trend point of view for CO_2 emissions (Tier 1, excluding and including LULUCF) and from trend point of view for CH_4 emissions (Tier 1, excluding and including LULUCF). Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors the reporting are used. Romania used the Default EFs from the 2006 IPCC Guidelines, Table 4.2.5, starting with the 2013 submission. At that time, these default EFs, according to the note from page 4.63, was considered suitable for Romania. Due to the majority of operators in the oil and natural gas national industry are working especially since 2000, with the best available technologies according to European Union requirements, Romania has reconsidered the default EFs values provided by 2006 IPCC Guidelines.

- ❖ For the 1989-1999 period are used default EFs values from the 2006 IPCC Guidelines, Volume 2, Chapter 4, pages 4.55 – 4.63, Table 4.2.5 "Tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developing countries and countries with economies in transition".
- ❖ For the 2000–2023 period are used default EFs values from the 2006 IPCC Guidelines, Volume 2, Chapter 4, pages 4.48 – 4.54, Table 4.2.4 "Tier 1 emission factors for fugitive emissions (including venting and

flaring) from oil and gas operations in developed countries".

Also, these values have been selected considering that the best available techniques/equipments used in natural gas industry are aligned with those used in the European Union based on applicable legislation. The formula used in the calculations is presented in *Equation 4.2.1 Tier 1: Estimating Fugitive Emissions from an industry segment*.

Figure 3.60 The different GHG's Fugitive emissions contribution from Oil sub–source category



Exploration oil (CRT 1.B.2.a.1)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission Factor

For *1989–1999* period have been used:

Default Emission Factor: *"Gas/Oil extraction–well Drilling, Testing, Servicing" according to 2006 IPCC GL for "Flaring and Venting" , volume 2, chapter 4.2.2.3., page 4.55, Table 4.2.5.*

	lower	**upper**	**average**	**units**
CH_4	0.000194	0.00321	0.001702	Gg per 10^3 m^3 total oil production
CO_2	0.0091019	0.151732	*0.08041695*	Gg per 10^3 m^3 total oil production
N_2O	0.000000068	0.0000011	0.000000584	Gg per 10^3 m^3 total oil production

For *2000–2023* period have been used:

Default Emission Factor: *"Gas/Oil extraction-well Drilling, Testing, Servicing" according to 2006 IPCC GL for "Flaring and Venting" , volume 2, chapter 4.2.2.3., page 4.48, Table 4.2.4.*

	lower	upper	average	units
CH_4	*0.000194*	-	*0.000194*	Gg per 10^3 m^3 total oil production
CO_2	*0.0091019*	-	*0.0091019*	Gg per 10^3 m^3 total oil production
N_2O	*0.000000068*	-	*0.000000068*	Gg per 10^3 m^3 total oil production

Activity Data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. According with the methodological provisions, activity data level used in Exploration Oil category is the sum of Eurostat/IEA data on the following parameters values:

- ***Crude oil*** – indigenous production (density = 881 kg/m^3 according to http://hypertextbook.com/facts/2007/ArtemGindin.shtml) ;
- ***Natural Gas Liquids*** – indigenous production (density ≈ 476 kg/m^3 according to http://kosancrisplant.com/media/5648/1-lng_basics_82809_final_hq.pdf);
- ***Other Hydrocarbons*** – indigenous production (density = 550 kg/m^3 according to http://pubs.acs.org/doi/abs/10.1021/je60058a030).
- ***NCV*** – from IEA/Eurostat Questionnaire 2023 – Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg].

As long as, the density values for each fuel type are different and the activity data values are not unitary as content on the time series analysed period, the implied emission factors of CO_2, CH_4 and N_2O are different.

Production and upgrading (CRT 1.B.2.a.2)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission Factor

For *1989–1999* period have been used:

Default Emission Factors: "Default weighted total" according to 2006 IPCC GL for "Fugitives", Volume 2, chapter 4.2.2.3, page 4.60, Table 4.2.5.

	lower	upper	average	units
CH_4	0.0022	0.037	*0.0196*	Gg per 10^3 m^3 total oil production
CO_2	0.00028	0.0047	*0.00249*	Gg per 10^3 m^3 total oil production
N_2O	NA			

For *2000–2023* period have been used:

Default Emission Factors: “Default weighted total” according to 2006 IPCC GL for “Fugitives”, Volume 2, chapter 4.2.2.3, page 4.52, Table 4.2.4.

	lower	upper	average	units
CH_4	0.0022	-	*0.0022*	Gg per 10^3 m^3 total oil production
CO_2	0.00028	-	*0.00028*	Gg per 10^3 m^3 total oil production
N_2O	NA			

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. According with the methodological provisions, activity data level used in *Production and upgrading Oil* category is the sum of Eurostat/IEA data on the following parameters values:

- Crude oil – Indigenous Production – (density = 881 kg/m^3 according to http://hypertextbook.com/facts/2007/ArtemGindin.shtml;
- *Natural Gas Liquids* – Indigenous Production – (density ≈ 476 kg/m^3 according to http://kosancrisplant.com/media/5648/1-lng_basics_82809_final_hq.pdf);
- *Other Hydrocarbons* – Indigenous Production – (density = 550 kg/m^3 according to http://pubs.acs.org/doi/abs/10.1021/je60058a030).
- ***NCV*** – from IEA/Eurostat Questionnaire 2023 – Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons in [kJ/kg].

Oil Transport (CRT 1.B.2.a.3)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission Factor

For *1989–2023* period have been used:

Default Emission Factors: “*Oil Transport Pipelines”* according to 2006 IPCC GL for “All”, Volume 2, chapter 4.2.2.3, Table 4.2.4 and page 4.61, Table 4.2.5.

	lower	upper	average	units
CH_4	0.0000054	-	*0.0000054*	Gg per 10^3 m^3 total oil production
CO_2	0.00000049	-	*0.00000049*	Gg per 10^3 m^3 total oil production
N_2O	NA			

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–

2023 time series have been used. From *IEA/Eurostat Questionnaire 2023 – Indigenous Production + Import + Export:*

❖ Crude Oil, Natural Gas Liquids and Other Hydrocarbons;
❖ *NCV* – from IEA/Eurostat Questionnaire 2023 – Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg].

Refining / Storage (CRT 1.B.2.a.4)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used for estimation of CH_4 emissions.

Emission factor

For *1989–2023* period have been used:

Default Emission Factors: "Oil Refining" according to 2006 IPCC GL for "All", Volume 2, chapter 4.2.2.3, page 4.53, Table 4.2.4.

	lower	**upper**	**average**	**units**
CH_4	0.0000026	0.000041	0.0000218	Gg per $10^3 m^3$ oil refined

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. From *IEA/Eurostat Questionnaire 2023* Refinery Intake (Observed):

❖ Crude oil, Natural Gas Liquids and Other Hydrocarbons;
❖ *NCV* – from IEA/Eurostat Questionnaire 2023 – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg]

The methodology used, as well as the emission factors used to estimate CO_2 emissions, are included in category 1.B.2.a.6 Other.

Distribution of oil products (CRT 1.B.2.a.5)

Refined Product Distribution: Gasoline, Diesel, Aviation Fuel, Jet Kerosene

CO_2 – N.A.

CH_4 – N.A.

N_2O – N.A.

Other (CRT 1.B.2.a.6)

This category includes Fugitive emissions from *petroleum coke,* not elsewhere accounted. Because of the fact that at the category *Refining/Storage (CRT 1.B.2.a.4)* there are different activity data for CH_4 and for

CO_2, in this category are estimated the CO_2 emissions.

Methodology

Tier 2 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Country Specific Emission Factors the reporting are used for 1995–2009 period.

Tier 2 and tier 3 combined Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 are used for 2010–2012 period and 2022-2023 period.

Tier 3 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and *Country Specific Emission Factors* the reporting are used for 2013–2021 period.

Emission factor

The country specific (1995–2012 period and 2022-2023 period) and plant specific (2010–2023 period) values of EF for CO_2 have been used:

Refining / Storage	
Years	**CO_2 (kt/PJ)**
1989–2007	93.73
2008	94.52
2009	91.85
2010	94.02
2011	98.50
2012	96.83
2013	92.80
2014	92.34
2015	94.93
2016	95.55
2017	95.05
2018	94.06
2019	93.90
2020	93.53
2021	92.64
2022	92.30
2023	93.94

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for the 1990–2009 time series have been used. From *IEA/Eurostat Questionnaire 2023 – Petroleum coke* – Refinery fuel:

Petroleum Coke used in refineries as catalytic regenerator.

For 2010–2012 period and for 2022-2023 period, activity data from the EU–ETS refineries operators and activity data from non–ETS operators calculated as the difference between the quantity of coke from *IEA/Eurostat Questionnaire 2023 – Petroleum coke – Refinery fuel* and the quantity of coke from EU–ETS refineries operators were used.

For 2013–2021 period, only activity data from the EU–ETS refineries operators were used. Two of the three operators provided the data regarding the coke deposited on the catalyst expressed in tons of coke. The third operator sent the data on coke consumption at the catalytic cracking and catalytic reforming facilities expressed in carbon equivalent. To express the amount of coke deposited on the catalyst in tons of coke and for the third operator, the carbon content of the coke deposited on the catalyst was taken into account (arithmetic average of the weighted averages from the other 2 operators calculated for the period 2010–2021 and, for the 2022-2023 period, the weighted average calculated on the basis of activity data from the other 2 operators).

NCV – Country Specific NCV in [TJ/t] has been used.

3.3.3.2.2 Natural Gas (CRT 1.B.2.b)

- Emissions: CH_4, CO_2
- Key source: Yes.

This *sub-source category* comprises emission from venting, flaring and all other fugitive sources associated with the *exploration, production, processing, transmission, storage and distribution of natural gas* (including both associated and non-associated gas). The 1.B.2.b. – Natural Gas source category are key category from both level and trend point of view for CH_4 emissions (Tier 1, excluding and including LULUCF). Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used. Romania used the default EFs from the 2006 IPCC Guidelines, Table 4.2.5, starting with the 2013 submission. At that time, these default EFs, according to the note from page 4.63, were considered suitable for Romania. Due to the majority of operators in the oil and natural gas national industry are working especially since 2000, with the best available technologies according to European Union requirements, Romania has reconsidered the default EFs values provided by 2006 IPCC GL.

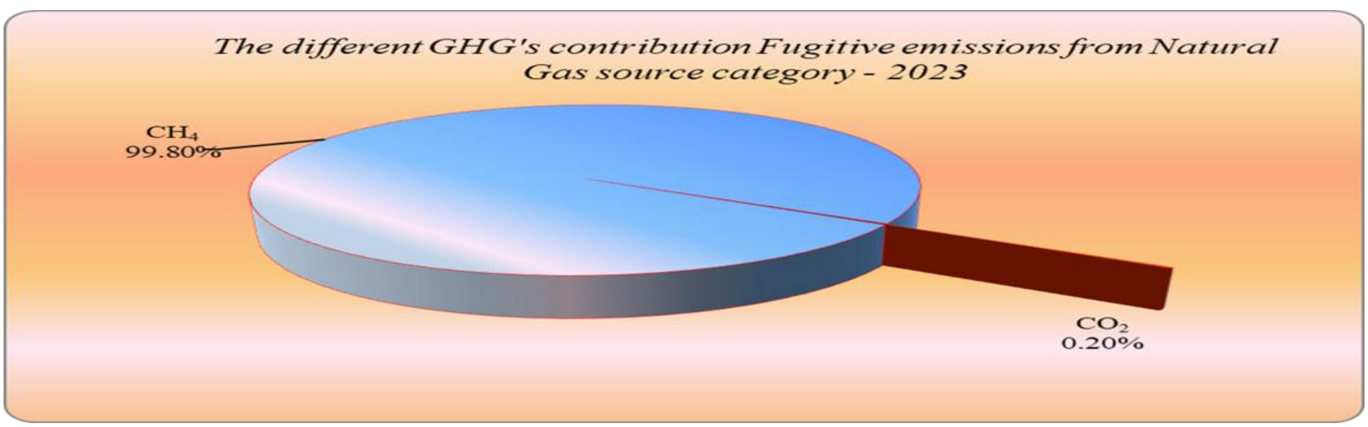
❖ For the 1989–1999 period are used the default EFs values from the 2006 IPCC Guidelines, Volume 2, Chapter 4, page 4.55, Table 4.2.5 “Tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developing countries and countries with economies in transition”.

❖ For the 2000–2023 period are used the default EFs values from the 2006 IPCC Guidelines, Volume 2, Chapter 4, page 4.48, Table 4.2.4 "Tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developed countries".

❖ Also, these values have been selected considering that the best available techniques/equipments used in natural gas industry are aligned with those used in the European Union based on applicable legislation. In the meantime, for Other (Other Leakage) (CRT 1.B.2.b.6) category, because the 2006 IPCC GL default EFs and country–specific EFs values are not available (CS EFs values availability is analized annually), default EFs from Revised 1996 IPCC, RM, Table 1-58, page 1.121 have been used: for 1989–1999 period, from "Former USSR, Central & Eastern Europe" column; for 2000–2023 period, from "Rest of the World column".

❖ The formula used in the calculations is presented in *Equation 4.2.1 Tier 1: Estimating Fugitive Emissions from an industry segment*.

Figure 3.61 The different GHG's Natural Gas sub-source category emissions contribution



Exploration (CRT 1.B.2.b.1)

According with IPCC 2006 Guidelines emissions are considered in 1.B.2.a.1.

Production (CRT 1.B.2.b.2)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission factor

For *1989–1999* period have been used:

Default Emission Factors: “Gas Production - All” according to 2006 IPCC GL for “Fugitives”, Volume 2, chapter 4.2.2.3, page 4.55, Table 4.2.5.

	lower	upper	average	units
CH_4	0.00038	0.024	*0.01219*	Gg per 10^6 m^3 gas production
CO_2	0. 000014	0.00018	*0.000097*	Gg per 10^6 m^3 gas production
N_2O	NA			

For *2000–2023* period have been used:

Default Emission Factors: “Gas Production - All” according to 2006 IPCC GL for “Fugitives”, Volume 2, chapter 4.2.2.3, page 4.48, Table 4.2.4.

	lower	upper	average	units
CH_4	0.00038	0.0023	*0.00134*	Gg per 10^6 m^3 gas production
CO_2	0. 000014	0.000082	*0.000048*	Gg per 10^6 m^3 gas production
N_2O	NA			

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. From *IEA/Eurostat Questionnaire* 2023 Indigenous Production:

- ***Natural Gas*** – in both units – *10^6 m^3 and TJ (GCV) * 0.9 → TJ (NCV);* (density = 0.77 kg/m^3 according to http://ro.wikipedia.org/wiki/Gaz).

Processing (CRT 1.B.2.b.3)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors the reporting are used.

Emission factor

For *1989–1999* period have been used:

Default Emission Factors: “Gas Processing – Default Weighted Total” according to 2006 IPCC GL for “Fugitives”, Volume 2, chapter 4.2.2.3, page 4.56, Table 4.2.5.

	lower	upper	average	units
CH_4	0.00015	0. 00035	*0.00025*	Gg per 10^6 m^3 gas production
CO_2	0.000012	0.000028	*0.00002*	Gg per 10^6 m^3 gas production
N_2O	NA			

For *2000–2023* period have been used:

Default Emission Factors: “Gas Processing – Default Weighted Total” according to 2006 IPCC GL for

“Fugitives”, Volume 2, chapter 4.2.2.3, page 4.49, Table 4.2.4.

	lower	upper	average	units
CH_4	0.00015	0.00103	*0.00059*	Gg per 10^6 m^3 gas production
CO_2	0.000012	0. 00032	*0.000166*	Gg per 10^6 m^3 gas production
N_2O	NA			

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. From *IEA/Eurostat Questionnaire* 2023 Indigenous Production:

❖ ***Natural Gas*** – in both units – *10^6 m^3 and TJ (GCV) * 0.9 → TJ (NCV);* (density = 0.77 kg/m^3 according to http://ro.wikipedia.org/wiki/Gaz).

Transmission and Storage (CRT 1.B.2.b.4)

This category includes Fugitive emissions from natural gas systems used to transport processed natural gas to market. Thus, fugitive emissions from *Transmission and Storage* category represent the sum of emissions from *Transmission* and *Storage.*

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission factor *(Transmission)*

For *1989–1999* period have been used:

Default Emission Factors: “Gas Transmission & Storage” according to 2006 IPCC GL for “Fugitives”, Volume 2, chapter 4.2.2.3, page 4.57, Table 4.2.5.

	lower	upper	average	units
CH_4	0.000166	0.0011	*0.000633*	Gg per 10^6 m^3 of marketable gas
CO_2	0.00000088	0.000002	*0.00000144*	Gg per 10^6 m^3 of marketable gas
N_2O	NA			

For *2000–2023* period have been used:

Default Emission Factors: “Gas Transmission & Storage” according to 2006 IPCC GL for “Fugitives”, Volume 2, chapter 4.2.2.3, page 4.49, Table 4.2.4.

	lower	upper	average	units
CH_4	0.000066	0.00048	*0.000273*	Gg per 10^6 m^3 of marketable gas
CO_2	0.00000088	-	*0.00000088*	Gg per 10^6 m^3 of marketable gas

	lower	upper	average	units
N_2O	NA			

***Activity data** (Transmission)*

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. From *IEA/Eurostat Questionnaire* 2023 Indigenous Production + Import:

- ***Natural Gas*** – in both units – *10^6 m^3 and TJ (GCV) * 0.9 → TJ (NCV);* (density = 0.77 kg/m^3 according to http://ro.wikipedia.org/wiki/Gaz)

***Emission factor** (Storage)*

For *1989–1999* period have been used:

Default Emission Factors: "Gas Transmission & Storage" according to 2006 IPCC GL for "Storage", Volume 2, chapter 4.2.2.3, page 4.57, Table 4.2.5.

	lower	upper	average	units
CH_4	0.000025	0.000058	*0.0000415*	Gg per 10^6 m^3 of marketable gas
CO_2	0.00000011	0.00000026	*0.000000185*	Gg per 10^6 m^3 of marketable gas

For *2000–2023* period have been used:

Default Emission Factors: "Gas Transmission & Storage" according to 2006 IPCC GL for "Storage", Volume 2, chapter 4.2.2.3, page 4.49, Table 4.2.4.

	lower	upper	average	units
CH_4	0.000025	-	*0.000025*	Gg per 10^6 m^3 of marketable gas
CO_2	0.00000011	-	*0.00000011*	Gg per 10^6 m^3 of marketable gas

***Activity data** (Storage)*

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. From *IEA/Eurostat Questionnaire* 2023 Closing stock level (National territory);

- ***Natural Gas*** – in both units – *10^6 m^3 and TJ (GCV) * 0.9 → TJ (NCV);* (density = 0.77 kg/m^3 according to http://ro.wikipedia.org/wiki/Gaz).

Distribution (CRT 1.B.2.b.5)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission factor

For *1989–1999* period have been used:

Default Emission Factors: "Gas Distribution" according to 2006 IPCC GL for "All", Volume 2, chapter 4.2.2.3, page 4.57, Table 4.2.5.

	lower	upper	average	units
CH_4	0.0011	0.0025	*0.0018*	Gg per 10^6 m^3 per utility sales
CO_2	0.000051	0.00014	*0.0000955*	Gg per 10^6 m^3 per utility sales
N_2O	NA			

For *2000–2023* period have been used:

Default Emission Factors: "Gas Distribution" according to 2006 IPCC GL for "All", Volume 2, chapter 4.2.2.3, page 4.50, Table 4.2.4.

	lower	upper	average	units
CH_4	0.0011	-	*0.0011*	Gg per 10^6 m^3 per utility sales
CO_2	0.000051	-	*0.000051*	Gg per 10^6 m^3 per utility sales
N_2O	NA			

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. From *IEA/Eurostat Questionnaire* 2023 Indigenous Production + Import:

- ***Natural Gas*** – in both units – *10^6 m^3 and TJ (GCV) * 0.9 → TJ (NCV)*; (density = 0.77 kg/m^3 according to http://ro.wikipedia.org/wiki/Gaz)

Other (CRT 1.B.2.b.6)

This category includes Fugitive emissions from natural gas systems not elsewhere accounted for in the above categories. Thus, fugitive emissions from *Other Leakage* category represent the sum of emissions from *Industrial plants and power stations* and *Residential and commercial sectors*.

Industrial plants and power stations

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission factors

Because 2006 IPCC GL default EFs and country–specific EFs values are not available, default EFs from Revised 1996 IPCC, Reference Manual (RM), Table 1–58, page 1.121 have been used.

For *1989–1999* period have been used:

Default Emission factors – from Revised 1996 IPCC, RM, Table 1-58, page 1.121 (Former USSR, Central

& Eastern Europe).

	lower	upper	average	units
CH_4	175,000	384,000	*279,500*	kg/PJ

For *2000–2023* period have been used:

Default Emission factors – from Revised 1996 IPCC, RM, Table 1-58, page 1.121 (Rest of the World).

	lower	upper	average	units
CH_4	0.00	175,000	*87,500*	kg/PJ

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 for 1990–2023 time series have been used:

❖ ***Natural Gas -*** sheet "2a_Consumption" row 18 (Energy Sector) (for 1992–2023 period, the updated activity data have been used)+ sheet "2ii_TFC_EnergyUse" row 10 (Industry Sector) (for 1990-2023 period, the updated activity data have been used) and from sheet "2iii_TFC_Non-EnergyUse" row 10 (Industry Sector) – in both units – 10^6 m^3 and TJ (GCV) * 0.9 → TJ (NCV); (density = 0.77 kg/m^3 according to http://ro.wikipedia.org/wiki/Gaz)

Residential and commercial sectors

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission factors

Because 2006 IPCC GL default EFs and country–specific EFs values are not available, default EFs from Revised 1996 IPCC, RM, Table 1–58, page 1.121 have been used.

For *1989–1999* period have been used:

Default Emission factors – from Revised 1996 IPCC, RM, Table 1–58, page 1.121 (Former USSR, Central & Eastern Europe).

	lower	upper	average	units
CH_4	87,000	192,000	*139,500*	kg/PJ

For *2000–2023* period have been used:

Default Emission factors - from Revised 1996 IPCC, RM, Table 1-58, page 1.121 (Rest of the World).

	lower	upper	average	units
CH_4	0.00	87,000	*43,500*	kg/PJ

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used:

- ***Natural Gas*** - sheet "2ii_TFC_EnergyUse" row 24 (Other sectors) – in both units – 10^6 m^3 and TJ (GCV) * 0.9 → TJ (NCV); (density = 0.77 kg/m^3 according to http://ro.wikipedia.org/wiki/Gaz).

3.3.3.2.3 Venting and Flaring (CRT – 1.B.2.c.)

The 1.B.2.c – Fugitive Emissions from Fuels - Venting and Flaring source category are key category from level point of view (Tier 1, excluding and including LULUCF) for CH_4 emissions.

➢ Emissions: CH_4, CO_2, N_2O

➢ Key source: Yes

Venting Oil* and *Venting Gas (CRT – 1.B.2.c.1)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission Factor - Venting Oil (CRT – 1.B.2.c.1.i)

For *1989–1999* period have been used:

Default Emission Factor: "Default weighted total – Venting" according to 2006 IPCC GL for "Oil production", volume 2, chapter 4.2.2.3, page 4.60, table 4.2.5.

Venting oil	lower	upper	average	units
CH_4	0.0087	0.012	*0.01035*	Gg per 10^3 m^3 total oil production
CO_2	0.0018	0.0025	*0.00215*	Gg per 10^3 m^3 total oil production
N_2O	NA			

For *2000–2023* period have been used:

Default Emission Factor: "Default weighted total – Venting" according to 2006 IPCC GL for "Oil production", volume 2, chapter 4.2.2.3, page 4.52, table 4.2.4.

Venting oil	lower	upper	average	units
CH_4	0.0087	-	*0.0087*	Gg per 10^3 m^3 total oil production
CO_2	0.0018	-	*0.0018*	Gg per 10^3 m^3 total oil production
N_2O	NA			

Emission Factor – Venting Gas (CRT – 1.B.2.c.1.ii)

For *1989–1999* period have been used:

Default Emission Factor: *"Gas Transmission & Storage" according to 2006 IPCC GL for "Transmission*

– Venting", volume 2, chapter 4.2.2.3, page 4.57, Table 4.2.5.

Venting gas	lower	upper	average	units
CH_4	0.000044	0.00074	*0.000392*	Gg per 10^6 m^3 of marketable gas
CO_2	0.0000031	0.0000073	*0.0000052*	Gg per 10^6 m^3 of marketable gas
N_2O	NA			

For 2000–2023 period have been used:

Default Emission Factor: *"Gas Transmission & Storage" according to 2006 IPCC GL for "Transmission – Venting", volume 2, chapter 4.2.2.3, page 4.49, Table 4.2.4.*

Venting gas	lower	upper	average	units
CH_4	0.000044	0.00032	*0.000182*	Gg per 10^6 m^3 of marketable gas
CO_2	0.0000031	-	*0.0000031*	Gg per 10^6 m^3 of marketable gas
N_2O	NA			

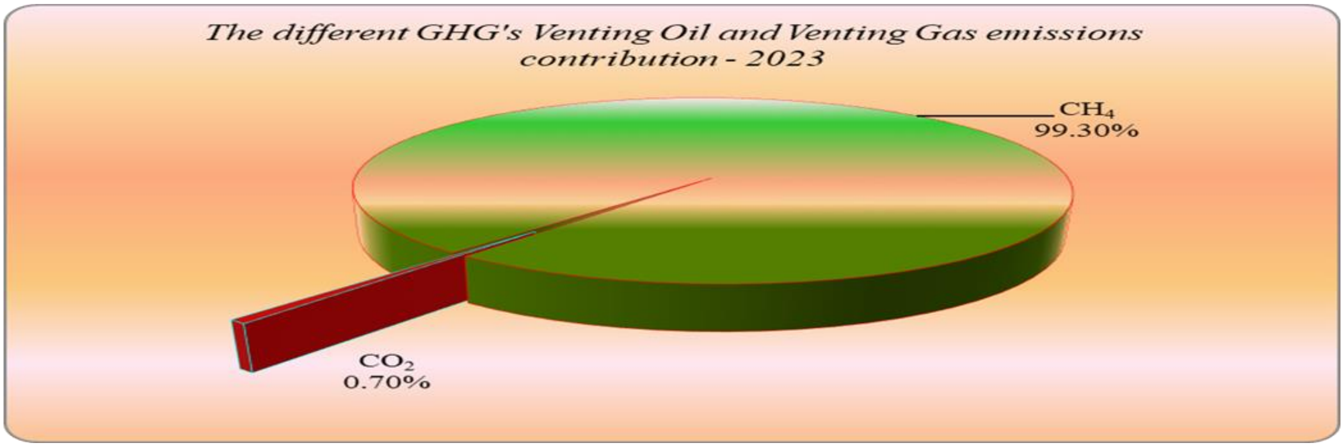
Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. According with the methodological provisions, activity data level used in *Venting Oil (1.B.2.c.1.i)* and *Venting Gas (1.B.2.c.1.ii)* categories are:

- ***Crude oil*** – indigenous production (density = 881 kg/m^3 according to http://hypertextbook.com/facts/2007/ArtemGindin.shtml) ;
- ***Natural Gas Liquids*** – indigenous production (density ≈ 476 kg/m^3 according to http://kosancrisplant.com/media/5648/1-lng_basics_82809_final_hq.pdf);
- ***Other Hydrocarbons*** – indigenous production (density = 550 kg/m^3 according to http://pubs.acs.org/doi/abs/10.1021/je60058a030);
- ***Natural Gas*** – Indigenous Production – in 10^6 m^3 units.

As long as the density values for each fuel type are different and the activity data values are not unitary as content on the time series analyzed period, the implied emission factors of CO_2 and CH_4 are different.

Figure 3.62 The different GHG's Venting oil and Venting Gas emissions contribution



Flaring Oil and Flaring Gas (CRT – 1.B.2.c.2)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors are used.

Emission factor:

Emission factor – Flaring Oil (CRT - 1.B.2.c.2.i)

For *1989–1999* period have been used:

Default Emission Factor: "Default weighted total – Flaring" according to 2006 IPCC GL for "Oil production", volume 2, chapter 4.2.2.3, page 4.60, table 4.2.5.

Flaring oil	lower	upper	average	units
CH_4	0.000021	0.000029	*0.000025*	Gg per 10^3 m^3 total oil production
CO_2	0.034	0.047	*0.0405*	Gg per 10^3 m^3 total oil production
N_2O	0.00000054	0.00000074	*0.00000064*	Gg per 10^3 m^3 total oil production

For *2000–2023* period have been used:

Default Emission Factor: "Default weighted total – Flaring" according to 2006 IPCC GL for "Oil production", volume 2, chapter 4.2.2.3, page 4.52, table 4.2.4.

Flaring oil	lower	upper	average	units
CH_4	0.000021	-	*0.000021*	Gg per 10^3 m^3 total oil production
CO_2	0.034	-	*0.034*	Gg per 10^3 m^3 total oil production
N_2O	0.00000054	-	*0.00000054*	Gg per 10^3 m^3 total oil production

Emission factor – Flaring Gas (CRT 1.B.2.c.2.ii)

For *1989–1999* period have been used:

Default Emission Factors: “Gas Production” according to 2006 IPCC GL for “All - Flaring” – 2006 IPCC, Volume 2, chapter 4.2.2.3, page 4.55, Table 4.2.5.

Flaring gas	lower	upper	average	units
CH_4	0.00000076	0.000001	*0.00000088*	Gg per 10^6 m^3 gas production
CO_2	0.0012	0.0016	*0.0014*	Gg per 10^6 m^3 gas production
N_2O	0.000000021	0.000000029	*0.000000025*	Gg per 10^6 m^3 gas production

For *2000–2023* period have been used:

Default Emission Factors: “Gas Production” according to 2006 IPCC GL for “All - Flaring” – 2006 IPCC, Volume 2, chapter 4.2.2.3, page 4.48, Table 4.2.4.

Flaring gas	lower	upper	average	units
CH_4	0.00000076	-	*0.00000076*	Gg per 10^6 m^3 gas production
CO_2	0.0012	-	*0.0012*	Gg per 10^6 m^3 gas production
N_2O	0.000000021	-	*0.000000021*	Gg per 10^6 m^3 gas production

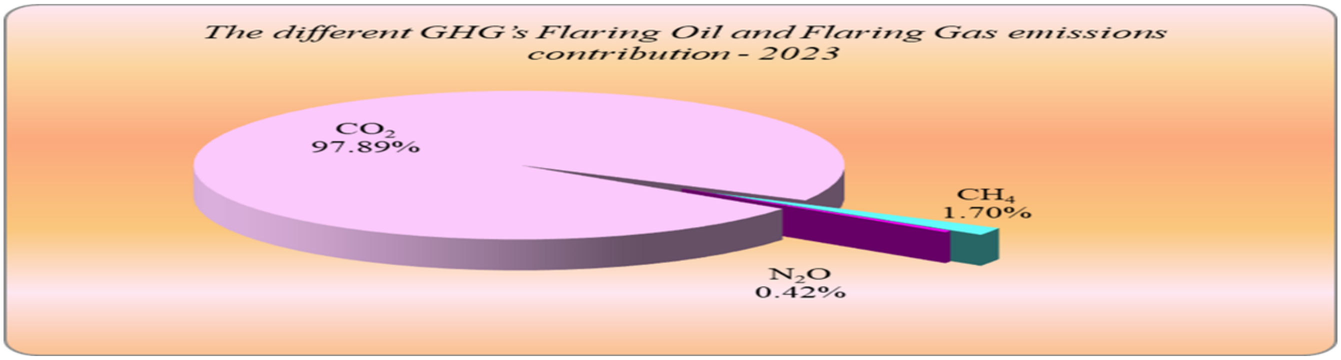
Activity data:

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2023 – for entire 1990–2023 time series have been used. According with the methodological provisions, activity data level used in *Flaring Oil (1.B.2.c.2.i)* and *Flaring Gas (1.B.2.c.2.ii)* categories are:

- ***Crude oil*** – indigenous production (density = 881 kg/m^3 according to http://hypertextbook.com/facts/2007/ArtemGindin.shtml);
- ***Natural Gas Liquids*** – indigenous production (density ≈ 476 kg/m^3 according to http://kosancrisplant.com/media/5648/1-lng_basics_82809_final_hq.pdf);
- ***Other Hydrocarbons*** – indigenous production (density = 550 kg/m^3 according to http://pubs.acs.org/doi/abs/10.1021/je60058a030);
- ***Natural Gas*** – Indigenous Production – in 10^6 m^3 units.

As long as the density values for each fuel type are different and the activity data values are not unitary as content on the time series analyzed period, the implied emission factors of CO_2, CH_4 and N_2O are different.

Figure 3.63 The different GHG's Flaring Oil and Flaring Gas emissions contribution



3.3.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

3.3.3.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

❖ ***Oil sub–source category (CRT 1.B.2.a)***

- AD: 3 %;
- EF:
  - CO_2: 50 %;
  - CH_4: 50 %;
  - N_2O: 50 %.
  - 50.09 % for CO_2, 50.09 % for CH_4 and 50.09 % for N_2O associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

❖ ***Natural Gas sub–source category (CRT 1.B.2.b)***

- AD: 2.24 %;
- EF:
  - CO_2: 50 %;
  - CH_4: 50 %;
  - N_2O: 0%;

- 50.05 % for CO_2 and 50.05 % for CH_4 and 2.24 % for N_2O associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

❖ ***Venting sub–source category (CRT 1.B.2.c.1)*:**

- AD: 2.24 %;
- EF:
  - CO_2: 50 %;
  - CH_4: 50 %;
  - N_2O: 0%;
  - 50.05 % for CO_2, 50.05 % for CH_4 and 2.24 % N_2O associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

❖ ***Flaring sub–source category (CRT 1.B.2.c.2)*:**

- AD: 3 %;
- EF:
  - CO_2: 50 %;
  - CH_4: 50 %;
  - N_2O: 0%;
  - 50.09 % for CO_2, 50.09 % for CH_4 and 3 % N_2O as resulted after the the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.28 from Chapter 3, Volume 1 of the IPCC 2006.

The values were selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. Due to the fact that all activity data were provided through the IEA/Eurostat Questionnaire 2023 and were obtained using the same method, that default emission factors were used for the whole time-series and the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

3.3.3.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

3.3.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the emissions estimates quality some important recalculations were made:

- ***NCV values:***
  - Fugitive emissions – Oil and Natural Gas – Oil – Other (CRT 1.B.2.a.6);
- ***Activity data:***
  - Fugitive emissions – Oil and Natural Gas – Natural Gas – Transmission and storage (CRT 1.B.2.b.4);
  - Fugitive emissions – Oil and Natural Gas – Natural Gas – Other (CRT 1.B.2.b.6).

Table 3.20 The effects of recalculations in Oil and Natural Gas and Other Emissions from Energy Production Subsector

The effects of recalculations in Oil and Natural Gas and Other Emissions from Energy Production Subsector			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	Emissions (kt CO_2 equivalent)		
1990	27,618.40	27,618.54	0.0005
1991	22,982.90	22,982.99	0.0004
1992	19,831.74	19,824.24	-0.0378
1993	19,497.98	19,492.28	-0.0292
1994	19,525.18	19,514.49	-0.0547
1995	19,657.29	19,648.38	-0.0453
1996	19,153.12	19,145.55	-0.0395
1997	17,865.64	17,858.38	-0.0406
1998	16,863.16	16,854.70	-0.0502
1999	16,356.58	16,344.60	-0.0732
2000	5,441.24	5,441.64	0.0073
2001	4,990.22	4,989.29	-0.0185
2002	5,923.01	5,917.97	-0.0850
2003	6,049.22	6,049.03	-0.0032
2004	5,184.07	5,185.31	0.0239
2005	5,445.69	5,449.72	0.0740
2006	5,756.46	5,762.88	0.1115
2007	4,985.79	4,994.77	0.1801
2008	4,996.85	4,996.44	-0.0082
2009	4,370.70	4,369.91	-0.0180
2010	4,429.19	4,429.02	-0.0037
2011	4,230.46	4,230.26	-0.0048
2012	4,093.71	4,093.27	-0.0108
2013	3,950.07	3,949.36	-0.0178
2014	3,894.31	3,893.40	-0.0234
2015	3,764.90	3,763.81	-0.0290
2016	3,666.92	3,666.20	-0.0196
2017	3,624.95	3,624.26	-0.0188
2018	3,710.98	3,709.26	-0.0463
2019	3,715.16	3,713.32	-0.0496
2020	3,498.47	3,496.27	-0.0627
2021	3,457.69	3,457.66	-0.0008
2022	3,342.97	3,343.17	0.0058
2023		3,236.47	

Table 3.21 The effects of recalculations of CH_4 emissions in Other subcategory

The effects of recalculations of CO_2 emissions in Oil - Other subcategory			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions (kt)		
1995	35.33	35.67	0.95
1996	47.11	47.56	0.95
1997	61.83	62.42	0.95
1998	471.07	475.56	0.95
1999	344.47	347.75	0.95
2000	594.72	600.39	0.95
2001	200.20	202.11	0.95
2002	279.70	282.36	0.95
2003	468.12	472.59	0.95
2004	571.17	576.61	0.95
2005	812.59	820.34	0.95
2006	1,104.07	1,114.59	0.95
2007	968.63	977.86	0.95
2010	918.25	918.25	-0.00000019
2011	640.72	640.72	-0.00000001
2012	612.78	612.78	0.00000008
2023		545.46	

Oil - Other (1.B.2.a.6)

Recalculations were made for the 1995-2007 and 2010-2012 periods for CO_2 emissions following the update of the NCVs values.

Table 3.22 The effects of recalculations of CO_2 emissions in Natural Gas – Transmission and storage subcategory

The effects of recalculations of CO_2 and CH_4 emissions in Natural Gas – Transmission and storage subcategory						
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions (kt)			**CH_4 emissions (kt)**		
2022	0.01075232	0.01075217	-0.001	3.31320	3.31317	-0.001
2023		0.01			3.31	

Natural Gas - Transmission and storage (1.B.2.b.4)

Recalculations have been made for the 2022 year for CO_2 and CH_4 emissions from the 1.B.2.b.4

Transmission and storage subcategory as a result of updating the activity data regarding Closing stock level (National territory) by the National Institute of Statistics.

Table 3.23 The effects of recalculations of CH_4 emissions in Natural Gas – Other subcategory

The effects of recalculations of CH_4 emissions in Natural Gas – Other subcategory			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CH_4 emissions (kt)		
1990	208.00	208.01	0.002
1991	150.11	150.11	0.002
1992	75.52	75.25	-0.35
1993	75.02	74.82	-0.27
1994	107.27	106.89	-0.36
1995	115.72	115.39	-0.29
1996	111.26	110.97	-0.26
1997	108.57	108.29	-0.26
1998	81.32	80.86	-0.57
1999	78.64	78.10	-0.69
2000	25.55	25.36	-0.74
2001	25.76	25.66	-0.39
2002	27.47	27.19	-1.00
2003	27.84	27.67	-0.60
2004	25.92	25.77	-0.58
2005	26.69	26.56	-0.50
2006	24.88	24.74	-0.59
2007	20.77	20.76	-0.04
2008	21.35	21.33	-0.07
2009	17.27	17.24	-0.16
2010	20.05	20.05	-0.03
2011	22.19	22.18	-0.03
2012	22.26	22.24	-0.07
2013	17.76	17.74	-0.14
2014	17.81	17.78	-0.18
2015	15.49	15.45	-0.25
2016	15.26	15.23	-0.17
2017	15.90	15.87	-0.15
2018	17.34	17.28	-0.35
2019	16.62	16.55	-0.40
2020	17.21	17.13	-0.46
2021	16.97	16.97	-0.01

The effects of recalculations of CH_4 emissions in Natural Gas – Other subcategory			
Years	NIR 2024	NIR 2025	Differences [%]
	CH_4 emissions (kt)		
2022	13.90	13.90	0.05
2023		12.19	

Natural Gas – Other (1.B.2.b.6)

Recalculations have been made for the 1990–2022 period for CH_4 emissions from the 1.B.2.b.6 Natural Gas - Other subcategory as a result of updating the activity data regarding the consumption of natural gas at industrial plants and power stations.

3.3.3.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

3.4 Carbon dioxide transport and storage (CRT 1.C)

CO_2 transport and CO_2 storage are not occurring in Romania.

3.5 Memo items (CRT 1.D)

Multilateral operations (CRT 1.D.2) are not occurring in Romania.

4 Industrial processes and product use (CRT sector 2)

4.1 Overview of the sector and background information

Only the process related emissions are considered in this sector; emissions due to fuel combustion in manufacturing industries are allocated in the Fuel Combustion–Manufacturing Industries and Construction (CRT sector 1.A.2). GHG emissions from Industrial Processes and Product Use are grouped in the following Sub-sectors: Mineral Industry (CRT 2.A), Chemical Industry (CRT 2.B), Metal Industry (CRT 2.C), Non–energy products from fuels and solvent use (CRT 2.D), Electronics Industry (CRT 2.E), Product uses as substitutes for ODS (CRT 2.F), Other product manufacture and use (CRT 2.G) and Other (CRT 2.H). The direct GHG emissions reported in this sector are associated with CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 (see Table 4.1).

Table 4.1 Status of emissions estimation within the Industrial Processes Sector

2 INDUSTRIAL PROCESSES AND PRODUCT USE	**Emissions estimation status**			
IPCC category	**CO_2**	**CH_4**	**N_2O**	**PFC**
2.A.MINERAL INDUSTRY				
2.A.1. CEMENT PRODUCTION	√	NA	NA	NA
2.A.2. LIME PRODUCTION	√	NA	NA	NA
2.A.3. GLASS PRODUCTION	√	NA	NA	NA
2.A.4. OTHER PROCESS USES OF CARBONATES 2.A.4.a. CERAMICS 2.A.4.b. OTHER USES OF CARBONATES 2.A.4.c. NON-METALLURGICAL MAGNESIUM PRODUCTION 2.A.4.d. OTHER	√	NA	NA	NA
2.B. CHEMICAL INDUSTRY				
2.B.1. AMMONIA PRODUCTION	√	NA	NA	NA
2.B.2. NITRIC ACID PRODUCTION	NA	NA	√	NA
2.B.3. ADIPIC ACID PRODUCTION	NO	NO	NO	NO
2.B.4. CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID PRODUCTION 2.B.4.a. CAPROLACTAM	NO	NO	NO	NO

2 INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions estimation status			
IPCC category	**CO_2**	**CH_4**	**N_2O**	**PFC**
2.B.4.b. GLYOXAL 2.B.4.c. GLYOXYLIC ACID				
2.B.5.a. SILICON CARBIDE PRODUCTION	IE	√	NA	NA
2.B.5.b. CALCIUM CARBIDE PRODUCTION	√	NA	NO	NO
2.B.6. TITANIUM DIOXIDE PRODUCTION	NO	NO	NO	NO
2.B.7. SODA ASH PRODUCTION	√	NA	NA	NA
2.B.8. PETROCHEMICAL AND CARBON BLACK PRODUCTION 2.B.8.a. METHANOL 2.B.8.b. ETHYLENE 2.B.8.c. ETHYLENE DICHLORIDE AND VINYL CHLORIDE MONOMER 2.B.8.d. ETHYLENE OXIDE 2.B.8.e. ACRYLONITRILE; 2.B.8.f. CARBON BLACK 2.B.8.g. OTHER	√	√	NA	NA
2.B.9. FLUOROCHEMICAL PRODUCTION	NO	NO	NO	NO
2.B.10. OTHER 2.B.10.a HYDROGEN PRODUCTION	√	NO	NO	NO
2.C. METAL INDUSTRY				
2.C.1 IRON AND STEEL PRODUCTION 2.C.1.a. STEEL 2.C.1.b. PIG IRON 2.C.1.c. DIRECT REDUCED IRON 2.C.1.d. SINTER 2.C.1.e. PELLET 2.C.1.f. OTHER	√	√	NA	NA
2.C.2. FERROALLOYS PRODUCTION	NO	NO	NO	NO
2.C.3. ALUMINIUM PRODUCTION	√	NA	NA	√
2.C.4. MAGNESIUM PRODUCTION	NO	NO	NO	NO
2.C.5. LEAD PRODUCTION	√	NA	NA	NA
2.C.6. ZINC PRODUCTION	√	NA	NA	NA

2 INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions estimation status			
IPCC category	**CO_2**	**CH_4**	**N_2O**	**PFC**
2.C.7. OTHER	NA	NA	NA	NA
2.D. NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE				
2.D.1. LUBRICANT USE	√	NA	NA	NA
2.D.2. PARAFFIN WAX USE	√	NA	NA	NA
2.D.3. OTHER	√	NA, NE	NA, NE	NA, NE
2.E. ELECTRONICS INDUSTRY				
2.E.1. INTEGRATED CIRCUIT OR SEMICONDUCTOR	NO	NO	NO	NO
2.E.2. TFT FLAT PANEL DISPLAY	NO	NO	NO	NO
2.E.3. PHOTOVOLTAICS	NO	NO	NO	NO
2.E.4. HEAT TRANSFER FLUID	NO	NO	NO	NO
2.E.5. OTHER	NO	NO	NO	NO
2.F. PRODUCT USES AS SUBSTITUTES FOR ODS				
2.F.1. REFRIGERATION AND AIR CONDITIONING	NA	NA	NA	√
2.F.2. FOAM BLOWING AGENTS	NA	NA	NA	√
2.F.3. FIRE PROTECTION	NA	NA	NA	√
2.F.4. AEROSOLS	NA	NA	NA	√
2.F.5. SOLVENTS	NA	NA	NA	√
2.F.6. OTHER APPLICATIONS	NA	NA	NA	√
2.G. OTHER PRODUCT MANUFACTURE AND USE				
2.G.1. ELECTRICAL EQUIPMENT	NO	NO	NO	√
2.G.2. SF_6 AND PFC_S FROM OTHER PRODUCT USE	NO	NO	NO	√
2.G.3. N_2O FROM PRODUCT USES	NO	NO	√	NO
2.G.4. Other	NO	NO	NO	NO
2.H. Other				
2.H.1. PULP AND PAPER	NO	NO	NO	NO
2.H.2. FOOD AND BEVERAGES INDUSTRY	NA	NA	NA	NO
2.H.3. OTHER	NO	NO	NO	NO

In 2023 the GHG emissions from Industrial Processes and Product Use Sector contributed with 8.11% to the total GHG emissions in Romania.

Emissions from this sector estimated in 2023 decreased by 81.30% compared with 1989 and by 18.90% compared with 2022. The decrease from 1989 to 2023 is the result of the restructuration and privatization in various activity sectors. After 1989 the whole Romania recorded a decrease within the Industrial Processes and Product Use because many categories of industrial production have decreased (Chemical Industry, Mineral Industry and Metal Industry):

- after 1989 the whole Romania recorded a decrease within the Industrial Processes, because many categories of industrial production have decreased (Chemical Industry, Mineral Industry and Metal Industry);
- starting with 2008 the emissions mainly decreased due to the reduction of various productions;
- starting with 2004 the Cement Production has recorded a minor increase.
- in 2009 a significant decrease of emissions level was recorded in cement, lime, limestone and dolomite, soda ash and glass industries due to the economic crisis;
- in 2010–2011 the emissions have recorded an increase due to increase of various industry productions (cement production, lime production, limestone and dolomite consumption, ammonia production and iron and steel production sub-sectors);
- in 2014–2016 the emissions increased due to increase of various production activities (cement production, glass production, limestone and dolomite consumption, nitric acid production, calcium carbide consumption, soda ash production, iron and steel production, lead production, product uses as substitutes for ODS sub–sectors-commercial refrigeration, industrial refrigeration, transport refrigeration, mobile air-conditioning, stationary air–conditioning);
- in 2017 the emissions increased due to increase of various production activities (lime production, limestone and dolomite consumption, ammonia production, soda ash production, iron and steel production, lubricant use, petroleum coke use, product uses as substitutes for ODS subsectors – commercial refrigeration, industrial refrigeration, transport refrigeration, mobile air–conditioning, stationary air–conditioning, foam blowing and aerosols category);
- in 2018 the emissions increased due to increase of various production activities (cement production, lime production, limestone and dolomite consumption, ammonia production, iron and steel production, lubricant use, product uses as substitutes for ODS subsectors - commercial refrigeration, industrial refrigeration, transport refrigeration, mobile air-conditioning, stationary air-conditioning and aerosols category);
- the reduction of PFC emissions from production of aluminum due to changes in technology starting with 1997 and 2003;

- in 2019 the emissions decreased due to decrease of various production activities (lime production, glass production, limestone and dolomite consumption, ammonia production, nitric acid production, soda ash production, aluminium production, petroleum coke use, product uses as substitutes for ODS subsectors - domestic refrigeration and stationary air-conditioning);
- in 2020, compared to 2019 there is a minor increase in emissions by total sector due to increase of various production activities (cement production, glass production, ammonia production, product uses as substitutes for ODS subsectors – commercial refrigeration, industrial refrigeration, mobile air-conditioning, SF_6 consumption in electrical equipments). Other activities recorded decreases in their production (lime production, limestone and dolomite consumption, nitric acid production, iron and steel production, aluminium production);
- in 2021 year, compared with 2020 there is a minor increase in emissions by total sector due to increase of various activities level (cement production, lime production, glass production, limestone and dolomite consumption, iron and steel production, aluminium production, lubricant use, petroleum coke use, product uses as substitutes for ODS subsectors – mobile air-conditioning, stationary air–conditioning). Other activities recorded decreases in their production (ammonia production, nitric acid production, solvent use, SF_6 consumption in electrical equipments);
- in 2022 year, compared with 2021 there is a decrease in emissions by total sector due to the decrease of various activities level: cement production (total clinker production and bypass dust production decreased by 7.90%), lime production (decreased by 22.83%), limestone, dolomite and other carbonates consumption (decreased by 5.46%), soda ash use (decreased by 35.26% because one of the largest producers of detergents reduced the consumption of soda ash by half), steel production (decreased by 22.39%); the biggest decreases in production occurred for the ammonia production which decreased by 87.84%, for nitric acid production which decreased by 83.48% and for aluminium production which decreased by 59.91%;
- in 2023 year, compared with 2022 there is a decrease in emissions by total sector due to the decrease of various activities level: lime production (decreased by 26.82%), glass production (decreased by 11.01%), limestone, dolomite and other carbonates consumption (decreased by 22.63%), soda ash use (decreased by 33.58% because one of the largest producers of detergents has closed and one of the largest producers of chemicals has reduced its production), steel production (decreased by 36.49%), ammonia production (decreased by 10.15%), aluminium production (decreased by 19.65%). Nitric acid production increased with 4.98% compared with 2022.

Mineral Industry and Chemical Industry are the two other main contributing Subsectors with 51.14% and 4.63%, respectively, of the total GHG emissions in this sector in 2023. Metal Industry contributes with

16.15% to the total GHG emissions from Industrial Processes and Product Use Sector in 2023. The contribution of Non-energy product from fuels and solvent use Subsector to the overall sector is low: 3.87%. The contribution of Product uses as ODS substitutes Subsector to the overall sector is 23.52%. Other product manufacture and use contributes with 0.69% to the total GHG emissions from Industrial Processes and Product Use Sector in 2023.

In the base year, various Industrial Processes and Product Use Sub–sectors contributions were: Mineral Industry 17.15%, Chemical Industry 28.82%, Metal Industry 50.82%, Non–energy product from fuels and solvent use 3.21%, Product uses as ODS substitutes 0.0003% and Other product manufacture and use 0.0021%.

Figure 4.1 Total GHG emissions trend in Industrial Processes and Product Use Sector, for 1989–2023 period

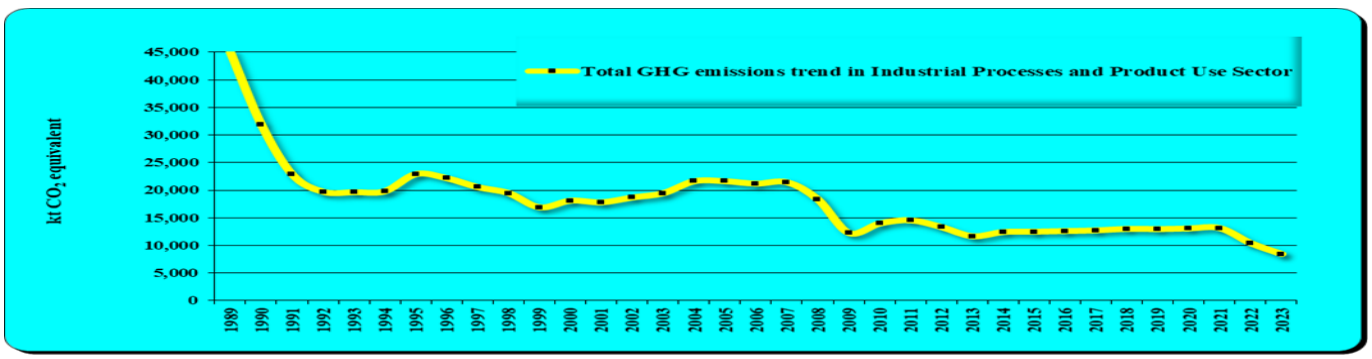


Figure 4.2 GHG emissions trends in in Industrial Processes and Product Use Sector, by sub–sectors, for 1989–2023 period

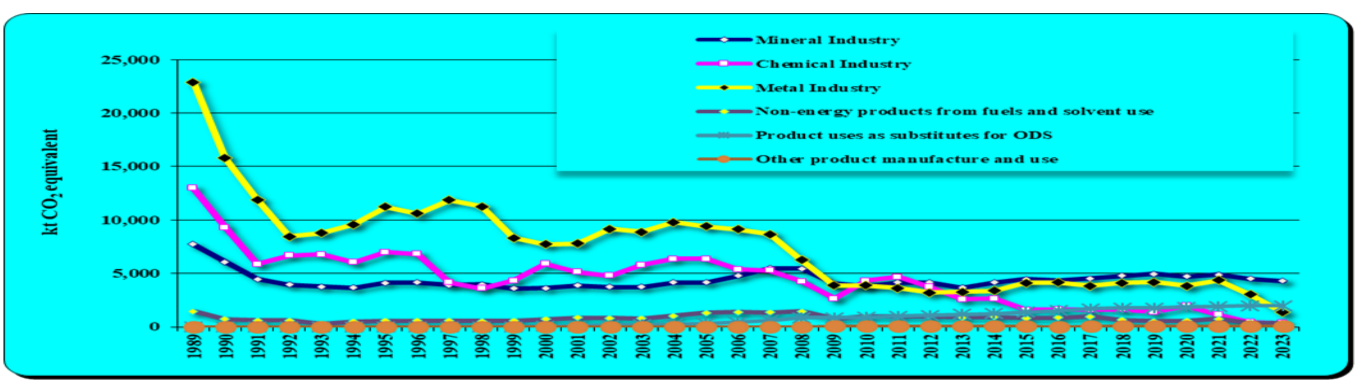
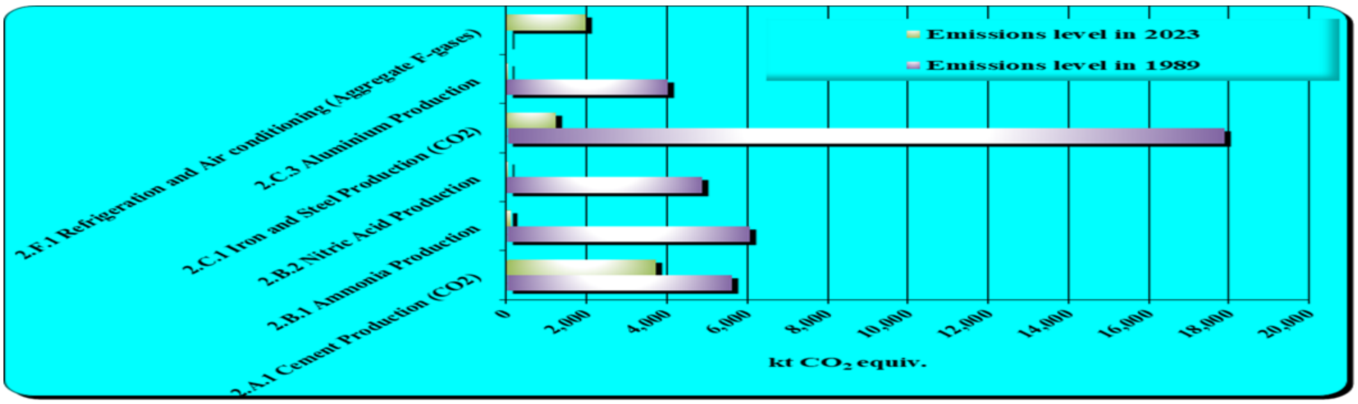


Figure 4.3 Key categories in Industrial Processes and Product Use Sector in 2023 year, both by level and trend criteria



The Tier 1 key category analysis performed for 2023 has revealed the following key categories presented in the Table 4.2.

Table 4.2 Key categories in Industrial Processes and Product Use Sector in 2023 year

Key category	GHG	Criteria (L and/or T)	Contribution in total GHG emissions/removals [%]	Methodological tier used
2.A.1 Cement Production	CO_2	L, T	3.58%	CS, T_2
2.F.1 Refrigeration and Air conditioning	Aggregate F–gases	L, T	1.89%	T_2
2.C.1 Iron and Steel Production	CO_2	L, T	1.20%	T_3
2.B.1 Ammonia Production	CO_2	T	0.09%	T_3
2.B.2 Nitric Acid Production	N_2O	T	0.01%	T_3
2.C.3 Aluminium Production	PFCs	T	0.001%	T_2

4.2 Mineral Industry (CRT 2.A)

4.2.1 Category description

GHG emissions reported include estimates for the following categories: Cement Production (CRT 2.A.1), Lime Production (CRT 2.A.2), Glass Production (CRT 2.A.3), Other Process Uses of Carbonates (CRT

2.A.4). CO_2 emissions from cement production represent an important key category of the inventory because of its contribution to the total inventory emissions level (in 2023 CO_2 emissions from production of cement contributed with 3.58% to total greenhouse gas emissions). In the base year, these emissions accounted for 1.81% from the total GHG emissions. GHG emissions in the Mineral Industry Sub-sector were decreased after 1989 year due to the decrease recorded in Cement Production, Lime Production, Glass Production and Other Process Uses of Carbonates; the emissions were relatively stable during 1993–2005 period. In 2004–2008 period the emissions rised due to increase of cement production, other process uses of carbonates, glass production. In 2009 a significant decrease of emissions level was recorded in cement, lime, limestone and dolomite, soda ash and glass industries due to the economic crisis. In 2015–2018 period the emissions rised due to increase of cement production, other process uses of carbonates, soda ash use. In 2019 the emissions increased due to the increase of the cement production, for the other categories registering a decrease of the emissions. In 2020, emissions decreased as a result of declining lime production, limestone and dolomite consumption and the use of soda ash. There was an increase in emissions for the cement production and glass production categories. In 2021, emissions increased due to the increase of the cement production, lime production, limestone and dolomite consumption and the use of soda ash. In 2022, emissions decreased due to the decrease of the cement production, lime production, limestone and dolomite consumption and the use of soda ash. In 2023, emissions decreased due to the decrease of the lime production, glass production, limestone and dolomite consumption and the use of soda ash.

Mineral Industry Sub-sector was responsible for 51.14% of the Industrial Processes and Product Use Sector related GHG emissions in 2023.

Figure 4.4 GHG emissions trend in the Mineral Industry Sub-sector for 1989–2023 period

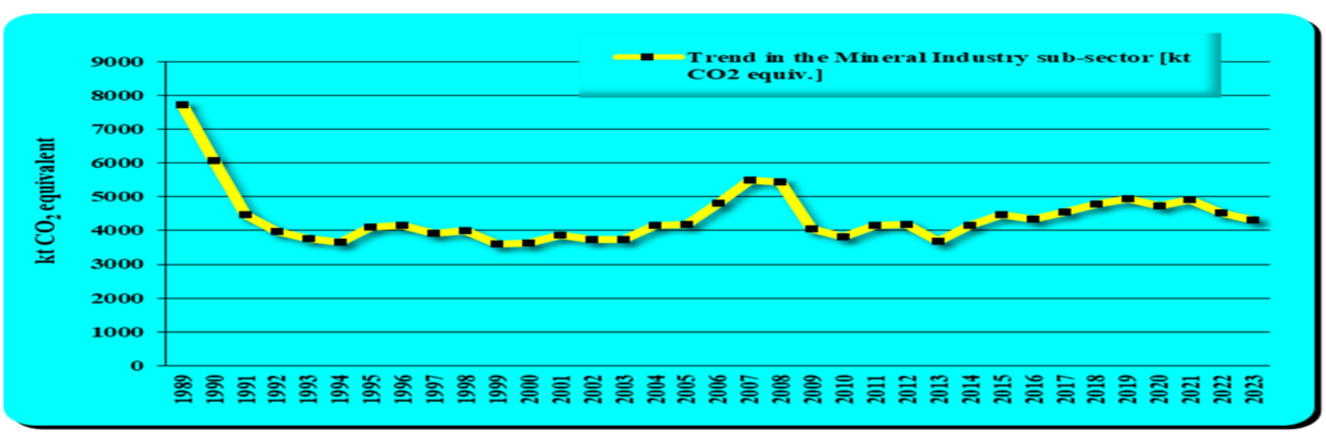
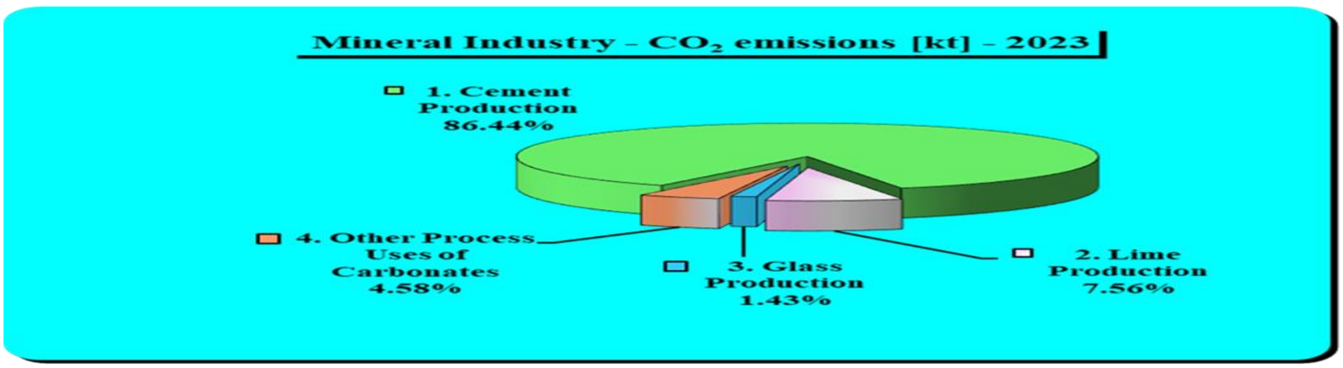


Table 4.3 CO_2 emissions in the Mineral Industry Sub–sector, in the 2023 year

Sector	CO_2 emissions [kt]
2.A Mineral Industry	**4,305.42**
2.A.1 Cement Production	3,721.39
2.A.2 Lime Production	325.49
2.A.3 Glass Production	61.41
2.A.4 Other Process Uses of Carbonates	197.13

Figure 4.5 Structure of the Mineral Industry Sub-sector, in 2023 year



4.2.2 Methodological issues

4.2.2.1 Cement Production (CRT 2.A.1)

Methodology

The Cement Production is a key category from both level and trend point of view (Tier 1, excluding and including LULUCF). The method for calculating emissions of CO_2 from cement is in line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC GL) (Tier 2), considering the "Decision Tree for Estimation of CO_2 Emissions from Cement Production" from 2006 IPCC GL – page 2.9 (Figure 2.1) and taking into account all the parameters described below.

Activity data

The AD necessary to estimate emissions from this source category are provided by the economic agents (clinker production data and bypass dust) and the National Institute for Statistics (Cement Production).

Process specific CO_2 is emitted during the production of clinker (calcination process) when calcium carbonate ($CaCO_3$) is heated in a cement kiln. During this process calcium carbonate is converted into lime (CaO – Calcium Oxide) and CO_2. Activity data related to the calcinations process were collected directly from the companies. Clinker production data was provided by each company for the 1989–2023 period; plant specific contents of CaO and MgO (%) in clinker were provided by each company (according with laboratory analyses) starting with 2008 year. Regarding to cement kiln dust (electrostatic powder that are not reintroduced in the system) for the period 1989–2007, only two of the three operators in the cement industry reported values of correction factor for CKD, one for the period 1989–2007 (values ranging between 1.00 and 1.13) and another operator for 2006 (1.02). For other operator who not reported values for correction factor for CKD was considered value of 1.00. The CKD correction factor values for the period 1989–2007 were used the raported by the operators, and applied to the production of clinker for which were declared values of the correction factor for CKD and value of 1.00 for the production of clinker for which was not declared values for CKD. For the period 2008–2021, following discussions with the cement industry operators, one of them said there was no technology to recover dust from cement kilns. CKD dust is not calcined and correction for CKD is not required. The other two operators recover the CKD dust and reintroduce it into the oven, so it is not lost. For 2022, one of the three operators in the cement industry reported values of correction factor for CKD (values ranging between 0.98 and 0.99), the other two operators declared values of 1 for correction factor for CKD. For 2023, one of the three operators in the cement industry reported values of 1 for correction factor for CKD, for the other two operators who did not declare values for correction factor for CKD, the value 1 was considered. Emissions from CKD are included in clinker emissions. For the calcined CKD dust that is not lost from the system, the correction factor for CKD is considered 1 (according to page 2.12 from 2006 IPCC GL). The only one leaving the system is bypass dust for wich analyzes are performed.

Emission factors

For 1989–2007 the specific EF was calculated considering the average between the default emission factor from the base year 1989 (0.527 t CO_2/t clinker) and the emission factor from 2008 (the first year with laboratory analyses for plant specific CaO and MgO content in clinker), 0.530 t CO_2/t clinker, the resulted specific emission factor is 0.5285 t CO_2/t clinker. Emissions from CKD are included in clinker emissions, using the Equation 2.2 from page 2.9 in according with 2006 IPCC GL methodology. For the period 1989-2007 the correction factor for discarded amounts of dust varies between 1.00 and 1.13. **Starting with 2008**, analyses have been made for CaO and MgO content and can be considered as representative in order to be used for calculating CO_2 emissions or plant specific clinker EF (plant specific content of CaO and MgO – % in clinker was provided by each company – according with laboratory analyses). The weighted average values related with the plant specific content of CaO and MgO – % in clinker for 2020 year are 0.654 for

CaO and 0.013 for MgO. The weighted average values related with the plant specific content of CaO and MgO – % in clinker for 2021 year are 0.642 for CaO and 0.013 for MgO. The weighted average values related with the plant specific content of CaO and MgO – % in clinker for 2022 year are 0.650 for CaO and 0.017 for MgO; for 2023 year these are 0.648 for CaO and 0.018 for MgO.

For the 2008-2023 period, EF for clinker is calculated based on the below presented IPCC formula.

Equation 4.1 Calculation of EF for clinker

$$EF_{clinker} = 0.785 \times CaO_{Content\ (Weight\ Fraction)\ in\ Clinker} + 1.091 \times MgO_{Content\ (Weight\ Fraction)\ in\ Clinker}$$

Starting with 2008 the value of correction factor for discarded amounts of dust is 1 – page 2.12 from 2006 IPCC GL. The only one leaving the system is bypass dust, for wich analyzes are performed for every plant. The total CO_2 emissions from clinker are estimated using a combined **Tier 2** with **country specific method**, by adding **the emissions from clinker production** and **the emissions from bypass dust: Total CO_2 Emissions = CO_2 Emissions from clinker production + CO_2 Emissions from bypass dust.** Emissions were calculated distinctly, for every plant; the activity and, respectively, emissions data were added and reported for the entire subsector. Starting with 2008 the figures related with clinker production, plant specific CO_2 EF for clinker production and CO_2 emissions from clinker production were compared with the data reported in monitoring plans associated with GHG emissions for the **EU–ETS cement production installations**. The difference between emissions from the GHG inventory and verified emissions are due to different emission estimation methodologies. For EU-ETS emissions, the conversion factor is also taken into account.

Table 4.4 Clinker Production data and CO_2 emissions from Clinker Production in the 2008–2023 period

Year	Activity data and CO_2 emissions from Cement Production Sub-sector		
	Clinker production+ Bypass dust production [kt]	Emission factor [tCO_2/t clinker]	Total CO_2 Emissions [kt]
2008	7,813.87	0.5302	4,142.66
2009	5,820.17	0.5314	3,093.07
2010	5,230.61	0.5311	2,777.89
2011	5,803.67	0.5322	3,088.84
2012	5,952.96	0.5292	3,150.25
2013	5,121.42	0.5261	2,694.53

Year	Activity data and CO_2 emissions from Cement Production Sub-sector		
	Clinker production+ Bypass dust production [kt]	Emission factor [tCO_2/t clinker]	Total CO_2 Emissions [kt]
2014	5,583.60	0.5272	2,943.95
2015	6,310.63	0.5289	3,337.47
2016	6,050.64	0.5257	3,181.00
2017	6,322.82	0.5235	3,310.25
2018	6,695.99	0.5234	3,504.83
2019	7,298.95	0.5245	3,828.02
2020	7,473.93	0.5225	3,905.04
2021	7,724.86	0.5129	3,961.86
2022	7,114.45	0.5234	3,723.36
2023	7,113.21	0.5232	3,721.39

4.2.2.2 Lime Production (CRT 2.A.2)

Methodology

Total CO_2 emissions from Lime Production were estimated using production data and the emission factors, in line with the 2006 IPCC GL (Tier 2 method), considering the "Decision Tree for Lime Production" from 2006 IPCC GL – page 2.20 (Figure 2.2) and taking into account the information from "Table 2.4 – Basic Parameters for the Calculation of Emission Factors for Lime Production" – page 2.22 in according with 2006 IPCC GL methodology.

Activity data

According to the Tier 2 method from the IPCC 2006 Guidelines, for the category CRT 2.A.2. – Lime Production needs the collection of data and information from economic operators based on questionnaires for the period 1989–2023. The data received from economic operators were centralized for each year.

For the production of dolomitic lime, two questionnaires completed were received from two operators, one for the period 2001–2007 (since 2008 the dolomite lime factory has been closed) and an other questionnaire for 2015 year. For the period 1989–2004, a single economic unit reported and it reported only the value of production of quicklime.

Estimating the calcium quicklime quantity produced in the period 1989–2023

Due to differences given by production data reported by the NIS and to the data collected, the estimation of the activity data upon the quantity of calcium quicklime produced during the period 1989–2018 was divided into two periods:

- 1989–2008, for which the activity data reported by the NIS was used, after being adjusted with a correction factor;
- 2009–2018 for which the annual activity data was used (calcium quicklime quantity) collected from economic operators based on questionnaires.

The calculation of the correction factor was made taking into account the collected data and the data reported by the NIS. The stages undergone are the following:

- Determining the percentage of the calcium quicklime produced (data collected) from the total lime reported by the NIS for the years 2009–2016. The value of these percentages varies between 54.43% in 2016 and 71.60% in 2014;
- Calculating the average weighted value of this correction factor for the years 2009–2016;
- Applying the correction factor value (62.33%) for the production data related to the calcium quicklime produced and reported by the NIS for the years 1989–2008.

For 2019–2023 period, the annual activity data was used, namely calcium quicklime quantity collected from economic operators based on questionnaires.

Estimating the quantity of dolomitic lime during the period 1989–2023

In order to estimate the quantity of dolomitic lime produced, the NIS data was used because the data collected from the economic operators were not sufficient (one single operator reported for the period 2001–2007 and other operator reported for the 2015 year). Between 2013–2014 and 2016–2023 there was no dolomite lime production.

Emission factors

In the case of Tier 2 method, the emission factor for each type of lime reflecting the stoichiometric relation between CO_2 and CaO or CaO•MgO adjusted with the content of CaO or CaO•MgO of lime. Also, it is necessary to know the structure of the national production on types of lime. A good practice is considered the development of emission factors considering the CaO or the CaO•MgO of lime.

For the above, we used the Equations 2.9 from Chapter 2 – page 2.23 in according with IPCC 2006 methodology.

Stoichiometric ratio

For calcium lime, the value of the stoichiometric ratio used is 0.785 t CO_2/t CaO, the default value presented in the 2006 IPCC Guidelines. For dolomitic lime, the value of the stoichiometric ratio used is 0.913 t CO_2/t CaO•MgO, the default value presented in the 2006 IPCC Guidelines (see Table 2.4 from Chapter 2 - page 2.22 from 2006 IPCC Guidelines).

The CaO or CaO•MgO content in the lime

The default value of CaO content in the high-calcium lime presented in IPCC 2006 is 0.95 t CaO/t calcium lime. This value depends on the combustion level of the limestone, the content of impurities and its final destination. In the data reported by lime producers, the CaO content parameter values vary between 0.8200 t CaO / t calcium lime and 0.9676 t / t calcium lime. For each of the 2005–2018 years was calculated the average value (as a weighted average) of this parameter and is vary between 0.9231 t CaO / t calcium lime for 2005 year and 0.9309 t CaO / t calcium lime for 2018 year. The value of CaO content in the calcium lime that will be used for the rest of the data series was calculated as a weighted average value. The period selected was 2009–2013 because the number of values collected are improved and remained steady. To determine the possibility of using the value of 0.9013 of the CaO content in the calcium lime an analysis was performed upon the activity data representation for which values have been reported. Thus, during the 2009–2013 period, the activity data for which values of the CaO content in the calcium lime have been provided are between 88% for the 2009 year and 93% for the 2013 year from the activity data collected. It can be considered that a value of the representativeness of approximately 90% is adequate so that the calculated value of the CaO content can be used as a national value for this parameter. For 2020, the average content of CaO in the high calcium lime was 0.9327 t CaO/t calcium lime. For 2021, the average content of CaO in the high calcium lime was 0.9322 t CaO/t calcium lime. For 2022, the average content of CaO in the high calcium lime was 0.9378 t CaO/t calcium lime. For 2023, the average content of CaO in the high calcium lime was 0.9188 t CaO/t calcium lime. Under these conditions, for estimating CO_2 emissions it is recommended to use the following values:

Table 4.5 Average content of CaO in the high calcium lime

Year	***Average content of CaO in the high calcium lime***
1989–2008	0.9013
2009	0.9057
2010	0.8976
2011	0.8990
2012	0.8995
2013	0.9054
2014	0.9232
2015	0.9295
2016	0.9259

Year	*Average content of CaO in the high calcium lime*
2017	0.9306
2018	0.9309
2019	0.9274
2020	0.9327
2021	0.9322
2022	0.9378
2023	0.9188

No data were completed related to values determined by the economic operators for the CaO•MgO content in the dolomitic lime, only by an operator for the year 2015. It is suggested that the implicit value of the CaO•MgO of the dolomitic lime be use.

The correction factor for lime dust

For the correction factor parameter for lime dust, the calculation is based on the amount of lime dust collected. This parameter was supplied by a single operator. In this situation it is recommended to applied an implicit correction factor of 1.02 to the CO_2 emissions calculated in according with 2006 IPCC Guidelines – Chapter 2 – page 2.24.

Estimating the CO_2 emission levels for the calcium lime production and for the dolomitic lime production

In order to estimate the CO_2 emission levels resulted at the production of calcium lime and dolomitic lime, we use the Equation 2.6 from Chapter 2 – 2006 IPCC Guidelines – page 2.21.

Table 4.6 Lime production and CO_2 emissions from Lime Production in the period 1989–2023

Year	Calcium lime production	Dolomitic lime production	Emissions from Lime Production Sub–sector
	kt	kt	CO_2 emissions [kt]
1989	2482.49	147.83	1,885.65
1990	1887.26	137.76	1,449.69
1995	1098.83	80.28	844.10
2000	1038.37	221.20	890.24
2005	1116.28	162.22	908.89
2007	1273.97	474.36	1,221.51
2008	1354.99	149.79	1,073.24

Year	Calcium lime production	Dolomitic lime production	Emissions from Lime Production Sub–sector
	kt	kt	CO_2 emissions [kt]
2009	1052.01	21.05	776.29
2010	1160.86	10.56	841.07
2011	1159.20	1.35	835.26
2012	1000.64	0.25	720.84
2013	964.39	NO	699.14
2014	1233.42	NO	911.80
2015	1049.37	0.82	781.51
2016	1061.93	NO	787.32
2017	1124.86	NO	838.14
2018	1164.71	NO	868.14
2019	1024.40	NO	760.72
2020	694.67	NO	518.78
2021	783.44	NO	584.77
2022	604.59	NO	453.97
2023	442.41	NO	325.49

In 2020 compared to 2019, there is a decrease in CO_2 emissions by 32%. This decrease is due to the decrease in the amount of lime produced by captive producers (one operator did not have lime production in 2020, another operator reduced its lime production by about 53% in 2020 compared to 2019). In 2021 compared to 2020, there is an increase in CO_2 emissions due to the increase in lime production by 12.78% in 2021 compared to 2020. In 2022, there is an decrease in CO_2 emissions due to the decrease in lime production by 22.83% compared to 2021. In 2023, there is an decrease in CO_2 emissions due to the decrease in lime production by 26.82% compared to 2022.

4.2.2.3 Glass Production (CRT 2.A.3)

Methodology

Total CO_2 emissions from Glass production were estimated using production data and the emission factors, in line with the 2006 IPCC GL (Tier 2 method), considering the “The decision tree for estimating CO_2 emissions resulted from glass production” – page 2.29 (Figure 2.3) and the Equation 2.11 – page 2.28 from 2006 IPCC GL methodology. Estimating the CO_2 emissions associated to the Mineral Industry sub-sector

(CRT 2.A) – Glass Production category (CRT 2.A.3) is based on the yearly national production (structured on types of glass) for each year (1989–2023) and correction factors for the quantity of cullet reintroduced in the process.

Activity data

According to Tier 2 method from the IPCC 2006 Guide for the category CRT 2.A.3. – Glass production, was collected data and information from economic operators based on questionnaires for the period 1989–2022. Four major glass producers submitted completed questionnaires. For the three glass categories produced in Romania were made comparisons between the activity data received from economic operators with the activity data from NIS. Thus the comparative analysis for the quantity of glass produced for plain/float glass, the following are observed:

- For the period 1989–2005 no activity data were reported by economic operators;
- The quantity of glass from the NIS data is higher during the period between 2005 and 2009, due to the high level of data collected and due to the fact that several economic operators were functioning;
- For the period 2010–2013 the data collected are close to the ones presented by the NIS which indicates a good identification of the NIS category. The existing differences are owed to the fact that data collected from the operators are the melted glass quantity and the NIS reports the sold glass quantity.

The comparative analysis performed, for keeping the consistency of the inventory for the period 1989–2012 the NIS data were used in estimating CO_2 emissions afferent to the plain/ float glass production. For the period 1989–2002 the data series are represented by those obtained by extrapolation, on the base of average percentages calculated for the period 2003–2012. For the period 2013–2023 the activity data collected were used because they represent the quantity of the melted glass and not the one produced. The comparative analysis for the glass quantity produced for glass recipients, the following are observed:

- The glass quantity in the NIS data is higher during the period 1989–2005, due to the level of data collecting and due to the fact that several operators were functioning;
- The glass quantity from the data collected from the economic operators for the period 2006–2022 is higher compared to the ones provided by the NIS, due to the fact that data collected from the operators are the melted glass quantity and data from the NIS represent the glass quantity sold. Also, it is observed for the period 2008–2013 that the quantity provided by the NIS represents 86.3% of the glass quantity value reported by the operators.

From the comparative analysis presented above and for keeping the consistency of the inventory for the period 1989–2007, the NIS data were used adjusted with 86.3%. Romania chose the period 2008–2013 to estimate the ratio between the amount of melted glass and that sold declared by the National Institute for Statistics because for this period the ratio is relatively constant compared to the period 1989–2007 in which the ratio varies within very large limits. For the period 2014–2023, this ratio was no longer calculated due to the fact that for this period the amount melted reported by the economic operators was taken into account for the emission calculation.

For the period 2008–2023 the activity data collected were used because they represent the quantity of the melted glass and not the one produced.

The comparative analysis for the glass quantity produced for glass wool shows the following:

- The data provided by the NIS show only one category where mineral wool productions and not only glass wool;
- For the period 1989–2006 there weren't any activity data reported by the economic operators;
- For the period 2008–2012, the glass quantity for the glass wool collected from the economic operators, amounts to 58 % from the value of the mineral wool quantity reported by the NIS.

From the comparative analysis presented above and for keeping the consistency of the inventory for the period 1989–2002 it is recommended to use the data series obtained by extrapolation, on the base of average percentages calculated for the period 2003–2012. For the period 2003–2008 the activity data for glass wool are calculate as a percentage (58%) from the date provided by NIS for the category mineral wool. For the period 2009–2015 and the period 2018–2023 the activity data collected were used because they represent the quantity of melted glass wool. For the 2016 and 2017 years no activity data were reported by economic operators (the mineral wool line did not work during these years).

Emission factors

Emission factors for glass recipients

Though in the level 2, 2006 IPCC method implicit emission factors were used for the glass category produced for recipients, a national factor was calculated. The emissions associated to the technological process were collected from the reports of EU–ETS of the economic operators for the period 2010–2012. The calculated emission factor (average weighted value) is 0.151 t CO_2/t of melted glass. In order to keep the consistency of the inventory, another emission factor was developed, taking into account the quantity of glass pieces reintroduced into the process. Thus, the value to be used is 0.194 t CO_2/t of melted glass, a value which is close to the implicit one.

Emission factor for flat glass

Because in the level 2 IPCC 2006 method, implicit factors are used, for the plain glass category, the implicit value 0.21 t CO_2/t of melted glass will be used.

Emission factor for the glass wool

In the level 2 IPCC 2006 method for the plain glass category, implicit emission factors are used, with the implicit value of 0.25 t CO_2/t melted glass.

Correction factors for the glass recipients

For the glass recipients category the operators provided data afferent to the quantity of the glass pieces reintroduced into the process for the entire period of time analyzed. Thus, the values of the parameter percentage of glass pieces reintroduced into the process will be national values. For the recipients, the average value of the glass percentage reintroduced into the process is 28% and it is lower than the values in Table 2.6, page 2.30 from 2006 IPCC Guidelines.

Correction factor for the flat glass

For the plain glass category the operators provided data afferent to the quantity of glass pieces reintroduced into the process for the period 2007–2013. The average value of this parameter is 17% and it was calculated as an average weighted value. This value is placed in the interval of the values presented in the Table 2.6, page 2.30 from 2006 IPCC Guidelines. For the period 1989–2006 the value of 17% was used, and for the period 2007–2023 the average values reported by the economic operators were used.

Correction factor for the glass wool

For the glass wool category, the operators used the data afferent to the quantity of glass pieces reintroduced into the process for the years 2008–2013. The average value of this parameter is 16.91% and it was calculated as a weighted average value. This value is located in the value interval presented in Table 2.6, page 2.30 from 2006 IPCC Guidelines. For the period 1989–2007 the value of 16.91% was used and for the 2008–2015 and 2018–2023 periods the average values reported by the economic operators were used.

Table 4.7 CO_2 emissions from Glass Production in the 1989–2023 period

Year	Emissions from Glass Production Sub–sector
	CO_2 emissions [kt]
1989	183.29
1990	149.94
1995	97.32
2000	61.85
2005	46.90
2007	74.85
2008	77.29
2009	61.48
2010	68.34

Year	Emissions from Glass Production Sub–sector
	CO_2 emissions [kt]
2011	65.31
2012	62.38
2013	62.29
2014	55.90
2015	58.52
2016	56.64
2017	53.39
2018	50.82
2019	42.41
2020	55.26
2021	66.97
2022	70.74
2023	61.41

4.2.2.4 Other Process Uses of Carbonates (CRT 2.A.4)

Methodology

The method for calculating emissions of CO_2 from Other Process Uses of Carbonates is in line with the 2006 IPCC GL (Tier 2 method), considering the "Decision tree for estimation of CO_2 emissions from other process uses of carbonates" from 2006 IPCC GL – page 2.35 (Figure 2.4) considering four broad source categories: (1) ceramics, (2) other uses of soda ash, (3) non-metallurgical magnesia production, and (4) other uses of carbonates. The method estimates the amount of Other Process Uses of Carbonates in ceramics plants, pulp and paper production, flue gas desulphurisation, water treatment, soap and detergents producers, production of chemicals, for all–time series.

Activity data

The activity data were provided directly by the plants (ceramics plants, pulp and paper production, flue gas desulphurisation, water treatment, soap and detergents producers, production of chemicals). In order to estimate CO_2 emissions from Other Process Uses of Carbonates Sub-sector it was made a questionnaire which it was sent to the Local Environmental Protection Agencies. Each agency manages all economic agents which are in its responsibility (ceramics plants, pulp and paper production, flue gas desulphurisation, water treatment, soap and detergents producers, production of chemicals) in order to complete the needed data. The completed questionnaire has been sent to NEPA where the data are aggregated. The CO_2 emissions from limestone and dolomite consumption in the iron and steel production are reported under 2.C.1 Iron and steel production category. It is considered that lime production activity in sugar factories as an activity neutral in terms of emissions and therefore was corrected in Other Process Uses of Carbonates category by subtracting the amount of limestone used in this sector. In the sugar industry, lime is used in treating diffusion juice, whereas this stage followed by the precipitation of the excess lime by saturation with carbon dioxide and by reshaping the calcium carbonates. By carbonation, the highest quantity of the calcium contained in the diffusion juice, under the shape of whitewash and the calcium which is loosely tied to the sucrose into mono-calcium and bi-calcium sugar transforms into calcium carbonate, releasing sucrose. Whitewash is obtained industrially in sugar factories by hydrating the lime produced by burning chalk. The carbonation gas (the saturation gas) comes from the gases captured in the lime kilns having undergone a purification process. The carbonation gas contains approximately 26–34% CO_2, [Felicia Dima, Sugar Technology, Dunărea de Jos University, Faculty of Food Science and Engineering, 2008, page 40]. The biggest part of the CO_2 produced for the production of limestone is recombined with calcium oxide from the whitewash used for treating diffusion juice and reforms the calcium carbonate [Best Available Techniques (BAT Reference Document for the Production of Cement, Lime and Magnesium Oxide, chapter 2.2.10.3 – lime kilns in the sugar Industry, 2013, page 221]. Thus, for the GHG inventory purpose of estimating process emissions resulted from producing the limestone at the location of the sugar factories, one may consider that the entire quantity of CO_2 produced is absorbed through the carbonation process and consequently there are no CO_2 emissions from producing lime in the industry of sugar. The CO_2 emissions resulting from the lime kiln from the decomposition of the limestone are captured and bubbled into the sucrose solution for purification. Impurities are precipitated in the form of carbonates. The proportion of CO_2 retransformed into carbonates is 100%. CO_2 emissions from the application of carbonates as an amendment to acidic agricultural soils are reported in the Agriculture sector. Following the consideration of the ERT recommendation, Romania revised the CO_2 emission estimates for CRT category 2.A.4 – Other process uses of carbonates, as follows: the CO_2 emissions estimates for the categories 2.A.4.b–2.A.4.d are the same with those reported in the 5.08.2016 submission and recalculate emissions from category 2.A.4.a – Ceramics. Methodology used for recalculation of CO_2 emissions from category 2.A.4.a – Ceramics are presented below. For the period 2007–2023 emissions are estimated taking into account also ETS data and emissions from clay, fly ash and other additives uses. Emissions for 1989–2006 were estimated using overlap method.

CO_2 emissions estimation methodology in the period 2007–2014

For the period 2007–2014, the CO_2 emissions estimates provided in 5.08.2016 submission, were based on data and information provided by both ETS and non–ETS operators, in reports distinct than the ETS reporting; following the use of this approach, differences between the inventory and ETS data were registered for the 2.A.4.a Ceramics category. The emissions estimates provided in 5.08.2016 submission for category 2.A.4.a – Ceramics were calculated based on limestone and dolomite consumption. For the entire period 1989–2014 – CO_2 emissions estimates from fly ash, clay and other additives consumptions were not included. Romania resolved the problem described in the above paragraph by directly including in the inventory the activity data and emissions data reported by ETS operators Tier 3 methodology emissions calculated based on limestone, dolomite, clay, fly ash and other additives consumptions). Additionally, the emissions from non–ETS operators remain unchanged and are based on activity data reported by operators and default emission factors provided through IPCC 2006 (Tier 2). Following identification of large differences between the data reported under ETS and data reported under the GHG inventory, in case of some operators, the initial data-series reported in 5.08.2016 submission has been revised (in order to correct the error). This approach has been used in order to achieve a consistent/homogenous data–series build based on the "approach used in the 5.08.2016" inventory. As a result, the emissions levels for the 2007 and 2010–2014 increased and those associated to the 2008 and 2009 decreased. This new data-series based "approach used in the 5.08.2016" is used to derive a correction factor who will be applied in CO_2 emissions estimates for the period 1989–2006.

CO_2 emissions estimation methodology in the period 1989–2006

In order to ensure the data-series consistency over the entire time-series was used overlapping alternative technique described in IPCC 2006. A correction factor was calculated for each year of the period 2007–2012 as a ration between the "new"-final revised emissions value (using ETS data and including emissions from clay, fly ash and other additives uses) and the "old"-revised value (based only on limestone and dolomite consumption). They were considered the first 6 years, the years near to the period for which emissions will be estimated. The correction factor that will be applied to data series 1989–2006 is calculated as a arithmetic mean of the correction factor for each year in the period 2008–2011 (the values of the 2007 and 2012 have not been included in the average, being extreme values). The correction factor was applied constantly for each year in the period 1989–2006, for emissions levels, according with the following formula and as result the emissions levels increased:

$$y_0 = x_0 \cdot CF$$

y_0 = the recalculated emission estimate computed using the overlap method

x_0 = the estimate developed using the previously used method

CF= correction factor

Also the AD for the period 1989–2006 were recalculate using the same methodology and same correction factor.

Table 4.8 Amount of Other Process Uses of Carbonates and CO_2 emissions in the 1989–2023 period

Year	Activity data and CO_2 emissions from Other Process Uses of Carbonates Sub–sector			
	Limestone, dolomite, clay, fly ash and other additives use (2.A.4.a Ceramics)	Limestone and Dolomite Use (2.A.4.d Other)	Soda ash use (2.A.4.b Other uses of Soda Ash)	CO_2 emission from Other Process Uses of Carbonates
	[kt]			[kt]
1989	10.85	59.22	33.21	44.70
1990	10.86	48.79	28.85	38.31
1995	11.02	24.94	23.94	25.85
2000	11.98	26.57	22.38	26.42
2005	21.33	33.65	36.16	39.47
2007	1,231.10	7.94	42.24	139.63
2008	1,504.38	6.77	30.08	143.79
2009	537.73	0.43	31.67	108.58
2010	345.56	0.39	39.96	125.45
2011	501.24	96.24	33.92	173.27
2012	256.48	316.47	51.75	238.46
2013	1,187.58	287.13	63.34	220.13
2014	1,158.02	312.44	71.90	245.14
2015	1,401.56	363.90	66.23	284.06
2016	1,426.29	449.01	68.67	319.50
2017	1,421.22	559.90	73.00	356.60
2018	1,470.18	554.26	65.90	352.57
2019	1536.28	494.23	53.08	324.56
2020	1,306.32	363.66	38.49	243.31
2021	1,372.22	431.26	43.20	292.23
2022	1,278.86	426.08	27.97	269.38
2023	970.17	349.02	18.58	197.13

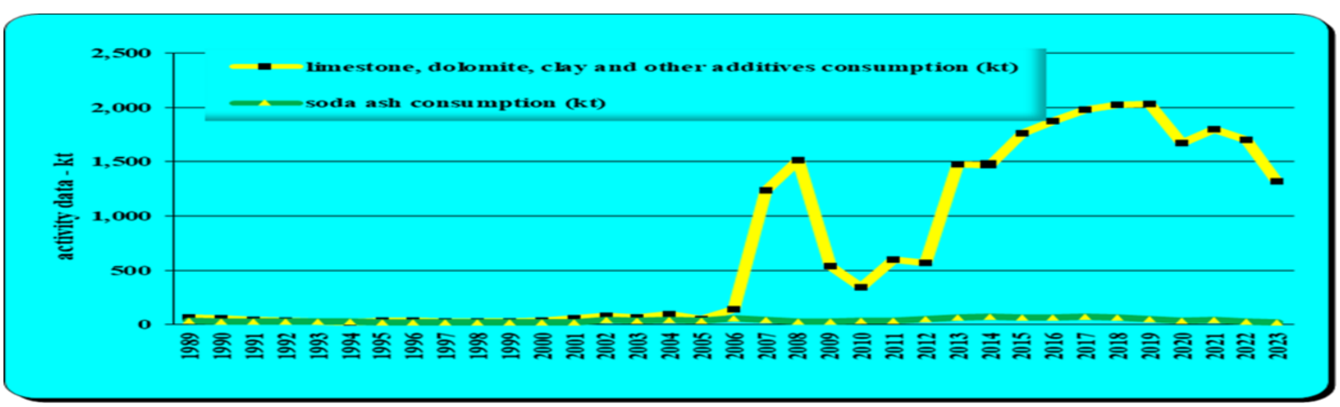
Emission factors

The default emission factors 0.440 t CO_2/t limestone, 0.477 t CO_2/t dolomite, 0.522 t CO_2/t magnesite, 0.415

t CO_2/t soda ash, 0.223 t CO_2/t barium carbonate and 0.318 t CO_2/t potassium carbonate are used. For 2.A.4.a Ceramics category, the variation of the implicit emission factor along the time series is due to the methodology used to estimate the emissions as well as the variation in the level of activity data. The low level of IEF after 2006 is due to the consideration of activity data from ETS operators, activity data that also include clay with different carbon contents, other additives, etc. For category 2.A.4.d, activity data and emissions related to flue gas desulfurization activity using limestone, data provided by ETS operators, are also taken into account. The emission factors are emission factors specific to the installation and have values between 0.412–0.478 t CO_2/t, which leads to a low level of IEF for CO_2 for the years 2017–2023.

In 2020, emissions have declined as consumption has been lower due to reduced pandemic orders. In 2021 compared to 2020, there was an increase in CO_2 emissions due to the increase in the consumption of carbonates in the production of ceramics, in the flue gas desulfurization processes and the increase of soda ash use in the production of detergents and the production of pulp and paper. In 2022 compared to 2021, there was a decrease in CO_2 emissions due to the decrease in the consumption of carbonates in the production of ceramics, in the flue gas desulfurization processes and as result of the decrease in the use of soda ash in the production of detergents (one of the largest producers of detergents reduced the consumption of soda ash by half). In 2023 compared to 2022, there was a decrease in CO_2 emissions due to the decrease in the consumption of carbonates in the production of ceramics, in the flue gas desulfurization processes (decreased by 22.63%) and as result of the decrease in the use of soda ash in the productions of detergents and chemicals (decreased by 33.58% because one of the largest producers of detergents has closed and one of the largest producers of chemicals has reduced its production).

Figure 4.6 Consumption of carbonates from Other Process Uses of Carbonates in the 1989–2023 period



4.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

4.2.4 Uncertainty assessment and time-series consistency

4.2.4.1 Cement Production (CRT 2.A.1)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 2%;
- EF: 2%;
- 2.83% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.2.4.2 Lime Production (CRT 2.A.2)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5%;
- EF: 2%;
- 5.39% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.2.4.3 Glass Production (CRT 2.A.3)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5%;
- EF: 20%;
- 20.62% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.2.4.4 Other Process Uses of Carbonates (CRT 2.A.4)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 3%;
- EF: 2%;
- 3.61% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.2.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

In respect to the Industrial Processes and Product Use Sector – Lime production category, Glass production category and Other process uses of carbonates category, Ms. Mihaela Bălănescu, a senior expert with significant experience related to the GHG industrial emissions, both considering her researcher, industry consultant, study developer, UNFCCC international expert reviewer profile, implemented a series of QA activities.

Following these activities there were unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

Starting with 2008 year the data used in order to estimate CO_2 emissions from clinker production were compared with the data reported in monitoring plans of GHG emissions for the EU–ETS **cement production installations**. The difference between emissions from the GHG inventory and verified emissions are due to different emission estimation methodologies. For EU-ETS emissions, the conversion factor is also taken into account.

The CO_2 emissions from Cement Production, Lime Production, Glass Production and Other Process Uses of Carbonates, were compared with the emissions reported in monitoring plans of GHG emissions for the EU–ETS installations. Further elements are presented within Annex V.12.

4.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

4.2.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

4.3 Chemical Industry (CRT 2.B)

4.3.1 Category description

CRT Sector 2.B includes: Ammonia Production (CRT 2.B.1), Nitric Acid Production (CRT 2.B.2), Adipic Acid Production (CRT 2.B.3), Caprolactam, glyoxal and glyoxylic acid production (CRT 2.B.4), Silicon Carbide Production (CRT 2.B.5.a), Calcium Carbide Production (CRT 2.B.5.b), Titanium dioxide production (CRT 2.B.6), Soda ash production (CRT 2.B.7), Petrochemical and carbon black production (CRT 2.B.8), Fluorochemical production (CRT 2.B.9), Hydrogen production (CRT 2.B.10.a) and Other production (CRT 2.B.10.b). Chemical Industry Sub–sector was responsible for 4.63% of the total Industrial Processes Sector GHG emissions in 2023.

GHG emissions trend in the Chemical Industry Sub-sector for 1989–2023 period is due to:

- lowest level of emissions from the ammonia production was recorded in 1997-1998 period (production decreased by almost 50% compared to the previous and the next year) due to closing of a producing plant in 1998 and closing of another plant in 1998 and reopening it the next year;
- nitric acid production decreased after 1989;
- adipic acid production had stopped at the end of 2001;
- carbide production had recorded a decrease after 1989 and it was stopped starting with 2007;
- for 2007-2009 a significant decrease of emissions level was recorded due to the economic crisis;
- in 2010-2011 the emissions rised due to increase of various production activities (ammonia production, nitric acid production, soda ash production and silicon carbide production);
- in 2012–2018 the emissions decreased due to decrease of various production activities (ammonia production, nitric acid production, carbide production);

- in 2019 the emissions decreased due to decrease of various production activities (ammonia production, nitric acid production, carbide production, soda ash production);
- in 2020 the emissions increased due to increase of various production activities (ammonia production, silicon carbide production);
- in 2021-2022 period the emissions decreased due to decrease of ammonia production and nitric acid production;
- in 2023 the emissions decreased due to decrease of various production activities (ammonia production, silicon carbide production, hydrogen production).

Figure 4.7 GHG emissions trend in the Chemical Industry Sub-sector for 1989–2023 period

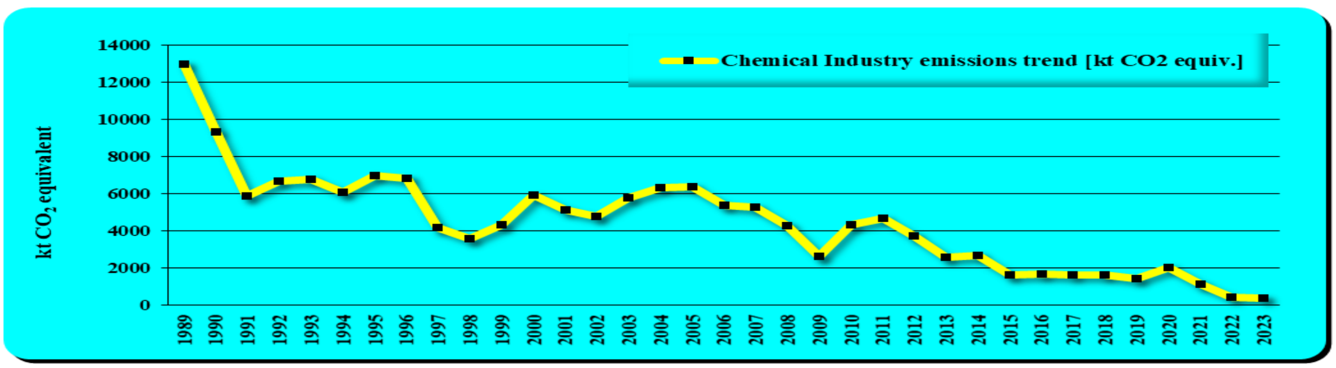


Table 4.9 GHG emissions from the Chemical Industry Sector, in 2023 year

Sector	CO_2	CH_4	N_2O
	[kt] – 2023		
2.B Chemical Industry	**372.27**	**0.11**	**0.06**
2.B.1 Ammonia Production	98.08	NA	NA
2.B.2 Nitric Acid Production	NA	NA	0.06
2.B.3 Adipic Acid Production	NO	NO	NO
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	NO	NO	NO
2.B.5.a Silicon Carbide Production	IE	0.11	NA
2.B.5.b Calcium Carbide Production	5.39	NA	NO
2.B.6 Titanium dioxide production	NO	NO	NO
2.B.7 Soda ash production	NO	NA	NA
2.B.8 Petrochemical and carbon black production	NO	NO	NA

Sector	CO_2	CH_4	N_2O
	[kt] – 2023		
2.B Chemical Industry	**372.27**	**0.11**	**0.06**
2.B.9 Fluorochemical production	NO	NO	NO
2.B.10.a Hydrogen Production	268.80	NO	NO
2.B.10.b Other production	NO	NO	NO

4.3.2 Methodological issues

4.3.2.1 Ammonia Production (CRT 2.B.1)

All the issues related with the Ammonia Production category have been implemented following the elaboration of the study "Elaboration/documentation of national emission factors/other parameters relevant to National Greenhouse Gas Inventory (NGHGI) Sectors Energy, Industrial Processes, Agriculture and Waste, values to allow for the higher tier calculation methods implementation". In all the Romania Ammonia Production installations the **Kellogg process** (see the Annex V.4) is used. This type of technology is based on steam reforming of methane. There are some aspects related with upgrading the installations and the chemical solutions used to absorb carbon dioxide from synthesis gas of ammonia. All the solutions used in absorption of carbon dioxide contain the potassium carbonate–K_2CO_3. Carbon dioxide is resulted from the regeneration process of the absorption solution. Typically, carbon dioxide resulting from the production process is used to manufacture of urea. If urea production plant is not functioning, carbon dioxide is released into the atmosphere.

Methodology

The Ammonia Production is a key category from trend point of view (Tier 1, excluding and including LULUCF). The CO_2 emissions from ammonia production are estimated according to the Tier 3 methodology. In order to estimate the CO_2 emission levels resulted at the production of ammonia production, we use the Equation 3.3 – page 3.13 from Chapter 3 in line with 2006 IPCC methodology. According to as described in Annex V.4, it results that CH_4 emissions from ammonia production are very low and are recycled in the system. According to the questionnaires received from economic operators associated with ammonia plants, there are no fugitive CH_4 emissions and therefore the notation key NA has been used. Within the chemical industry sector, Ammonia Production is one of the most important GHG emission source. The lowest level of emissions was recorded in 1997-1998 period, due to the activity data decreased by almost a half compared to the previous and next year. This happened as one producing plant has stopped its activity since 1998 and another plant has been closed in 1998 and reopened in the next year. In the 2012–2016 period the emissions decreased due to decrease of ammonia production. In the 2017–2018 period the emissions increased due to increase of ammonia production. In 2019 the emissions decreased due to decrease of ammonia production. In 2020, emissions have increased due to the increase in ammonia production (another plant has reopened). In 2021, emissions decreased due to the fact that two of the three economic operators producing ammonia had no production in 2021. In 2022, emissions decreased due to the fact that the ammonia production decreased by 87.84% compared with 2021. Also, in 2023, ammonia production decreased compared to the previous year.

Activity data

In order to estimate de CO_2 emissions have been taking into account the data provided directly from Ammonia Production plant considering the information from the questionnaires completed by all seven economic agents ammonia producers for the 1989–1996 period. In the period 1997–2014 the number of operators that transmitted data varied, hence the trend of emissions. In 2015 two ammonia production plants have ceased its activities, remaining three plants that provided data on the production of ammonia. In 2016 one ammonia production plant have ceased its activities, remaining two plants that provided data on the production of ammonia. In 2020 another plant has reopened, therefore, at the level of 2020 there are three installations producing ammonia. At the level of 2021–2023 period, there was only one ammonia-producing installation.

For each installation there were request the next parameters:

- Annual ammonia production, tonne/year;
- The annual amount of natural gas used as feedstock in Ammonia Production process, m^3/year;
- Carbon content of natural gas used as feedstock in Ammonia Production process, kg carbon/m^3 gas;
- Annual amount of CO_2 resulted from Ammonia Production process with is used in urea production, kg/year;
- Annul amount of urea production, kg/year.

According to the BREF-BAT documentation (source 2.3.2), ch. 2.3.1, table 2.6, division of energy consumption in ammonia production is:

- 71.9% of energy contained in natural gas used as feedstock;
- 28.1% of energy contained in natural gas used as fuel and other energy consumption converted into natural gas.

Based on these percentages, are calculated the annual quantity of natural gas used as fuel in the production ammonia.

Emission factors

In order to estimate the CO_2 emissions inside the Ammonia Production Sub–sector it is used the Equation 3.3 – page 3.13 from Chapter 3 in line with 2006 IPCC methodology.

CO_2 emissions

- Unit measurement: kt CO_2 emissions/ year;
- Carbon dioxide is formed by oxidation of carbon from the fuel (natural gas);
- CO_2 emissions estimation is done by calculations using Tier 3 method, in compliance with 2006 IPCC methodology. CO_2 emissions are calculated based on natural gas consumption (energy and non-energy use). CO_2 emissions from the use of natural gas as fuel were calculated on the basis of the emission factors and net calorific values country specific from the Energy sector (see *Table 3.6 Country–Specific CO_2 emission factors for stationary combustion, oxidation included, from ETS verified reports and Annex V.1 Detailed discussion of meth. and data for estimating CO_2 emissions from fossil fuel combustion_stationary combustion).*

Methodology

Annual amount of natural gas used as feedstock

- Unit measurement: Nm^3/year;
- Amount of natural gas is proportional to the production of ammonia 100% expressed in t / year;
- For accurate calculations, the amount of natural gas used as feedstock is obtained from the operators;
- For the period 2013–2021, in order to ensure consistency with ETS data, activity data on annual amount of natural gas used as feedstock as well as CO_2 emissions from the use of natural gas as feedstock in the ammonia production process were taken from the ETS reports.

Annual amount of natural gas used as fuel

- Unit measurement: Nm^3/year;
- For accurate calculations, for the period 1989–2019, the amount of natural gas used as fuel is obtained from the study "Elaboration/documentation of national emission factors/other parameters relevant to National Greenhouse Gas Inventory (NGHGI) Sectors Energy, Industrial Processes, Agriculture and Waste, values to allow for the higher tier calculation methods implementation", according to the BREF-BAT documentation 28.1% of energy contained in natural gas used as fuel and other energy consumption converted into natural gas;
- For 2020–2023 period, the amount of natural gas used as fuel is obtained from the operators;
- CO_2 emissions from the use of natural gas as fuel were calculated on the basis of the emission factors and net calorific values country specific from the Energy sector.

Total CO_2 emissions are calculated based on natural gas consumption (energy and non–energy use). From CO_2 emissions from ammonia production are substracted, in addition to the CO_2 emissions resulting from the use of urea as a fertilizer, wich are included in the Agriculture sector in H, the annual amounts of CO_2 used for the production of urea exported and for the production of urea used as a reducing agent in the non-catalytic selective reduction of nitrogen oxides (NSCR).

For the year 2022, the amount of CO_2 resulting from the use of urea was divided between the use of urea as a fertilizer in agriculture and the use of urea as a reducing agent in the non-catalytic selective reduction of nitrogen oxides (CO_2 emissions are from the ETS reports).

For the 2021–2022 period, from the CO_2 emissions related to ammonia production is substracted and the amount of CO_2 used for the production of the $CaCO_3$ precipitate obtained in the technological process of producing complex fertilizers, which is included in the 3.G Liming category, in the Agriculture sector.

For 2023 year, from the CO_2 emissions related to ammonia production is substracted the amount of CO_2 used for the production of the $CaCO_3$ precipitate obtained in the technological process of producing complex fertilizers, which is included in the 3.G Liming category, in the Agriculture sector.

Carbon content of natural gas used as feedstock

- Unit measurement: kg C / Nm^3 natural gas;
- In order to convert Nm^3 of natural gas in kg of natural gas, the density of the natural gas was used (ρ= 0.8779 kg/m^3);
- For accurate calculations, the Carbon content of natural gas used as feedstock is obtained from the operators.

Conversion factor of carbon in carbon dioxide

- Unit measurement: dimensionless;

Conversion factor of carbon in carbon dioxide is stoichiometric ratio between molecular weight of carbon dioxide – CO_2 (44) and molecular weight of carbon – C (12). Value is 44/12.

Ammonia annual production

- Unit measurement: t/year (tone Ammonia Production 100%/year);
- Annual production is annually obtained from operators.

Table 4.10 The amount of urea exported in the 1989–2023 period

Year	The amount of urea exported (kt/year)
1989	NO
1990	NO
1991	502.884
1992	920.979
1993	819.905
1994	974.341

Year	The amount of urea exported (kt/year)
1995	1293.808
1996	1340.696
1997	601.196
1998	33.315
1999	396.767
2000	800.772
2001	854.328
2002	697.226
2003	937.608
2004	632.849
2005	987.656
2006	944.571
2007	761.106
2008	645.041
2009	693.045
2010	665.257
2011	898.023
2012	898.268
2013	498.918
2014	467.818
2015	58.622
2016	63.765
2017	164.148
2018	84.12
2019	81.79
2020	351.08
2021	94.71
2022	104.69
2023	156.17

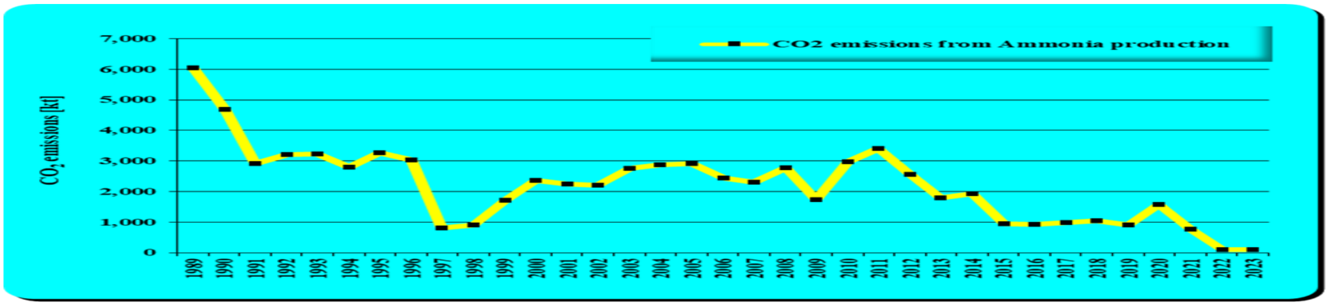
(Source: National Institute of Statistics)

The annual amount of CO_2 used for the production of exported urea is calculated based on the annual amount of CO_2 resulting from the ammonia production process that is further used for the production of urea, the annual amount of urea produced and the amount of exported urea. Due to the fact that the values of these parameters are not constant but vary from year to year, the annual amount of CO_2 used for the production of exported urea varies accordingly.

Table 4.11 Ammonia Production related to the CO_2 emissions in the 1989–2023 period

Year	Activity data and emissions from Ammonia Production Subsector					
	Natural gas consumption [kt]	CO_2 emissions [kt]	The amount of CO_2 resulting from the use of urea as a fertilizer [kt]	The annual amount of CO_2 used for the production of exported urea [kt]	The amount of CO_2 resulting from the use of urea as a catalyst (kt)	The amount of CO_2 used for production of $CaCO_3$ precipitate obtained in the technological process of producing complex fertilizers (kt)
1989	2,707.96	6,053.18	117.30	0.00	0.00	-
1990	2,101.40	4,693.50	115.68	0.00	0.00	-
1995	1,943.01	3,277.39	53.93	1,123.48	0.00	-
2000	1,314.41	2,367.14	42.19	611.45	0.00	-
2005	1,615.83	2,912.85	52.75	755.23	0.00	-
2007	1,279.31	2,315.73	46.81	581.28	0.00	-
2008	1,443.92	2,788.58	49.35	493.33	0.00	-
2009	1,039.08	1,739.78	52.20	556.90	0.00	-
2010	1,504.20	2,981.56	53.91	494.22	0.00	-
2011	1,732.17	3,414.83	55.25	676.75	0.00	-
2012	1,449.87	2,568.81	51.13	1,053.02	0.00	-
2013	974.04	1,801.60	60.65	375.28	0.00	-
2014	1,013.22	1,937.82	53.42	350.79	0.00	-
2015	469.67	945.43	62.95	57.69	0.00	-
2016	459.19	935.95	60.71	48.40	0.00	-
2017	510.63	984.19	67.24	116.51	0.00	-
2018	523.50	1,040.31	82.63	64.86	1.39	-
2019	470.54	914.35	80.40	72.68	1.61	-
2020	859.88	1,586.45	82.67	303.40	1.77	-
2021	C	762.92	94.97	72.93	1.13	52.80
2022	C	99.79	12.94	0.00	1.02	6.10
2023	C	98.08	0.00	0.00	0.00	10.60

Figure 4.8 The trend of CO_2 emissions from ons from Ammonia Production in the 1989–2023 period



4.3.2.2 Nitric Acid Production (CRT 2.B.2)

Methodology

The nitric acid production is a key category from trend point of view (Tier 1, excluding and including LULUCF). The nitrous oxide and nitrogen oxide emissions were estimated according to the “2006 IPCC Guidelines for National Greenhouse Gas Inventories” for each facility and each year of operation between 1989 and 2014, by using, based on the existing activity data, approach level 2 or approach level 3. Approach level 2 was used for nitric acid production facilities that do not have continuous emission monitoring systems. Approach level 3 was used for nitric acid production facilities that have Continuous Emissions Monitoring Systems – CEMS. Emissions have been calculated by multiplying annual Nitric Acid Production (tons HNO_3 100% by each plant) by a default emission factor, which reflects the process, in line with 2006 IPCC GL and CORINAIR Methodology. According with the Decision Tree for N_2O Emissions from Nitric Acid Production from 2006 IPCC GL – page 3.22 (Figure 3.2), in order to use of a higher Tier calculation method it is need to collect the information regarding emissions and destruction data directly from plants.

Activity data

In recent years, most nitric acid production facilities have been fitted with emission reduction and monitoring systems, leading to the drop of emissions. The nitric acid productions submitted by economic agents were compared to the productions acquired from the National Institute of Statistics, and it was discovered that the HNO_3 production registered by the National Institute of Statistics is constantly lower than that reported by the economic agents. This can be explained through the fact that certain economic agents do not report the production values, as they are confidential. There were seven chemical plants in Romania in 1989, with ten nitric acid production facilities. In 2014 year seven facilities were in operation in five chemical plants. Of the seven facilities, only six were equipped with continuous emission monitoring systems. The seven plants were grouped grouped in:

- Medium and high pressure operation facilities (six plants);
- Old facilities, erected before 1975, without NSCR (one plant).

In 2015 year five facilities were in operation in three chemical plants. All installations were equipped with selective catalytic reduction system with continuous emission monitoring system.

In the 2016-2020 period, four facilities were in operation in two chemical plants. All installations were equipped with selective catalytic reduction system with continuous emission monitoring system.

In the 2021 - 2022 period two chemical plants (where four production factories are in operation) produced nitric acid. In 2022, nitric acid production decreased by 83.48% compared with 2021.

In the 2023 year, one chemical plant (where two production factories are in operation) produced nitric acid and nitric acid production increased with 4.98% compared with 2022.

According to the "2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3. Industrial Processes and Product Use", the relevant, specific parameters used to estimate the nitrous oxide emissions in approach level 2 are as follows:

- Nitrous oxide emissions;
- Emission factor;
- Nitric acid production;
- The destruction factor for the reduction technology;
- The reduction technology utilization factor.

According to the "2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3. Industrial Processes and Product Use", on the establishment of continuous emission monitoring systems (CEMS), the relevant, specific parameters for approach level 3 are as follows:

- Nitrous oxide emissions (continuous measurements);
- Emission factor;
- Nitric acid production.

Emission factors

The emission factors used in the spreadsheets for approach level 2 reflect the nitric acid production process:

a) For medium and high pressure facilities – "dual pressure":

- The N_2O default emission factor is 9 kg N_2O/t HNO_3, according to the 2006 IPCC Guideline, table 3.3 (for high pressure plants), in the absence of continuous emission measurements.

b) For old facilities, commissioned before 1975, without a NSCR, operating under low pressure:

- The N_2O emission factor is 10 – 19 kg N_2O/t HNO_3, according to the 2000 IPCC GPG, Table 3.8. The 14.5 kg N_2O/t HNO_3 average value was used for the emission estimate, in the absence of continuous emission measurements. No emission factor is indicated in the 2006 IPCC Guideline for very old low pressure facilities.

Starting with 2015, all the remaining installations applied the level 3 for calculating emissions, all being equipped with continuous emission monitoring systems. The calculation formula used to estimate the N_2O emission levels in the Nitric acid production sub–sector – emissions estimated according to approach level 2 – IPCC 2006 is:

$$EN_2O = \Sigma [EFi * NAPi * (1 – DFj * ASUFj)]$$

where:

- EN_2O = N_2O emissions, expressed in kg/year
- EFi = The N_2O emission factor for the type “i” technology, expressed in N_2O kg / 100% HNO_3 tons

NAPi = Nitric acid production obtained via the type “i” technology, expressed in 100% HNO_3 tons / year

- DFj = The destruction factor for the type “j” technology, expressed in a fraction
- ASUFj = The utilization of the type “j” technology, expressed in a fraction.

The DFj * ASUFj product is the efficiency of the oxide emission reduction system.

In the table below are presented the activity data and N_2O emissions from nitric acid production, by type of technology, but from reason of confidentiality the nitric acid production is not split between both proceses (plants without NSCR and dual pressure type process – ammonia oxidation takes place at medium pressure and absorption takes place at high pressure).

Table 4.12 Nitric Acid Production related to the N_2O emissions in the 1989–2023 period

Years	**Activity data and emissions from Nitric Acid Production Sub–sector**		
	Nitric acid production [kt]	**plants without NSCR**	**dual pressure type process (ammonia oxidation takes place at medium pressure and absorption takes place at high pressure)**
		N_2O Emissions kt]	**N_2O Emissions [kt]**
1989	1,993.70	1.06	17.28
1990	1,260.98	0.81	10.85
1995	1,025.81	0.10	9.17
2000	874.12	0.26	7.70
2005	1,102.14	0.21	9.79
2007	981.38	0.28	8.66
2008	867.39	0.56	3.07
2009	642.48	0.31	1.97

Years	Activity data and emissions from Nitric Acid Production Sub–sector		
	Nitric acid production [kt]	plants without NSCR	dual pressure type process (ammonia oxidation takes place at medium pressure and absorption takes place at high pressure)
		N_2O Emissions kt]	N_2O Emissions [kt]
2010	1,055.38	0.50	3.48
2011	1,076.96	0.68	3.29
2012	983.80	0.55	2.80
2013	949.58	0.23	1.48
2014	1,001.15	0.36	1.00
2015	734.50	NO	1.13
2016	C	NO	1.15
2017	C	NO	0.84
2018	C	NO	0.78
2019	C	NO	0.40
2020	C	NO	0.31
2021	C	NO	0.29
2022	C	NO	0.055
2023	C	NO	0.056

***HNO_3* production trend**

The HNO_3 production trend decreased between 1989 and 2001, following the economic decline; several low–efficiency production capacities were shut down. The HNO_3 production trend increased between 2002 and 2014, following the economic recovery; several production capacities were upgraded. In 2015 the HNO_3 production decreased because two nitric acid production plants have ceased its activities, remaining three plants that provided data on the production of nitric acid. In the 2016–2020 period, four facilities were in operation in two chemical plants. In the 2021–2022 period two chemical plants (where four production factories are in operation) produced nitric acid. In 2022 year, nitric acid production decreased by 83.48% compared with 2021. In 2023 year, nitric acid production increased with 4.98% compared with 2022.

***N_2O* emission level trend**

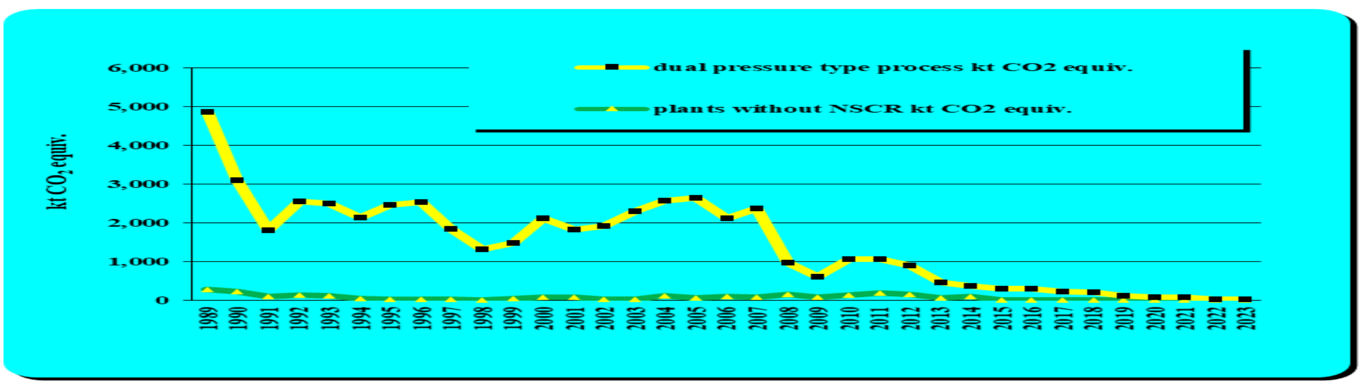
- The emissions decreased between 1989 and 2001, following the decrease of production.
- The emission level was maintained between 2002 and 2007, simultaneous with the production increase. Explanation: technological improvements, catalyst replacement.

- A drop of emissions was registered between 2008 and 2014, while the production level was maintained. Explanation: the mounting of the N_2O reduction systems.
- Starting with 2015, there is a decrease in N_2O emissions from nitric acid production, this is due to the fact that some plants have closed their activity and some have reduced their activity level.

N_2O emission monitoring systems

N_2O emission monitoring systems use analyzers manufactured by internationally renowned companies, designed according to the U.S. EPA 40 CFR 60875 norms and the 2000/76/EC (WID), 2001/80/EC (LCPD) norms. The type of flow analyzers is the MIR 9000 Multi – Gas InfraRed GFC Analyzer. The economic agents have also specified the efficiency of the oxide emission reduction system values in the range of 94.47-96.14% for the 2023 year.

Figure 4.9 The trend of CO_2 emissions from Nitric Acid Production, 1989–2023 period



4.3.2.3 Adipic Acid Production (CRT 2.B.3)

Methodology

The adipic acid production is not a key category. The default methodology has been followed for estimating the emissions from Adipic Acid Production, according with the 2006 IPCC Guidelines for National GHG Inventories.

Activity data

Emissions are estimated based on national statistics for the period 1989–1997, after this year no reports on Adipic Acid Production are made. Based on response from the local Environment Protection Agencies that were requested to provide information on this activity (1998–2001), only one producer has been identified. The facility stopped its activity at the end of 2001. Starting with 2002, this activity is suspended.

Emission factors

Table 4.13 The default EFs used to estimate emissions from Adipic Acid Production

EMISSION FACTORS FOR ADIPIC ACID PRODUCTION (KG/TONNE PRODUCT)
N_2O
300

4.3.2.4 Caprolactam, glyoxal and glyoxylic acid production (CRT 2.B.4)

Methodology

Caprolactam, glyoxal and glyoxylic acid production is not a key category. The method for calculating emissions of N_2O from Caprolactam, Glyoxal and Glyoxylic Acid Production is in line with the 2006 IPCC GL (Tier 1 method), considering the "Decision tree for estimation of N_2O emissions from caprolactam, glyoxal or glyoxylic acid production" from 2006 IPCC GL – page 3.36 (Figure 3.4).

Activity data

The caprolactam production data was provided by the National Institute for Statistics. The N_2O emissions from caprolactam production are estimated for the period 1989–2000. In 2001 the production of caprolactam was stopped. The glyoxal and glyoxylic acid productions are not occurring.

Emission factors

For confidentiality reasons the presentation of N_2O emission factor used to estimate emission from Caprolactam Production is omitted.

4.3.2.5 Silicon Carbide Production (CRT 2.B.5.a)

Methodology

Total CH_4 emissions from Silicon Carbide Production were estimated using the production data and the 2006 IPCC GL emission factor. According with 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 3.44 the default value on CH_4 emission factor was used, considering that the Silicon Carbide Sub-sector is not a key source category. The CO_2 emissions from Silicon Carbide Production are noted as IE because the emissions related with coke consumption are accounted in Energy Sector (1AA2F–Other non–specified – solid fuels subsector). Within the Romanian Energy Balance there are provided the information related with coke consumption on "Manufacture of other non-metallic mineral products", the data are not disaggregated per industry type, the coke consumption being provided from all "Manufacture of other non–metallic mineral products industry" and implicitly for the production of silicon carbide subsector.

Activity data

National Statistics provided annually the amount of Silicon Carbide Production starting with 2003 year. In 2007 the production was stopped and was reopened in 2008. The data related with Silicon Carbide Productions are confidential starting with 2008.

Emission factors

For confidentiality reasons the presentation of CH_4 emission factor used to estimate emission from Silicon Carbide Production is omitted.

4.3.2.6 Calcium Carbide Production (CRT 2.B.5.b)

Methodology

Total CO_2 emissions from Calcium Carbide Production were estimated using the production data and calcium carbide use data and the default emission factor, in line with 2006 IPCC GL. According with 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the default values on CO_2 emission factor were used (Table 3.8, page 3.44), considering that the Calcium Carbide Sub–sector is not a key source category.

Activity data

As activity data, carbide production and carbide use were used. The calcium carbide production data provided by the National Institute for Statistics. The calcium carbide used amount was obtained as balance of production, import and export data provided by the National Institute for Statistics (the amount used equals the production amount plus the imported amount minus the exported amount; for the 2007–2020 period, carbide are not produce, instead, in 2021–2023 period carbide production took place; for 1989, 1990, 1991 and 1993 years calcium carbide was not imported).

Emission factors

According with 2006 IPCC GL in order to estimate CO_2 emission from Calcium Carbide Subsector were used default emission factors provided in production process of calcium carbide: the 1.09 tonnes CO_2/tonne carbide corresponding to the reduction step and the default emission factor of 1.100 tonnes CO_2/tonne carbide corresponding to the use of product. Emissions from the CaO step are reported as emissions from lime production.

Table 4.14 CO_2 emissions from Calcium Carbide Production in the 1989–2023 period

Emissions from Calcium Carbide Subsector			
Years	**CO_2 emissions from Carbide production [kt]**	**CO_2 emissions from Carbide use [kt]**	**Total CO_2 emissions [kt]**
1989	196.20	92.57	288.77
1990	140.61	83.69	224.30
1995	98.10	65.39	163.49
2000	59.95	31.90	91.85
2005	37.06	23.82	60.88
2007	NO	21.68	21.68
2008	NO	13.19	13.19
2009	NO	15.82	15.82
2010	NO	18.35	18.35
2011	NO	13.61	13.61
2012	NO	9.39	9.39
2013	NO	6.59	6.59
2014	NO	0.69	0.69
2015	NO	6.12	6.12
2016	NO	7.45	7.45
2017	NO	5.85	5.85
2018	NO	5.79	5.79
2019	NO	5.69	5.69
2020	NO	4.49	4.49
2021	0.00073	4.4399	4.4407
2022	0.77	4.40	5.17
2023	1.39	4.00	5.39

4.3.2.7 Titanium Dioxide Production (CRT 2.B.6)

Methodology

Titanium dioxide are not produced in Romania and therefore there are no emissions related to this production.

Activity data

Data are requested annually at the National Institute of Statistics, production does not happen in Romania.

Emission factors

The default IPCC emission factors cannot be used because this activity does not take place in the country.

4.3.2.8 Soda Ash Production (CRT 2.B.7)

Methodology

Total CO_2 emissions from Soda Ash Production were estimated using the quantity of trona utilized and the emission factor, in line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the "Decision tree for estimation of CO_2 emissions from natural soda ash production from 2006 IPCC GL – page 3.53 (Figure 3.7).

Activity data

Soda Ash Production data are annually provided by the National Statistics. Starting with 2007 the data related with Soda Ash Production are confidential. In 2020–2023 period, soda ash are not produced in Romania.

Emission factors

For confidentiality reasons the presentation of CO_2 emission factor used to estimate emission from Soda Ash Production is omitted.

Figure 4.10 CO_2 emissions from Soda Ash Production the 1989–2023 period

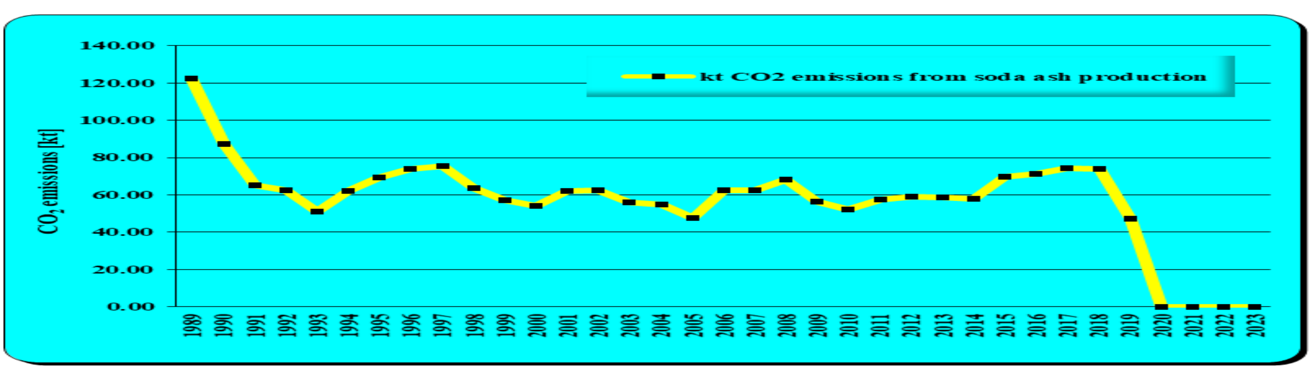


Table 4.15 CO_2 emissions from Soda Ash Production in the 1989–2023 period

Year	**Emissions from Soda Ash Production Sub-sector**
	CO_2 emissions [kt]
1989	122.57
1990	87.14
1995	69.49
2000	53.91
2005	47.70
2007	62.32
2008	68.11
2009	56.39
2010	51.98
2011	57.49
2012	59.01
2013	58.60
2014	57.77
2015	69.63
2016	71.14
2017	74.45
2018	73.90
2019	47.35
2020-2023	NO

4.3.2.9 Petrochemical and carbon black Production (CRT 2.B.8)

Methodology

The CO_2 emissions from Methanol Production were estimated in line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 2 method), considering the "Decision tree for estimation of CO_2 emissions from petrochemical industry and carbon black industry"– page 3.63 (Figure 3.8) and the Equation 3.17 – page 3.67 from 2006 IPCC GL methodology. Total CO_2 emissions from Petrochemical and Carbon Black Production were estimated in line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the "Decision tree for estimation of CO_2 emissions from petrochemical industry and carbon black industry from 2006 IPCC GL – page 3.63 (Figure 3.8). Total CH_4 emissions from from Petrochemical and Carbon Black Production were estimated in line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the "Decision tree for estimation of CH_4 emissions from petrochemical industry and carbon black industry" from 2006 IPCC GL – page 3.64 (Figure 3.9).

Activity data

Institute National of Statistics provided annually the amounts of these production processes (carbon black, ethylene, methanol, acrylonitrile, ethylene dichloride, ethylene oxide, vinyl chloride monomer, propylene, polystyrene, polyethylene, sulphuric acid, phthalic anhydride, polypropylena, polyvinylchloride, 1, 2 dichloroethane). Carbon black, ethylene, acrylonitrile, ethylene dichloride, and ethylene oxide are not produce anymore. In the 2015–2017 period methanol are not produce, instead, in 2018–2019 methanol production took place. In 2020–2023 there was no methanol production in Romania. Starting 2013 year, EU–ETS data on methanol production and related CO_2 emissions are available. The EU–ETS CO_2 emissions are calculated on the basis of the mass balance (Regulation (EU) No 2066/2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Regulation (EU) no. 601/2012 of the Commission), using the tier 2 approach. For the years 2013, 2014, 2018 and 2019, EU–ETS data on methanol production and CO_2 emissions were taken into account. In order to ensure consistency over the entire time series, for the period 1989–2012, in the emissions estimations the IEF calculated for 2014 from EU–ETS data was taken into account, which is much more relevant than the value in 2013 (when production was very low).

Emission factors

For methanol production, the IEFs values calculated for the years 2013 (IEF = 0.707 t CO_2/ t product), 2014 (IEF = 0.484 t CO_2/ t product), 2018 (IEF = 0.627 t CO_2/ t product) and 2019 (IEF = 0.851 t CO_2/ t product) from EU–ETS data are determined by production efficiency. In 2013 methanol production was very low compared to the previous series. For the period 1989–2012, the IEF calculated for 2014 from EU–ETS data, which is much more relevant than the value in 2013 (when production was very low), was taken into account in the emissions estimations. In the case of Romania, ethane was considered as the raw material for ethylene production. Starting with 2007 the data regarding the productions have become confidential. For confidentiality reasons the presentation of emission factors used to estimate emission from those productions are omitted. Emissions of CO_2 and CH_4 were estimated from those productions.

4.3.2.10 Fluorochemical Production (CRT 2.B.9)

Methodology

Fluorochemical are not produced in Romania and therefore there are no fugitive emissions from manufacturing. Additionally, there is no production of other fluorinated gases (HCFC) that could lead to by–product F–gas emissions.

Activity data

This activity is not applicable in the country.

Emission factors

The default IPCC emission factors cannot be used because this activity is not applicable in the country.

4.3.2.11 Hydrogen Production (CRT 2.B.10.a)

Methodology

The method for calculating of CO_2 emissions from Hydrogen Production is in line with the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 3 method) considering the "Decision tree for estimation of CO_2 emissions from hydrogen production" – page 3.45 (Figure 3.20).

The hydrogen is produced by chemical conversion, a process that is based on the catalytic reforming reaction of natural gas / refinery gas in the presence of steam at high temperatures in a reformer.

The chemical reactions that occur are as follows:

$$CnHm + n\ H_2O = n\ CO + (m/2+n)\ H_2\ (1)$$

$$CO + H_2O = CO_2 + H_2\ (2)$$

Reaction (1) is reforming; reaction (2) is exchange conversion.

The separation of hydrogen from the synthesis gas is performed using the PSA system (alternating / oscillating pressure adsorption).

Activity data

In order to estimate de CO_2 emissions have been taking into account the data provided directly from hydrogen production plants considering the information from the questionnaires completed by all four economic operators hydrogen producers. The CO_2 emissions are calculated based on natural gas / refinery gas consumption (energy and non-energy use). Emissions from hydrogen production are calculated by multiplying activity data by emission factors.

For each installation there were request the next parameters:

- The annual amount of natural gas used as feedstock, tonne/year or 1000Nmc/year;

- The annual amount of natural gas used as fuel, tonne/year or 1000Nmc/year;
- The annual amount of refinery gas used as feedstock, tonne/year or 1000Nmc/year;
- The annual amount of refinery gas used as fuel, tonne/year or 1000Nmc/year;
- Emission factor, tonne CO_2/tonne or tonne CO_2/1000Nmc;
- CO_2 emissions resulted from Hydrogen Production process, tonne/year;

Some of the activity data were expressed in tons / year, and another part were expressed in 1000Nmc / year. To determine the total consumption of raw material / fuel (in tonnes / year), for plants that had activity data expressed in 1000Nmc/year, they were converted to tons/year using the absolute density of natural gas under normal temperature and pressure conditions (0.7-0.84 kg/mc). The values of the densities used were requested from the economic operators.

For the period for which EU-ETS data were available, in order to ensure consistency with EU-ETS data, activity data and the associated CO_2 emissions were taken from the EU-ETS reports. There is no information on recovered CO_2 and the amounts of solid carbon stored, so it is assumed that all CO_2 is emitted into the atmosphere.

Annual amount of natural gas used as feedstock and fuel

- Unit measurement: tonne/year or Nm3/year;
- For the 1989-2023 period, natural gas is used as feedstock in hydrogen production plants. For accurate calculations, the amounts of natural gas used as feedstock and fuel are obtained from the operators;
- Starting with 2008, the data on the consumption of natural gas as a feedstock, respectively the associated CO_2 emissions were taken from the EU-ETS reports; CO_2 emissions from the use of natural gas were calculated on the basis of the plant specific emission factors and plant specific net calorific values.
- Regarding the use of natural gas as a fuel in hydrogen plants, the operators have stated its use since 2003. For one of the operators, starting with 2015, the data on the consumption of natural gas as fuel, respectively the associated CO_2 emissions were taken from the EU-ETS reports;
- For previous years, the data were requested directly from economic operators. For cases where emission factors were not available, an emission factor calculated as a weighted average was used in estimating emissions.
- One operator submitted data on the consumption of natural gas as a feedstock in the hydrogen production plant for the period 1989-2023, respectively, data on the consumption of natural gas as a fuel for the period 2003-2023. For the period 1989-2002, the activity data values for the consumption of natural gas as a fuel were calculated by extrapolation based on the ratio between energy use and total use (arithmetic average for the period 2004-2008);
- The second operator submitted data for the period 2007-2010 on the consumption of natural gas as a

feedstock. Starting with 2011, the hydrogen plant ceased its activity;

- The third operator transmitted data on the consumption of natural gas both as feedstock and as fuel for the period 2004-2023;
- The fourth operator transmitted data on the consumption of natural gas as a raw material, respectively as a fuel in hydrogen installations for the period 2014-2023.

Annual amount of refinery gas used as feedstock and fuel

- Unit measurement: tonne/year;
- For the period 2016-2023, one of the installations also used refinery gas as feedstock and as fuel; respectively data on the consumption of refinery gas as a feedstock for the period 2016-2023 and the consumption of refinery gas as and fuel for the period 2014-2023;
- The data on the refinery gas consumption as feedstock and associated CO_2 emissions were taken from the EU ETS reports;
- The data on refinery gas consumption as fuel were requested directly from the operator; operator have stated its use since 2014.

Emission factors

Emission factors used to calculate CO_2 emissions from hydrogen production are plant-specific emission factors.

Figure 4.11 CO_2 emissions from Hydrogen Production in the 1989–2023 period

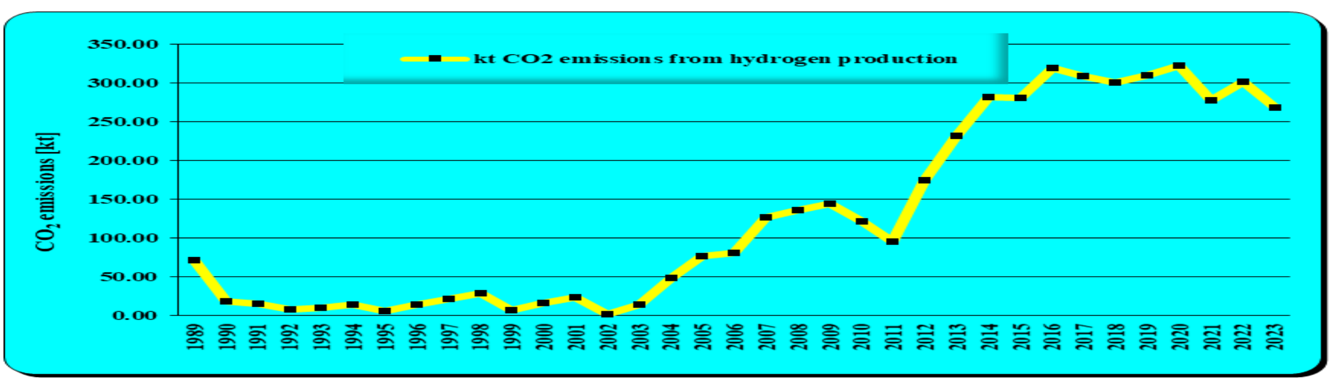


Table 4.16 CO_2 emissions from Hydrogen Production in the 1989–2023 period

Year	Emissions from Hydrogen Production category
	CO_2 emissions [kt]
1989	71.90
1990	18.74

Year	Emissions from Hydrogen Production category
	CO_2 emissions [kt]
1991	16.02
1992	7.98
1993	10.70
1994	14.63
1995	6.48
1996	14.05
1997	21.62
1998	29.19
1999	6.97
2000	16.20
2001	23.85
2002	1.76
2003	14.64
2004	49.04
2005	76.48
2006	81.21
2007	126.76
2008	135.93
2009	144.49
2010	121.97
2011	95.92
2012	174.39
2013	232.08
2014	281.89
2015	281.39
2016	318.99
2017	309.52
2018	300.98
2019	309.88
2020	322.54
2021	278.28
2022	301.93
2023	268.80

4.3.2.12 Other Production (CRT 2.B.10)

Other emissions are not known to be occurring.

4.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG’s do not apply for Romania.

4.3.4 Uncertainty assessment and time-series consistency

4.3.4.1 Ammonia Production (CRT 2.B.1)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 10 %;
- 11.18% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.2 Nitric Acid Production (CRT 2.B.2)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 40 %;
- 40.31 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.3 Adipic Acid Production (CRT 2.B.3)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 15 %;
- EF: 10 %;
- 18.03% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.4 Caprolactam, Glyoxal and Glyoxylic Acid Production (CRT 2.B.4)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 2%;
- EF: 10%;
- 10.20% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.5 Silicon Carbide Production (CRT 2.B.5.a)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5%;
- EF: 0%;
- 5% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.6 Calcium Carbide Production (CRT 2.B.5.b)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5%;
- EF: 2%;
- 5.39% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.7 Titanium Dioxide Production (CRT 2.B.6)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 0%;
- EF: 0%;
- 0% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

4.3.4.8 Soda Ash Production (CRT 2.B.7)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5%;

- EF: 20%;

- 20.62% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.9 Petrochemical and carbon black Production (CRT 2.B.8)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 0 %;
- 5 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.10 Fluorochemical Production (CRT 2.B.9)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 0 %;
- EF: 0 %;
- 0 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

4.3.4.11 Hydrogen Production (CRT 2.B.10.a)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 10 %;
- 11.18% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.3.4.12 Other Production (CRT 2.B.10.b)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 0 %;
- EF: 0 %;
- 0 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

4.3.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament

and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

4.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the emissions estimates quality some important recalculations were made:

- ***CO_2 emissions:***
  - *Ammonia Production (CRT 2.B.1)*
- ***Activity data and CO_2 emissions:***
  - *Hydrogen Production (CRT 2.B.10.a)*

Table 4.17 The effects of recalculations in Chemical Industry Subsector

The effects of recalculations in Chemical Industry Subsector			
Years	NIR 2024	NIR 2025	Differences [%]
	CO_2 emissions [kt]		
1989	12,955.06	12,973.88	0.15
1990	9,321.70	9,324.13	0.03
1991	5,888.10	5,890.74	0.04
1992	6,663.53	6,663.05	-0.01
1993	6,793.81	6,794.27	0.01

The effects of recalculations in Chemical Industry Subsector			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions [kt]		
1994	6,053.82	6,055.79	0.03
1995	6,980.60	6,979.28	-0.02
1996	6,814.81	6,816.25	0.02
1997	4,146.13	4,151.67	0.13
1998	3,587.44	3,596.28	0.25
1999	4,336.92	4,337.62	0.02
2000	5,922.91	5,925.90	0.05
2001	5,117.63	5,123.19	0.11
2002	4,773.86	4,772.29	-0.03
2003	5,799.11	5,796.40	-0.05
2004	6,352.25	6,349.61	-0.04
2005	6,360.46	6,357.60	-0.05
2006	5,392.13	5,389.66	-0.05
2007	5,284.22	5,281.58	-0.05
2008	4,264.81	4,261.26	-0.08
2009	2,641.47	2,639.88	-0.06
2010	4,347.36	4,346.47	-0.02
2011	4,670.13	4,669.12	-0.02
2012	3,749.18	3,749.62	0.01
2013	2,565.84	2,566.06	0.01
2014	2,655.92	2,655.84	-0.003
2015	1,613.81	1,613.92	0.01
2016	1,645.96	1,645.93	-0.002
2017	1,602.10	1,602.06	-0.003
2018	1,641.75	1,641.82	0.004
2019	1,397.18	1,397.42	0.02
2020	2,001.94	2,002.01	0.003
2021	1,133.41	1,133.60	0.02
2022	428.39	428.38	-0.004
2023		390.05	

Table 4.18 The effects of recalculations in Ammonia Production Subsector

The effects of recalculations in Ammonia Production Subsector			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions [kt]		
1989	6,053.18	6,048.38	-0.08
1990	4,693.50	4,689.77	-0.08

The effects of recalculations in Ammonia Production Subsector			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions [kt]		
1991	2,913.36	2,910.74	-0.09
1992	3,216.03	3,212.92	-0.10
1993	3,225.62	3,222.57	-0.09
1994	2,790.23	2,787.40	-0.10
1995	3,277.39	3,273.95	-0.11
1996	3,041.80	3,038.63	-0.10
1997	811.04	809.47	-0.19
1998	903.10	902.34	-0.08
1999	1,722.76	1,721.17	-0.09
2000	2,367.14	2,364.81	-0.10
2001	2,257.83	2,255.55	-0.10
2002	2,211.46	2,209.31	-0.10
2003	2,757.87	2,755.16	-0.10
2004	2,881.60	2,878.96	-0.09
2005	2,912.85	2,909.99	-0.10
2006	2,449.38	2,446.91	-0.10
2007	2,315.73	2,313.09	-0.11
2008	2,788.58	2,785.03	-0.13
2009	1,739.78	1,738.19	-0.09
2010	2,981.56	2,980.67	-0.03
2011	3,414.83	3,413.83	-0.03
2012	2,568.81	2,569.25	0.02
2013	1,801.60	1,801.82	0.01
2014	1,937.82	1,937.74	0.00
2015	945.43	945.55	0.01
2016	935.95	935.92	0.00
2017	984.19	984.15	0.00
2018	1,040.31	1,040.38	0.01
2019	914.35	914.59	0.03
2020	1,586.45	1,586.52	0.00
2021	762.92	763.11	0.02
2022	99.79	99.78	-0.02
2023		98.08	

Ammonia production (2.B.1)

Recalculations were made for the CO_2 emissions, for the period 1989-2022, following the update of the emission factors and NCVs values for natural gas.

Table 4.19 The effects of recalculations in Hydrogen Production category

The effects of recalculations in Hydrogen Production category			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions [kt]		
1989	48.28	71.90	48.92
1990	12.59	18.74	48.92
1991	10.75	16.02	48.92
1992	5.36	7.98	48.92
1993	7.18	10.70	48.92
1994	9.83	14.63	48.92
1995	4.35	6.48	48.92
1996	9.43	14.05	48.92
1997	14.52	21.62	48.92
1998	19.60	29.19	48.92
1999	4.68	6.97	48.92
2000	10.88	16.20	48.92
2001	16.01	23.85	48.92
2002	1.18	1.76	48.92
2023		268.80	

Hydrogen production (2.B.10.a)

Recalculations have been made for the 1989-2002 period as a result of updating activity data on the quantity of natural gas used as fuel.

4.3.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

4.4 Metal Industry (CRT 2.C)

4.4.1 Category description

The emission estimates cover sub-categories Iron and Steel Production (CRT 2.C.1), Ferroalloys Production (CRT 2.C.2), Aluminium Production (CRT 2.C.3), Magnesium Production (CRT 2.C.4), Lead Production (CRT 2.C.5), Zinc Production (CRT 2.C.6) and Other (CRT 2.C.7). The use of SF_6 in Aluminium and

Magnesium Foundries is not applicable in Romania. Metal Industry Subsector is responsible for 16.15% of the total Industrial Processes and Product Use Sector GHG emissions in 2023. CO_2 emissions from Iron and Steel Production represent an important key category of the inventory because of its contribution to the total inventory level (in 2023 CO_2 emissions from production of iron and steel contributed 1.20% to total greenhouse gas emissions). In the base year, these emissions accounted for 5.78% from the total GHG emissions. GHG emissions trend in the Metal Industry Sub-sector for 1989–2023 period is due to:

- iron and steel production recorded decreases after 1989;
- ferroalloys production has recorded a decrease after 1989. The lowest level of emissions was recorded in 1999 due to the cease of production;
- the reduction of PFC emissions from production of aluminium due to changes in technology starting with 1997 and 2003;
- after 2008 the trend of emission decreases due to reduction of production level recorded in iron and steel production, aluminium production and ferroalloys production;
- in 2010–2014 period the emissions trends have recorded an decrease due to decreased of various production activities (iron and steel production, lead production, zinc production and ferroalloys production); starting with 2013 the ferroalloys production was stopped;
- in 2015-2016 period the emissions trends have recorded an increase due to increased of various production activities (iron and steel production, aluminium production, lead production and zinc production);
- in 2017 year the emissions trends have recorded an decrease due to decreased of iron and steel production and aluminium production;
- in 2018 year the emissions trends have recorded an increase due to increased of iron and steel production and aluminium production;
- in 2019 year the emissions trends have recorded an increase due to increased of iron and steel production and lead production;
- in 2020 year the emissions trends have recorded an decrease due to decreased of iron and steel production, aluminium production and lead production;
- in 2021 year the emissions trends have recorded an increase due to increased of iron and steel production, aluminium production and zinc production;
- in 2022-2023 period the emissions trends have recorded an decrease due to decreased of iron and steel production and aluminium production.

Figure 4.12 GHG emissions trend in the Metal Industry Sub–sector for 1989–2023 period

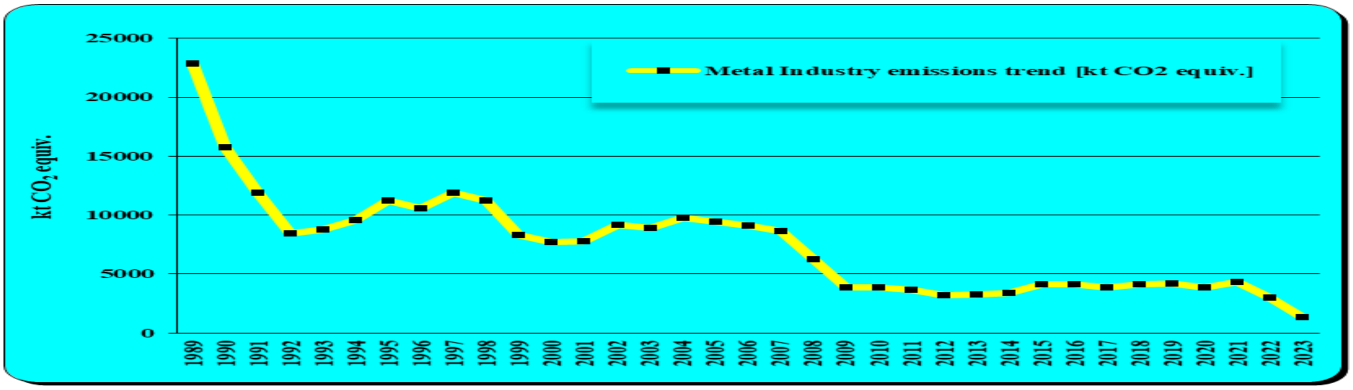
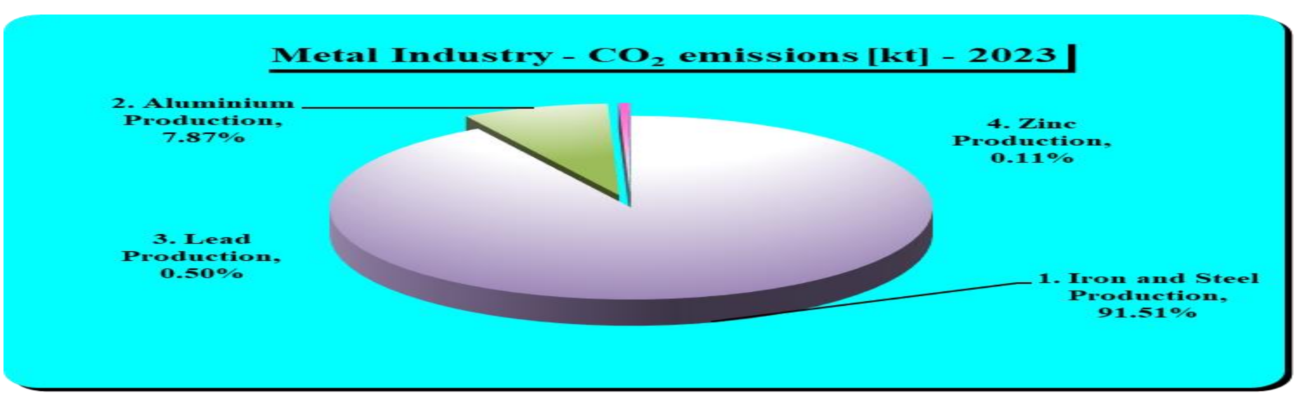


Table 4.20 GHG emissions from Metal Industry Sub–sector, in the 2023 year

Sector	CO_2	CH_4	PFCs
	CO_2 equivalent [kt] – 2023		
2.C Metal Industry	**1,357.69**	**1.48**	**0.81**
2.C.1 Iron and Steel Production	1,243.11	1.48	NA
2.C.2 Ferroalloys Production	NO	NO	NO
2.C.3 Aluminium Production	106.23	NA	0.81
2.C.4 Magnesium Production	NO	NO	NO
2.C.5. Lead Production	6.84	NA	NA
2.C.6. Zinc Production	1.51	NA	NA

Figure 4.13 Structure of the Metal Industry Sub–sector, in 2023 year



4.4.2 Methodological issues

4.4.2.1 Iron and Steel Production (CRT 2.C.1)

Methodology

Iron and Steel Production Sub–sector results in a large amount of CO_2 emissions, and it represents a key category within the Industrial Processes Sub-sector, from both level and trend point of view (Tier 1, excluding and including LULUCF). The method for calculating emissions of CO_2 from Iron and Steel Production is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 3 method), considering the "Decision tree for estimation of CO_2 emissions from iron and steel production" from 2006 IPCC Guidelines – page 4.20 (Figure 4.7) and taking into account all the information provided by each Iron and Steel Production company. Because, for Romania, iron and steel production is key category is required using Tier 3 method. The method for calculating emissions of CH_4 from Iron and Steel Production is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the "Decision tree for estimation of CH_4 emissions from iron and steel production" from 2006 IPCC Guidelines – page 4.20 (Figure 4.8) and taking into account all the information provided by each Iron and Steel Production company.

Activity data

The data collection was performed based on questionnaires sent to the economic agents identified by the Local Agencies for Environmental Protection. Questionnaires were made for the three methods for iron and steel production and they were made in accordance with the requirements of the IPCC 2006 methodology (Tier 3 method). The questionnaire for the assessment of the emissions from iron and steel production on the integrated flow contains requirements for the two subsequent processes: sinter production and iron and steel production in furnaces and basic oxygen furnaces. The questionnaires include elements for the identification of the economic agent, contact data, and request data from the period between 1989 and 2023. The data requested for the assessment of the emissions from sinter production and iron and steel production are shown in the tables below.

Table 4.21 Data requested for the sinter production process

Parameter type	Quantity, t or GJ	Average carbon content, tC/t product or tC/GJ
Iron ore	√	√
Coke breeze	√	√

Parameter type	Quantity, t or GJ	Average carbon content, tC/t product or tC/GJ
Limestone	√	√
Dolime	√	√
Other materials with carbon content	√	√
Sinter produced	√	√
Coke gas used in sinter production	√	√
BF gas used in sinter production	√	√

Table 4.22 Data types for the iron and steel production on the integrated flow

Parameter type	Quantity, t or GJ	Average carbon content, tC/t product or tC/GJ
Sinter	√	√
Coal dust	√	√
Coke	√	√
Limestone	√	√
Dolime	√	√
Other materials (ex. Plastics, coke by-product)	√	√
Scrap iron	√	√
Ferroalloys	√	√
External lime	√	√
Steel	√	√
Pig iron produced and not transformed in steel	√	√
Coke gas used to BF/BOF	√	√
BF gas transferred outside installation (sold)	√	√
BF gas transferred to sinter plant	√	√
Sludge slam furnace	√	√

Since the data requirements for the assessment of the emissions from iron and steel production on the BF–OH flow are similar to those for the BF–BOF flow, there was no separate questionnaire and the questionnaire for the integrated flow were used. The data required for the assessment of the emissions from steelmaking in electric arc furnaces are:

- quantity of scrap iron used in electric furnaces for electric raw steel production, tonnes/year;

- average carbon content of the scrap iron (weighted average), %;
- quantity of raw steel produced in electric furnaces, tonnes/year;
- average carbon content in raw steel (weighted average), %;
- electrode consumption, tonnes/an;
- average carbon content in electrodes (weighted average), %;
- consumption of other carbon content materials, tonnes/year;
- average carbon content on other materials (weighted average), %.

For assessing the emissions from steelmaking in induction furnaces, the following data were requested:

- quantity of reduction agent used for iron production (metallurgical coke, coal, oil coke, coal dust, other), tonnes/year;
- average carbon content in the reduction agent (weighted average), %;
- quantity of iron used for the making of raw steel in induction furnaces, tonnes/year;
- average carbon content in the iron used for making raw steel in induction furnaces (weighted average), %;
- quantity of raw steel made in induction furnaces, tonnes/year;
- average carbon content in the raw steel obtained from iron made in induction furnaces (weighted average), %.

The data requested for the assessment of the emissions from iron/steel production in cupola furnaces are:

- quantity of reduction agent used for iron production (metallurgical coke, coal, oil coke, coal dust, other), tonnes/year
- average carbon content in the reduction agent (weighted average), %.

Since some of the economic agents do not produce iron and steel with a single technology and since the production structure has changed in the last 25 years, the data were centralized according to technology type.

Emission factors

Estimation of CO_2 Emissions for Iron and Steel Production (CRT 2.C.1) for 1989–2023 period

From the analysis of data received against the data from energy balance was decided that given the most complete character of the energy balance for quantities of reduction agents used in EAF, cupola and induction furnaces steel/iron making process, the CO_2 emissions released from this reduction agents will be calculated and reported in the energy sector. Emissions from the use of coke and coal dust from BF-BOF steel are calculated and reported under 2.C.1. category, also emissions from electrode consumption in EAF steel making process.

Estimation of CO_2 emissions for the Integrated Flow

In Romania is only one economic unit which produces iron and steel with the integrated flow. The data production in basic oxygen converters. The emissions of CO_2 were calculated based on the data provided by the economic agent and considering the structure of the data provided. Since the activity data and the carbon contents of the materials provided in the questionnaire on iron and steel production also cover the activity data for the sinter production sector, and considering that such data were reported and checked at EU–ETS, it was decided to use them as basis for the calculation. The CO_2 emissions were calculated with the Tier 3 method presented in IPCC 2006 Guideline, for the period 1989–2023. Where there were no data, the following assumptions were used:

- For the carbon content in the furnace gas and coke gas, specific values of the economic unit calculated in specific studies were used;
- The quantity of coal dust and coke used for the period 1989–2006, was calculated based on the specific quantities used in 2007;
- The quantities of limestone and dolomite used in process for the period 1989–2011 are estimated based on average value of specific quantity (t limestone/t BOF steel and t dolime/t BOF steel) used in the period 2012–2013;
- The average carbon contents for coke, coal dust, limestone, dolomite, and steel for the period 1989–2006 are those in the last year for which there are specific analyses, namely 2007. The carbon content of coke, coal dust, limestone, dolomite and steel for the period 2008–2013 that were taken into account are those declared by the economic operator.

For the period 2014–2023, the emissions from the consumption of iron, ferroalloys and lime were also taken into account in the inventory, these data being available under the EU-ETS. The consistency of the time series is ensured by using the data provided by the only economic operator that produces iron and steel with the integrated flow. The table below shows the CO_2 emissions estimated for the period 1989–2023. For the year 2022, there is a reduction in CO_2 emissions due to the decrease in steel production by 28.83% compared to the year 2021. For the year 2023, there is a reduction in CO_2 emissions due to the decrease in steel production by 58.63% compared to the year 2022.

Table 4.23 CO_2 emissions estimated for the 1989–2023 period

Year	CO_2 emissions [kt]
1989	11,661.95
1990	8,846.24
1995	6,872.59

Year	CO_2 emissions [kt]
2000	5,661.09
2005	8,618.03
2007	7,998.31
2008	5,640.97
2009	3,528.20
2010	3,482.39
2011	3,232.41
2012	2,826.04
2013	2,912.20
2014	3,023.53
2015	3,750.01
2016	3,786.33
2017	3,454.60
2018	3,712.07
2019	3,818.04
2020	3,497.69
2021	4,001.78
2022	2,890.09
2023	1,232.59

Estimation of CO_2 emissions for the Electric Flow

The data used in CO_2 emissions calculation were based on a survey study to all existing steel plants.

Since 1989 in the romanian steel sector a lot of change happens, starting with technological change (e.g. units who close OH and BF and keep only EAF) and owner change (from state to private ownership). The economic crisis from 2008 affect a lot the romanian iron and steel sector and many capacity was worked at low capacity or start an insolvency procedure (e.g. Mechel Group). For this reasons, reporting data by units with necesary plant specific informations (e.g. plant specific carbon content of the scrap or of the carbon electrode) in order to allow the calculation of CO_2 emissions using tier 3 method are poor in the begining of the time serie. Calculation of the CO_2 emissions for the units who reported necessary data (plant specific) was made for each unit and for each year. The total production from the EAF route considered are the one provided by the NIS. In Romania, there are several economic units which produce steel in electric arc furnaces. The emissions of CO_2 were calculated with the Tier 3 method based on the data provided by the economic units and considering the data structure of the data provided by them. For the 2021 NGHGI submission compared to previous submission, for the 2007–2008 and 2010–2018 periods, detailed data on the quantity of raw steel produced in electric furnaces, quantity of scrap iron used in electric furnaces for electric raw steel production, the consumption of electrodes, ferroalloys, lime, dolomite and carbon content were identified in the reports of the EU–ETS operators and were included in the inventory. For the year 2009, data previously collected from economic operators through questionnaires were used to estimate emissions (the amount of scrap used for raw steel production in EAF, raw steel production, electrode consumption and carbon content specific to each parameter). For the 2019–2023 period, EU–ETS data are available (the amount of scrap used for raw steel production in EAF, the amount of raw steel produced in electric furnaces, the amount of scrap iron used in electric furnaces for the production of electric raw steel, consumption of electrodes, ferroalloys, lime, dolomite and specific carbon content). The emissions from the reduction agents used was not take into account, except the electrode consumption. These emissions are calculated and reported under Energy sector. For the calculation of the CO_2 emissions for the units which have not reported enough data and for the units that have been shut down and who have not reported, a weighted emission factor was calculated for each year in the 1989–2023 period. This emission factor was applied to the difference between the quantities provided by NIS (National Institute of Statistics) and the EAF steel production (production with EF) for the 1989–2007 period and for the 2009 year, and to the difference between the quantities provided by operators and the EAF steel production (production with EF) for the 2008 year and for the 2010–2023 period. In 2020, a decrease in steel production in the EAF was registered due to the fact that two large steel producers did not have steel production during this year. In the 2021–2022 period, there was also a reduction in steel production in the EAF, which led to a reduction in CO_2 emissions. The table below shows the CO_2 emissions estimated for the 1989–2023 period.

Table 4.24 CO_2 emissions estimated for the 1989–2023 period

Year	**Total CO_2 emissions EAF [kt]**
1989	224.23
1990	135.04
1995	75.17
2000	51.09
2005	56.33

Year	Total CO_2 emissions EAF [kt]
2007	75.28
2008	53.76
2009	12.25
2010	29.21
2011	26.68
2012	27.86
2013	29.57
2014	30.64
2015	22.21
2016	28.07
2017	36.23
2018	36.75
2019	27.51
2020	14.99
2021	12.20
2022	10.76
2023	10.52

Estimation of CO_2 emissions for steel/iron production in Induction Furnaces

In Romania, there are several economic units which produce steel or iron in induction furnaces. The process of iron and steel making in induction furnaces consist mainly in melting the iron and steel scraps. Considering the fact that emissions from the reduction agents used was not take into account (the emissions are calculated and reported under Energy sector category) and this represent almost all the emissions from this type of steel/pig iron production was assume that are no emissions from this category.

Estimation of CO_2 Emissions for Iron Production in Cupola Furnaces

In Romania, there are several economic units which produce iron in cupola furnaces.

The process of iron making in cupola furnaces consist mainly in melting the iron ore or scraps steel based on reduction agents (coke, coal, different wastes) consumption. Considering the fact that emissions from the reduction agents used was not take into account (the emissions are calculated and reported under Energy sector category) and this represent almost all the emissions from this type of steel/pig iron production was assume that are no emissions from this category.

Estimation of CO_2 Emissions for Steel Production with the OH Flow

In Romania, the steel production in Siemens-Martin furnaces took place in two economic units and was ceased in 1999. However, data have been collected from one of the economic agents, data which are insufficient for the calculation of emissions with the Tier 3 methodology. Therefore, emissions were calculated by applying the default emission factor from IPCC 2006 (1.72 t CO_2/t steel) to the activity data. For the period 1993–1999, the data for Romania provided by World Steel Statistics were used as activity data, and for the period 1989–1992 the data for Romania provided by National Institute for Statistics were used as activity data. The table below shows the CO_2 emissions estimated.

Table 4.25 CO_2 emissions for steel production in OHF

Year	CO_2 emissions [kt]
1989	6,021.72
1990	3,639.52
1991	2,227.40
1992	1,530.80
1993	1,644.32
1994	1,735.48
1995	1,664.96
1996	1,611.64
1997	1,608.20
1998	1,155.84
1999	557.28

Estimation of CO_2 Emissions for Iron and Steel Production (CRT 2.C.1)

CO_2 emissions for Iron and Steel Production during the period 1989–2023, represent the sum of CO_2 emissions for the flows/technologies shown in the previous subchapters. Table 4.26 shows these emissions, as well as the total corresponding to Iron and Steel Production category (CRT 2.C.1). In the emissions from steel production category 2C1a (steel) are also included emissions from the iron production 2C1b.

Table 4.26 CO_2 emissions from Iron and Steel Production for the 1989–2023 period

Year	CO_2 emissions [kt]					Total CO_2 emissions [kt]
	BOF	EAF	CI	Cupola furnace	OHF	
1989	11,661.95	224.23	NO	NO	6,021.72	17,907.89
1990	8,846.24	135.04	NO	NO	3,639.52	12,620.80
1995	6,872.59	75.17	NO	NO	1,664.96	8,612.72
2000	5,661.09	51.09	NO	NO	NO	5,712.18
2005	8,618.03	56.33	NO	NO	NO	8,674.35
2007	7,998.31	75.28	NO	NO	NO	8,073.59
2008	5,640.97	53.76	NO	NO	NO	5,694.73
2009	3,528.20	12.25	NO	NO	NO	3,540.45
2010	3,482.39	29.21	NO	NO	NO	3,511.60
2011	3,232.41	26.68	NO	NO	NO	3,259.08
2012	2,826.04	27.86	NO	NO	NO	2,853.89
2013	2,912.20	29.57	NO	NO	NO	2,941.77
2014	3,023.53	30.64	NO	NO	NO	3,054.17
2015	3,750.01	22.21	NO	NO	NO	3,772.22
2016	3,786.33	28.07	NO	NO	NO	3,814.40
2017	3,454.60	36.23	NO	NO	NO	3,490.83
2018	3,712.07	36.75	NO	NO	NO	3,748.83
2019	3,818.04	27.51	NO	NO	NO	3,845.55
2020	3,497.69	14.99	NO	NO	NO	3,512.67
2021	4,001.78	12.20	NO	NO	NO	4,013.98
2022	2,890.09	10.76	NO	NO	NO	2,900.85
2023	1,232.59	10.52	NO	NO	NO	1,243.11

Figure 4.14 The trend of CO_2 emissions from Iron and Steel Production (BOF, EAF and OHF) in the 1989–2023 period

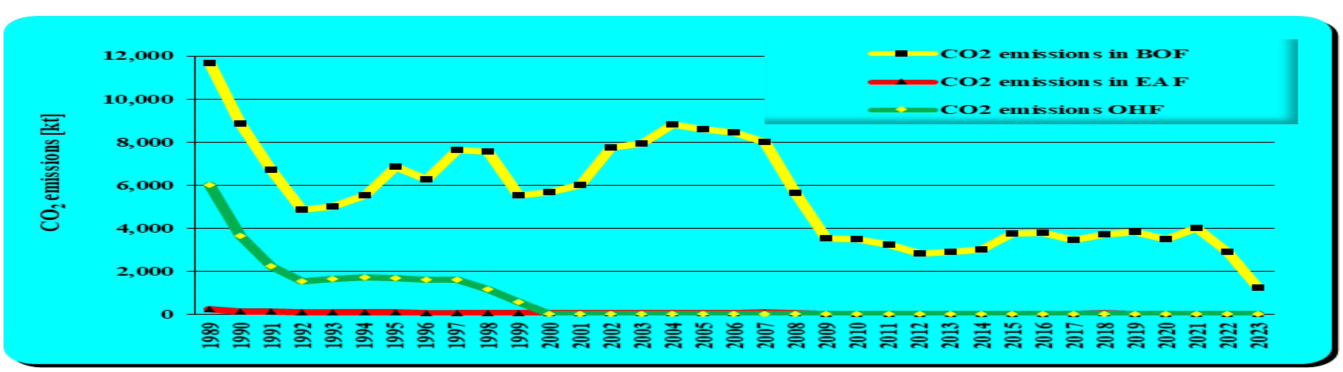
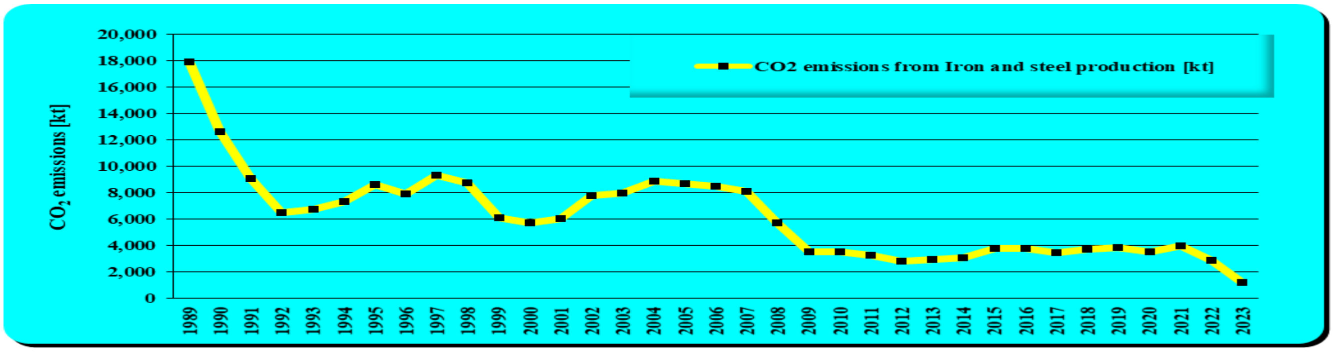


Figure 4.15 The trend of CO_2 emissions from Iron and Steel Production in the 1989–2023 period



Estimation of CH_4 Emissions for Iron and Steel Production (CRT 2.C.1) for the 1989–2023 period

The CH_4 emissions for the period 1989–2023 were estimated based on the Tier 1 methodology in IPCC 2006 (sinter production data x default emission factor). Table 4.27 shows the CH_4 emissions for category CRT 2.C.1 – Iron and Steel Production.

Table 4.27 CH_4 emissions for Iron and Steel production for the 1989–2023 period

Year	Sinter [kt]	Emission factor [kg/t]	CH_4 emissions [kt CO_2 equivalent]
1989	13,626.00	0.07	26.71
1990	11,357.00	0.07	22.26
1995	6,671.00	0.07	13.08
2000	3,875.00	0.07	7.60
2005	6,600.00	0.07	12.94
2007	6,359.22	0.07	12.46
2008	3,445.55	0.07	6.75
2009	1,806.98	0.07	3.54
2010	1,977.60	0.07	3.88
2011	1,841.84	0.07	3.61
2012	1,705.94	0.07	3.34
2013	2,111.45	0.07	4.14
2014	2,165.68	0.07	4.24
2015	2,661.89	0.07	5.22

Year	Sinter [kt]	Emission factor [kg/t]	CH_4 emissions [kt CO_2 equivalent]
2016	2,592.59	0.07	5.08
2017	2,346.47	0.07	4.60
2018	2,458.20	0.07	4.82
2019	2,457.75	0.07	4.82
2020	2,331.37	0.07	4.57
2021	2,466.16	0.07	4.83
2022	1,806.30	0.07	3.54
2023	754.54	0.07	1.48

4.4.2.2 Ferroalloys Production (CRT 2.C.2)

The CO_2 and CH_4 emissions within the Production of Ferroalloys Sub-sector are calculated based on the production volume and the emission factors, in line with 2006 IPCC GL. The Ferroalloys Production Sub–sector is not a key source category. In order to estimate the emission the production data are take into account in a disaggregate manner, by type of products (Ferromanganese Production, Ferrosilicon Production, Silicon Manganese Production, Ferrochromium Production). During de time series the ferroalloys production have decreased therefore there were just Silicon Manganese and Ferrochromium Production, for 2007 and 2008 and only Ferrochromium Production for 2009. In 2010 year the Ferroalloys Production and the CO_2 emissions have increased due to improve the Production of Silicon Manganese. In 2011–2012 period the Ferroalloys Production and the CO_2 emissions have decreased due to decreasing of the Ferrochromium Production. Starting with 2002 year there are no emissions of CH_4 because there was no Ferrosilicon Production. Starting with 2013 the Ferroalloys Production was stopped.

Activity data

The National Statistics reports the Ferroalloys Production for the period 1992–2008, in a disaggregate manner, by type of products. National Institute for Statistics did not provide any data for the periods 1989–1991. The activity data for the beginning of the time series (1989–1991) were provided by Ministry of Economy. The lowest level of emissions was recorded in 1999. This happened because ferroalloys producing plant stopped its activity in 1999 and reopened in the next year. Starting with 2007 the data related with Ferroalloys Production are confidential.

Emission factors

For confidentiality reasons the presentation of CO_2 emission factors used to estimate emission from Ferroalloys Production are omitted.

Table 4.28 CO_2 emission from Ferroalloys Production in the 1989–2023 period

Years	Emissions from Ferroalloys Production Subsector
	CO_2 emissions [kt]
1989	451.72
1990	313.06
1995	213.79
2000	123.07
2005	165.55
2007	37.62
2008	19.21
2009	19.99
2010	43.97
2011	32.98
2012	19.11
2013-2023	NO

Table 4.29 CH_4 emission from Ferroalloys Production in the 1989–2023 period

Years	Emissions from Ferroalloys Production Subsector
	CH_4 emissions [kt]
1989	0.07
1990	0.05
1995	0.02
2000	0.01
2002-2023	NO

4.4.2.3 Aluminium Production (CRT 2.C.3)

Methodology

The Aluminium Production is a key category from trend point of view (Tier 1, excluding and including LULUCF) for PFCs emissions. Primary Aluminium Production is carried out in one facility in Romania, where the pre–baked process is used. The most significant emissions process resulted are:

- **Carbon dioxide (CO_2)** emissions resulted from the consumption of carbon anodes in the reaction to convert aluminum oxide to aluminum metal;
- **Perfluorocarbons (PFCs)** emissions of **CF_4** and **C_2F_6** during anode effects.

The PFC process emissions calculation taking into account the technology use within the facility along the time period 1989–2023:

- From **1989 to 1996**, the technology used was **SWPB** (Side Worked Pre-baked);
- From **1997 to 2002** the combined technology was used **(SWPB and CWPB)** in different percentages;
- **Starting with 2003**, the technology was changed to **CWPB** (Centre Worked Pre–baked).
- For the period **1989–2002 the CO_2** emissions within the production of primary aluminium are calculated based on the production volume in line with **IPCC 2006 Methodology (Tier 1 Method)** and the **PFC emissions** from aluminium production are calculated in line with **IPCC 2006 Methodology (Tier 1 Method) for CF_4** emissions and also **IPCC 2006 Methodology (Tier 2 Method) for C_2F_6 emissions**, considering the type of technology use within the facility.
- **Starting with 2003 the CO_2** emissions within the production of primary aluminium are calculated in line with **IPCC 2006 Methodology (Tier 3 Method)** and the **PFC emissions** are calculated based on **IPCC 2006 Methodology (Tier 2 Method)** using the technology specific over voltage coefficient and weight fraction C_2F_6/CF_4 from **IPCC 2006 Methodology (Tier 2 Method)**.

Activity data

Along the time period (1989–2023), the emissions processes within the Production of Primary Aluminium are calculated used the specific operating facility data in order to respect the IPCC Methodology as following:

- For the period **1989–1996** the technology used was **SWPB** (Side Worked Pre-baked). In this period the **CO_2 emissions** are calculated based on **Aluminium Production** in line with **IPCC 2006 Methodology (Tier 1 Method).** The calculation of CO_2 emissions does not include the emissions from anode baking. The **PFC emissions** are calculated based also on **Aluminium Production** and taking into account the **technology use** within the facility, in line with **IPCC 2006 Methodology (Tier 1 Method) for CF_4 emissions and IPCC 2006 Methodology (Tier 2 Method) for C_2F_6** emissions;
- **From 1997 to 2002** the combined technology was used: **SWPB** (Side Worked Pre-baked) and **CWPB** (Center Worked Prebaked) in different percentages. **The CO_2 emissions** are also calculated based on **Aluminium Production** in line with **IPCC 2006 Methodology (Tier 1 Method).** The calculation of CO_2 emissions does not include the emissions from anode baking. For the period 1997-2002, the emissions resulting from the decomposition of sodium carbonate were not included in the CO_2 emissions. The **PFC emissions** for this period were estimated based on **Aluminium Production** and taking into account a

weighted average of the two **constants related technologies** applied SWPB and CWPB, in line with **IPCC 2006 Methodology (Tier 1 Method) for CF_4 emissions and IPCC 2006 Methodology (Tier 2 Method) for C_2F_6** emissions;

- **Starting with 2003** the technology was changed to **PFPB** (Point Feed Prebake) for CO_2 emissions and **CWPB** (Centre Worked Pre-baked) for PFC emissions. **The CO_2 emissions** within the Production of Primary Aluminium are calculated in line with **IPCC 2006 Methodology (Tier 3 Method** – Equation 4.21**)** taking into account the **specific operating facility data**. The economic operator completed the modernization of the electrolysis cells in 2002 and therefore was able to report the emissions from the production of primary aluminium using higher level methods starting from 2003. Starting with this year, the CO_2 emissions from the production of aluminum by electrolysis are reported as follows:

  - emissions from anode consumption using the level 3 method from IPCC 2006;

  - to these emissions are added the emissions from the decomposition of the sodium carbonate used in the electrolysis cell.
- The **PFC emissions** are calculated based on **IPCC 2006 Methodology (Tier 2 Method –** Equation 4.27**)**, considering **the plant specific** data and using the technology specific over voltage coefficient and weight fraction C_2F_6/CF_4 from **IPCC 2006 Methodology**.

In 2022 year, aluminium production decreased by 59.91% compared with 2021 year. In 2023 year, aluminium production decreased by 19.65% compared with 2022 year.

Table 4.30 The activity data, PFC and CO_2 emissions from Aluminium Production Sub–sector in the 1989–2023 period

Year	Emissions and activity data from Aluminium Production Sub–sector			
	CF_4 emissions	C_2F_6 emissions	CO_2 emissions	Aluminium Production
	[tones]		[kt]	[kt]
1989	424.87	107.07	424.87	265.54
1990	268.38	67.63	268.38	167.74
1995	224.96	56.69	224.96	140.60
2000	173.27	32.32	277.23	173.27
2005	10.75	1.30	372.62	239.01
2007	3.18	0.38	402.14	262.51
2008	2.02	0.24	399.93	265.24
2009	0.92	0.11	299.04	200.56

Year	Emissions and activity data from Aluminium Production Sub–sector			
	CF_4 emissions	C_2F_6 emissions	CO_2 emissions	Aluminium Production
	[tones]		[kt]	[kt]
2010	1.03	0.12	314.75	206.72
2011	1.44	0.17	335.98	224.51
2012	0.84	0.10	335.63	202.08
2013	0.70	0.08	319.57	197.25
2014	0.71	0.09	317.51	195.25
2015	0.74	0.09	334.03	205.88
2016	0.61	0.07	336.09	207.33
2017	0.63	0.08	334.61	206.14
2018	0.56	0.07	339.07	210.536
2019	0.43	0.05	329.04	200.10
2020	0.40	0.05	314.90	192.45
2021	0.42	0.05	337.02	201.87
2022	0.16	0.02	119.59	80.93
2023	0.10	0.01	106.23	65.03

Emission factors

Along the period 1989–2023 the emissions processes within the production of primary aluminium are calculated used the specific operating facility data in order to respect the IPCC Methodology as following:

- For the period **1989–1996** the technology used was **SWPB** (Side Worked Pre-baked). For this period the **CO_2 emissions** are calculated based on primary Aluminium Production data and the **default EF (1.6 tonnes CO_2/tonne Al)** in line with **IPCC 2006 Methodology (Tier 1 Method).** The calculation of CO_2 emissions does not include the emissions from anode baking. The **PFC emissions** are calculated based also on Aluminium Production and taking into account the technology use within the facility, in line with **IPCC 2006 Methodology (Tier 1 Method) for CF_4 emissions and IPCC 2006 Methodology (Tier 2 Method) for C_2F_6** emissions. **Emissions of CF_4** were estimated by multiplying annual primary Aluminium Production with the default emission factor **(1.6 kg CF_4/tonne Al)** provided by **IPCC 2006 Methodology (Tier 1 Method)** and considering the technologies in this period, **SWPB** (Side Worked Pre–baked). Compliance with **IPCC 2006 Methodology (Tier 2 Method)** it is recommended that the default rate **C_2F_6/CF_4 = 0.252 for SWPB.**
- From **1997 to 2002** period the combined technology was used **SWPB** (Side Worked Pre–baked) and **CWPB** (Center Worked Pre–baked) in different percentages. The **CO_2 emissions** are also calculated based

on Aluminium Production data and the **default EF (1.6 tonnes CO_2/tonne Al)** in line with **IPCC 2006 Methodology (Tier 1 Method)**. The calculation of CO_2 emissions does not include the emissions from anode baking. The **PFC emissions** for this period were estimated based on Aluminium Production and taking into account a **weighted average** of the two constants related technologies applied **SWPB and CWPB**, in line with **IPCC 2006 Methodology (Tier 1 Method) for CF_4 emissions and IPCC 2006 Methodology (Tier 2 Method) for C_2F_6** emissions; **Emissions of CF_4** were estimated by multiplying annual primary Aluminium Production with the default emission factors **(1.6 kg CF_4/tonne Al – SWPB technology and 0.4 kg CF_4/tonne Al – CWPB technology)** provided by **IPCC 2006 Methodology (Tier 1 Method**) and considering the **percentage of each technology** for every period years (SWPB and CWPB). Compliance with **IPCC 2006 Methodology (Tier 2)** it is recommended that the default rate **C_2F_6/CF_4 = 0.252 for SWPB and 0.121 for CWPB**.

- **Starting with 2003** the technology was changed to **PFPB** (Point Feed Prebake) for CO_2 emissions and **CWPB** (Centre Worked Pre-baked) for PFC emissions.

I. The CO_2 emissions within the production of primary aluminium are calculated in line with **IPCC 2006 Methodology,** considering the specific operating facility data **(Tier 3 Method**–Equation 4.21, page 4.45). The **parameters used** in order to estimate the **CO_2 emissions** are: total metal production (aluminium), net prebaked anode consumption, CO_2 molecular mass, ash content in baked anodes, sulphur content in baked anodes, in compliance with the Equation 4.21, page 4.45. At these emissions are added the **emission from decomposition of sodium carbonate** used in electrolysis cell.

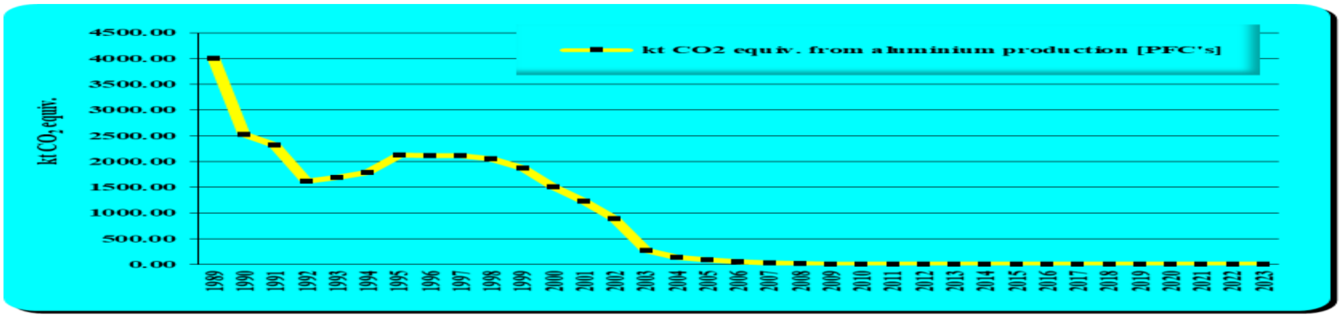
II. The PFC emissions are calculated based on **IPCC 2006 Methodology (Tier 2 Method)**, using **Overvoltage Method** and considering the plant specific data and also average parameters from measurements at numerous facilities.

In order to calculate **CF_4 emission** there was used **IPCC 2006 Methodology (Tier 2 Method**–Equation 4.27) and default parameter obtain from measurements at numerous facilities compliance with **IPCC 2006 Methodology (Tier 2 Method).** The parameters used in order to estimate the CF_4 emissions are: Overvoltage coefficients, Anode effect over-voltage, Aluminium Production process current efficiency, total metal production (aluminium), in compliance with the Equation 4.27 from IPCC 2006 Methodology. Measurement data are not available to determine smelter-specific Overvoltage coefficients, therefore default coefficients were used (an average parameters from measurements at numerous facilities), compliance with **IPCC 2006 Methodology (Tier 2 Method - Table 4.16 at page 4.54)**: Overvoltage Coefficient = **1.16 [(kg CF_4/tAl) / (mV)]**. Anode effect overvoltage parameter greatly decreased due to changing production technology leading to lower emission factor for CF_4.

In order to **calculate C_2F_6 emission** there was used the Equation 4.27 at page 4.52 from **2006 IPCC**

Methodology (Tier 2 Method). The data related with weight fraction of C_2F_6/CF_4, kg C_2F_6/kg CF_4 was in line with **2006 IPCC Methodology (Tier 2 Method – Table 4.16):** weight fraction is **C_2F_6/CF_4 = 0.121.**

Figure 4.16 The trend of PFC emissions from Primary Aluminium Production Sub-sector in the 1989–2023 period



4.4.2.4 MagnesiumProduction (CRT 2.C.4)

Methodology

Magnesium are not produced in Romania and therefore there are no emissions from manufacturing.

During the production of magnesium different emission are produced during different stages of processing. Quantity and type of emissions from this industry are influenced by the type of material (ore) and type of gas environment, which is used to protect the product obtained by oxidation. Usually as gas environment SF_6 is used. It is known that this gas is inert and therefore easily emitted into the atmosphere. Meanwhile, independent studies have shown that SF_6 to some extent is destroyed on contact with liquid/gaseous magnesium in the ordinary course of processing temperatures of magnesium. One of the most popular alternatives to SF_6 is HFC–134a. It is thermodynamically more unstable. Therefore, this gas is expected to respond (therefore to destruct) more intensively in contact with the liquid/gaseous magnesium, leading to receipt of various fluorinated gases (such as PFCs). Independent study (Tranell et al., 2004) shows that as a general rule one can say that when SF_6 is replaced by HFCs, less than half of active fluorine compound is necessary to protect the same work surface of magnesium. For the secondary magnesium production was identified a magnesium recycling plant which has a production hall – magnesium ingots and anodes. Secondary magnesium production includes the recovery and recycling of metallic magnesium from a variety of magnesium containing scrap materials e.g., post consumer parts, machine cuttings, casting scraps, furnace residues, etc. The raw materials used for the production process – melting magnesium are: waste containing magnesium alloy of 90% and primary magnaziu with minimum purity of 93% – waste clean, compact, known composition, waste from casting covered with paint, varnish or coating substances; clean waste from pressing – slags; other magnesium waste. In order to prevent oxidation and ignition of the magnesium using a mixture of nitrogen with SO_2 in a proportion of up to 3% SO_2, rather than inert GHGs.

Activity data

Magnesium are not produced in Romania and therefore there are no CO_2 emissions from manufacturing. From the secondary magnesium production there are no CO_2 emissions, only SO_2 emissions.

Emission factors

The default IPCC emission factors for CO_2 from primary production cannot be used because this activity is not applicable in the country.

4.4.2.5 Lead production (CRT 2.C.5)

Methodology

The method for calculating emissions of CO_2 from Lead Production is in line with the 2006 IPCC GL (Tier 1), considering the "Decision tree for estimation of CO_2 emissions from lead production" from 2006 IPCC GL – page 4.72 (Figure 4.15).

Activity data

The lead production data was provided by the National Institute for Statistics. The CO_2 emissions from lead production are estimated for the entire period 1989–2023.

Emission factors

For confidentiality reasons the presentation of CO_2 emission factor used to estimate emission from Lead Production is omitted.

4.4.2.6 Zinc production (CRT 2.C.6)

Methodology

The method for calculating emissions of CO_2 from Zinc Production is in line with the 2006 IPCC GL (Tier 1 method), considering the "Decision tree for estimation of CO_2 emissions from zinc production" from 2006 IPCC GL – page 4.81 (Figure 4.16).

Activity data

The zinc production data was provided by the National Institute for Statistics. The CO_2 emissions from zinc production are estimated for the entire period 1989–2023.

Emission factors

For confidentiality reasons the presentation of CO_2 emission factor used to estimate emission from Zinc Production is omitted.

4.4.2.7 Other Production (CRT 2.C.7)

Other emissions are not known to be occurring.

4.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

4.4.4 Uncertainty assessment and time-series consistency

4.4.4.1 Iron and Steel Production (CRT 2.C.1)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 5 %;
- 7.07 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire period 1989–2023.

4.4.4.2 Ferroalloys Production (CRT 2.C.2)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 30 %;
- 30.41 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related

uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire period 1989–2023.

4.4.4.3 Aluminium Production (CRT 2.C.3)

4.4.4.3.1 CO_2 emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 20 %;
- 20.62% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire period 1989–2023.

4.4.4.3.2 PFC emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 50 %;
- 50.25% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire period 1989–2023.

4.4.4.4 Magnesium Production (CRT 2.C.4)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 0 %;
- EF: 0 %;
- 0 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire period 1989–2023.

4.4.4.5 Lead Production (CRT 2.C.5)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 10 %;
- EF: 50 %;
- 50.99 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire period 1989–2023.

4.4.4.6 Zinc Production (CRT 2.C.6)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 10 %;
- EF: 50 %;

- 50.99 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire period 1989–2023.

4.4.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

In respect to the Industrial Processes and Product Use Sector - Iron and steel production category, Ms. Mihaela Bălănescu, a senior expert with significant experience related to the GHG industrial emissions, both considering her researcher, industry consultant, study developer, UNFCCC international expert reviewer profile, implemented a series of QA activities.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.

Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs. AD on primary Aluminium Production obtained from economic agent has been checked against the data obtained from the National Statistics. The differences in AD generated by these two different data sources are negligible (there are some small differences in the first part of the time series, when statistical data are a little bit higher, but the data from plant are consider to be more reliable).

Both the operator, the data/information provider, and the National Environmental Protection Agency (NEPA), the inventory compiler, performs Quality Control checks as outlined within the IPCC 2006 Methodology in relation to every inventory submission. Considering that the latest available plant-specific data/information provided by the operator, data used in emission estimation, and the quality control activities described above, the data series are considered to be consistent, according with the provisions in the IPCC 2006 Methodology. The CO_2 emissions from Iron and Steel Production were compared with the emissions reported in monitoring plans of GHG emissions for the EU-ETS installations. Further elements are presented within Annex V.12.

4.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

4.4.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

4.5 Non–energy products from fuels and solvent use (CRT 2.D)

4.5.1 Category description

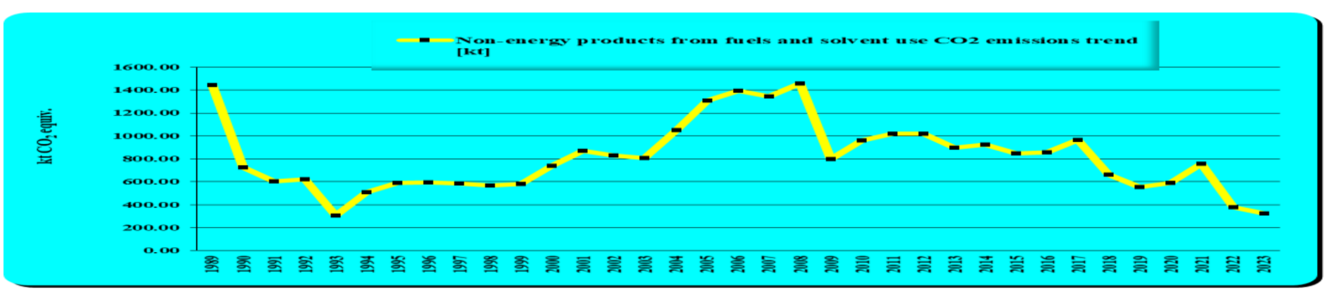
The emission estimates cover sub–categories Lubricant use (CRT 2.D.1), Paraffin wax use (CRT 2.D.2) and

Other [(CRT 2.D.3: Solvent use (CRT 2.D.3.a), Road paving with asphalt (CRT 2.D.3.b), Asphalt roofing (CRT 2.D.3.c); Other – Petroleum coke use (CRT 2.D.3.d) and Other –Urea use (CRT 2.D.3.d)]. Non–energy products from fuels and solvent use Sub-sector is responsible for 3.87% of the total Industrial Processes and Product Use Sector GHG emissions in 2023.

Table 4.31 CO_2 emissions from Non–energy products from fuels and solvent use Sub–sector, in the 2023 year

Sector	CO_2 emissions [kt] – 2023
2.D Non-energy products from fuels and solvent use	**325.41**
2.D.1 Lubricant use	64.71
2.D.2 Paraffin wax use	3.56
2.D.3.a Other – Solvent use	109.71
2.D.3.d Other – Petroleum coke use	146.73
2.D.3.d Other – Urea use	0.70

Figure 4.17 CO_2 emissions trend in the Non-energy products from fuels and solvent use Sub–sector for 1989–2023 period



4.5.2 Methodological issues

4.5.2.1 Lubricant use (CRT 2.D.1)

Methodology

Lubricants use is not a key source category. The method for calculating emissions of CO_2 from Lubricant use is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the "Decision tree for CO_2 from non–energy uses of lubricants" from 2006 IPCC Guidelines –

page 5.8 (Figure 5.2).

Activity data

The data on Lubricant use are provided by National statistics and are extracted from ENERGY_PETRO_A_RO_2023_0000, Lubricants – Gross inland deliveries for non energy use (Annex V.6.2).

Emission factors

CO_2 emissions are calculated according to Equation 5.2 at page 5.7 from 2006 IPCC GL (Tier 1 method) with aggregated default data for the limited parameters available and the ODU factor based on a default composition of oil and greases in total lubricant figures (in TJ units). The emission factor is composed of a specific carbon content factor (tonne C/TJ) multiplied by the ODU factor (0.2), based on default composition of oil and grease. A further multiplication by 44/12 (the mass ratio of CO_2/C) yields the emission factor (expressed as tonne CO_2/TJ). For lubricants the default carbon contents factor is 20.0 kg C/GJ on a Lower Heating Value basis.

4.5.2.2 Paraffin wax use (CRT 2.D.2)

Methodology

Paraffin wax use is not a key source category. The method for calculating emissions of CO_2 from Paraffin wax use is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the "Decision tree for CO_2 from non-energy uses of paraffin waxes" from 2006 IPCC Guidelines – page 5.12 (Figure 5.3).

Activity data

The data on Paraffin wax use are provided by National statistics and are extracted from ENERGY_PETRO_A_RO_2023_0000, Paraffin waxes - Gross inland deliveries for non energy use (Annex V.6.2).

Emission factors

CO_2 emissions are calculated according to Equation 5.4 at page 5.11 from 2006 IPCC GL (Tier 1 method) with aggregated default data for the limited parameters available. It can be assumed that 20 percent of paraffin waxes are used in a manner leading to emissions, mainly through the burning of candles, leading to a default ODU factor of 0.2.

4.5.2.3 Solvent Use (CRT 2.D.3.a)

Category description

Solvents are chemical compounds, which are used to dissolve substances as paint, glues, ink, rubber, plastic, and pesticides or for cleaning purposes (degreasing). After application of these substances or other procedures of solvent use most of the solvent is released into air. The use of solvents leads to emissions of non-methane volatile organic compounds (NMVOC), which is regarded as an indirect greenhouse gas. The NMVOC emissions will over a period of time in the atmosphere oxidize to CO_2, which is included in the total greenhouse gas emissions reported to the UNFCCC Secretariat. These source categories are:

- Paint Application – source category includes emissions resulted from: domestic use, automobile manufacture and repairing, construction and buildings;
- Degreasing and Dry Cleaning – source category refers to emissions resulted from metal degreasing, dry cleaning, electronic components manufacturing, other industrial cleaning, processes using organic solvents to remove contamination furs, leather, down leathers, textiles, or other objects made of fibres;
- Chemical Products, Manufacture and Processing - source category includes emissions from chemicals manufacturing or processing: polyester processing, polyvinyl chloride processing, polyurethane foam processing, rubber processing, pharmaceutical products manufacturing, paints manufacturing, glues manufacturing;
- Other product use - source category refers to emissions resulted from other use of solvents, such as: mineral wool induction, preservation of wood, domestic solvent use (other than paint application), products for the maintenance or improvement of personal appearance, health, or hygiene, products used to maintain or improve of household's durables, products used for improving the appearance or the structure of buildings, products used for improving the appearance of vehicles, to maintain vehicles or winter products such as antifreeze, such as garden fungicides, herbicides and insecticides, and household insecticide sprays may be considered as consumer products.

Methodology

IPCC guidelines do not provide methodology to determine NMVOC emissions, which is the main source of emissions in this sector. Due to this reason, the NMVOC emissions resulted from Solvents and Other Product Use are estimated based on EMEP/EEA air pollutant emission inventory guidebook 2023, using the correspondence between IPCC categories and SNAP codes (Table 4.32), the source of these emissions being the inventory of air pollutants under Directive (EU) 2284/2016. The following sources are included in the NMVOC emissions estimations:

- Domestic solvent use including fungicides (NFR 2.D.3.a);

- Coating applications (NFR 2.D.3.d);
- Degreasing (NFR 2.D.3.e);
- Dry cleaning (NFR 2.D.3.f);
- Chemical products (NFR 2.D.3.g);
- Printing (NFR 2.D.3.h);
- Other solvent use (NFR 2.D.3.i);
- Other product use (please specify in the IIR) (NFR 2.G).

Table 4.32 Correspondence between IPCC categories and SNAP codes

IPCC categories	SNAP codes
Paint application	0601 Paint application
Degreasing and Dry Cleaning	0602 Degreasing, dry cleaning and electronics
Chemical Products, Manufacture and Processing	0603 Chemical products manufacturing and processing
Other	0604 Other use of solvents & related activities

Activity data

For 2025 submission the AD used to calculate emissions are provided by the National Institute of Statistics (NIS) (for some activities, activity data is still represented by the total population of Romania) and economic agents but the main data source is NIS.

Due to the large and diverse number of activity data, the "NE" notation key was used for reporting activity data in CRT 2(I).A-H.

Emission factors

The CO_2 emissions from Solvent Use were calculated from NMVOC emissions of this sector and is calculated using the carbon content conversion factor (0.60) multiplying with (44/12) and multiplying with emissions of the NMVOC. Due to the lack of activity data for 1989 year, CO_2 emissions were calculated by linear extrapolation.

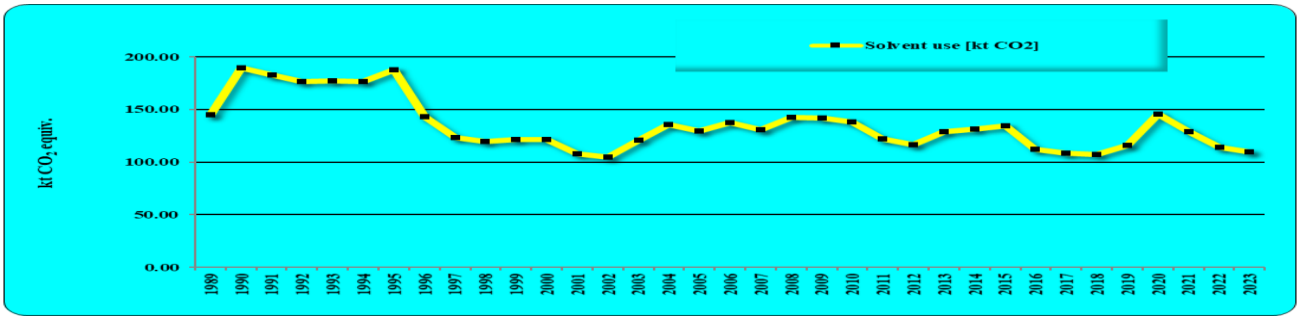
Table 4.33 CO_2 emissions resulted from Solvent Use in the 1989–2023 period

Solvents Use					
Year	Paint application	Degreasing and Dry Cleaning	Chemical Products, Manufacture and Processing	Other	Total
	CO_2 emissions [kt]				
1989	3.65	22.20	15.22	104.17	145.24

Solvents Use					
Year	Paint application	Degreasing and Dry Cleaning	Chemical Products, Manufacture and Processing	Other	Total
	CO_2 emissions [kt]				
1990	13.73	60.08	42.43	73.20	189.43
1995	14.80	72.51	28.99	71.27	187.58
2000	11.82	16.85	21.99	70.82	121.48
2005	23.49	14.30	21.81	70.13	129.73
2007	20.63	17.60	24.59	67.80	130.62
2008	22.48	17.56	33.19	69.40	142.62
2009	36.83	13.88	23.36	67.70	141.78
2010	32.61	17.11	20.26	68.21	138.19
2011	19.74	11.96	22.27	68.24	122.22
2012	19.16	3.98	26.49	66.92	116.54
2013	19.01	2.68	26.06	80.97	128.73
2014	20.29	1.41	29.66	80.03	131.39
2015	22.58	0.56	31.90	79.73	134.78
2016	21.73	0.45	34.24	55.59	112.02
2017	20.19	0.50	31.78	56.38	108.84
2018	20.75	0.47	32.18	53.84	107.24
2019	20.99	0.42	32.73	61.87	116.01
2020	17.55	0.31	33.28	94.79	145.92
2021	15.74	0.38	36.96	76.19	129.28
2022	14.96	0.40	34.10	64.37	113.82
2023	14.14	0.41	31.61	63.55	109.71

The trend of CO_2 emissions for the entire period shows a fluctuating variation (as a result of the fluctuating variation in the level of economic activities, including the restructuring of the economy, the economic crisis), with several periods in which the emissions are relatively stable: 1990–1995, 1997–2000, 2008–2010, 2013–2015 and 2016–2019. In 2020, there is an increase in emissions followed by a decrease in the period 2021-2023.

Figure 4.18 The trend of CO_2 emissions resulted from Solvent Use Sector, in the 2023 year



4.5.2.4 Other - Petroleum coke use (CRT 2.D.3.d)

Methodology

The method for calculating emissions of CO_2 from Petroleum coke use is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the Equation 5.1, page 5.5 from 2006 IPCC Guidelines.

Activity data

The data on Petroleum coke use are provided by National statistics and are extracted from ENERGY_PETRO_A_RO_2023_0000, Petroleum coke – Gross inland deliveries for non energy use (Annex V.6.2).

Emission factors

CO_2 emissions are calculated according to Equation 5.1 at page 5.5 from 2006 IPCC GL (Tier 1 method) with aggregated country–specific data for the limited parameters available. The emission factor (country–specific CO_2 emission factors for stationary combustion, oxidation included, from ETS verified reports) is composed of a specific carbon content factor (tonne C/TJ) multiplied by the ODU factor. For petroleum coke the carbon was presumed that is fully emitted and not stored, having the full oxidation during use; ODU factor is 1. A further multiplication by 44/12 (the mass ratio of CO_2/C) yields the emission factor (expressed as tonne CO_2/TJ).

4.5.2.5 Other - Urea use (CRT 2.D.3.d)

Category description

In power plant, to reduce the content of nitrogen oxides in the combustion gases, a non–catalytic NOx reduction system (NSCR plant) was implemented, that uses urea as a reducing agent. From CO_2 emissions

from ammonia production (2.B.1 category) are subtracted the CO_2 emissions related to the use of urea as a reducing agent in the non-catalytic selective reduction of nitrogen oxides and reported under this category [according to note (10) of CRT 2(I).A-H - Emissions from urea used as a catalyst should be reported here].
In accordance with art. 24, paragraph 2, page 20 from Regulation (EU) No 2066/2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Regulation (EU) no. 601/2012 of the Commission, process emissions on the urea source stream are determined by multiplying the activity data corresponding to raw material consumption by the emission factor and the corresponding conversion factor.

Activity data

The amount of urea used as a reducing agent in NSCR systems has been reported by EU–ETS operators (power plants) together with CO_2 emissions since 2018.

Emission factors

Emission factors used to calculate CO_2 emissions from urea use as a reducing agent in the non-catalytic selective reduction of nitrogen oxides are default emission factors. The emission factor is calculated by multiplying the stoichiometric carbon content of the pure substance (t C / t $(NH_2)_2CO$) by the carbon to CO_2 conversion factor (respectively 3.664 t CO_2/ t C).

4.5.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

4.5.4 Uncertainty assessment and time-series consistency

4.5.4.1 Lubricant use (CRT 2.D.1)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 15 %;
- EF: 50 %;
- 52.20 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz

consortium; additional information are included in Annex V.10.
Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.5.4.2 Paraffin wax use (CRT 2.D.2)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 15 %;
- EF: 100 %;
- 101.12% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.
Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.5.4.3 Solvent use (CRT 2.D.3.a)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 300 %;
- EF: 20 %;
- 300.67% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.
Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.5.4.4 Other - Petroleum coke use (CRT 2.D.3.d)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 15 %;
- EF: 50 %;
- 52.20 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.5.4.5 Other - Urea use (CRT 2.D.3.d)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 7.5 %;
- EF: 0 %;
- 7.50 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.5.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no.

663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

4.5.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the emissions estimates quality some important recalculations were made:

- ***Emissions:***
    - *Solvent use (CRT 2.D.3.a)*
    - *Other - Petroleum coke use (CRT 2.D3.d)*

Table 4.34 The effects of recalculations in Non–energy products from fuels and solvent use Sector

The effects of recalculations in Non–energy products from fuels and solvent use Sector			
Years	NIR 2024	NIR 2025	Differences [%]
	CO_2 emissions [kt]		
1989	1,432.94	1,443.49	0.74
1990	719.97	727.08	0.99
1991	599.72	605.86	1.03
1992	615.64	622.29	1.08

The effects of recalculations in Non–energy products from fuels and solvent use Sector			
Years	NIR 2024	NIR 2025	Differences [%]
	CO_2 emissions [kt]		
1993	301.33	305.57	1.41
1994	504.54	510.88	1.26
1995	583.95	591.96	1.37
1996	590.72	596.54	0.98
1997	576.81	584.04	1.25
1998	558.15	565.94	1.40
1999	574.51	583.39	1.55
2000	730.18	741.25	1.52
2001	859.08	868.70	1.12
2002	822.93	832.10	1.11
2003	798.00	806.82	1.11
2004	1,039.81	1,050.69	1.05
2005	1,297.21	1,309.92	0.98
2006	1,378.81	1,393.78	1.09
2007	1,332.95	1,346.26	1.00
2008	1,457.13	1,457.90	0.05
2009	798.87	799.60	0.09
2010	960.57	961.17	0.06
2011	1,017.56	1,018.22	0.07
2012	1,017.80	1,018.46	0.07
2013	898.06	898.69	0.07
2014	923.72	924.33	0.07
2015	846.61	847.23	0.07
2016	854.59	855.26	0.08
2017	966.88	967.51	0.07
2018	662.34	663.33	0.15
2019	552.53	553.17	0.12
2020	588.62	589.21	0.10
2021	755.34	755.98	0.08
2022	375.66	376.75	0.29
2023		325.41	

Table 4.35 The effects of recalculations in Solvent use category

The effects of recalculations in Solvent use category			
Years	NIR 2024	NIR 2025	Differences [%]
	CO_2 emissions [kt]		
1990	185.74	189.43	1.99

The effects of recalculations in Solvent use category			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions [kt]		
1991	178.98	182.66	2.06
1992	173.15	176.82	2.12
1993	173.58	177.26	2.12
1994	173.02	176.70	2.12
1995	182.82	187.58	2.60
1996	141.04	143.49	1.74
1997	119.69	123.45	3.14
1998	114.96	119.40	3.87
1999	116.09	121.32	4.50
2000	115.49	121.48	5.19
2001	105.24	108.07	2.69
2002	101.72	104.55	2.79
2003	118.10	120.94	2.41
2004	133.26	136.11	2.14
2005	127.63	129.73	1.65
2006	134.16	137.69	2.63
2007	128.39	130.62	1.74
2008	141.86	142.62	0.54
2009	141.05	141.78	0.52
2010	137.59	138.19	0.44
2011	121.55	122.22	0.55
2012	115.88	116.54	0.57
2013	128.09	128.73	0.50
2014	130.79	131.39	0.46
2015	134.15	134.78	0.47
2016	111.34	112.02	0.61
2017	108.21	108.84	0.58
2018	106.26	107.24	0.93
2019	115.37	116.01	0.55
2020	145.33	145.92	0.41
2021	128.64	129.28	0.50
2022	112.73	113.82	0.97
2023		109.71	

Solvent use (2.D.3.a)

Recalculations were made for the period 1990–2022. Recalculations of CO_2 emissions have been made as a result of the recalculation of NMVOC emissions, to ensure the consistency of the data used to estimate emissions in preparation of the greenhouse gas inventories with the data used to prepare inventories of air pollutants pursuant to the Directive (EU) 2284/2016.

Table 4.36 The effects of recalculations in Petroleum coke use category

The effects of recalculations in Petroleum coke use category			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	CO_2 emissions [kt]		
1989	1,107.01	1,117.56	0.95
1990	359.19	362.61	0.95
1991	259.09	261.56	0.95
1992	312.08	315.06	0.95
1993	58.88	59.44	0.95
1994	279.70	282.36	0.95
1995	341.52	344.78	0.95
1996	353.30	356.67	0.95
1997	365.08	368.56	0.95
1998	350.36	353.70	0.95
1999	382.74	386.39	0.95
2000	532.90	537.97	0.95
2001	712.49	719.28	0.95
2002	665.38	671.72	0.95
2003	627.11	633.09	0.95
2004	842.03	850.06	0.95
2005	1,112.90	1,123.50	0.95
2006	1,201.22	1,212.67	0.95
2007	1,162.95	1,174.03	0.95
2023		146.73	

Other - Petroleum coke use (2.D.3.d)

Recalculations were made for the CO_2 emissions, for the period 1989-2007, following the update of the NCVs values.

4.5.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

Improve in the estimation of CO_2 emissions from urea use in SCR systems under 2.D.3 and in the estimation of CO_2 emissions from lubricant use under 2.D.1 category, by excluding the quantity of lubricants used in two-stroke engines from the total quantity of lubricants and reporting it in the energy sector. The planned improvement is associated with the recommendation with ID I.4 from table 3 of ARR 2022.

4.6 Electronics Industry (CRT 2.E)

4.6.1 Category description

CRT Sector 2.E includes: Integrated circuit or semiconductor (CRT 2.E.1), TFT flat panel display (CRT 2.E.2), Photovoltaics (CRT 2.E.3), Heat transfer fluid (CRT 2.E.4), Other (CRT 2.E.5).

4.6.2 Methodological issues

Methodology

Many modern processes for the manufacture of electronic components use fluorinated chemicals needed for cleaning of reaction chambers, temperature control, plasma etching of complex patterns, etc. This industry emits fluorinated chemical compounds that are gases at room temperature and those which are in liquid form. Such substances include CF_4, C_2F_6, C_3F_8, C_4F_6, C_5F_8, CHF_3, CH_2F_2, SF_6 and others. Most of the emissions resulting from that small part of the input quantities are fully utilized.

Activity data

In order to collect activity data, a survey of the electronics industry has been conducted using as input data the registration codes (CAEN codes) from the National Trade Register Office. The following codes have been used to identify potential companies in this field:

- 2611 – Manufacture of electronic components;
- 2931 – Manufacture of electrical and electronic equipment for motor vehicles and their engines;
- 2932 – Manufacture of other parts and accessories for motor vehicles and their engines.

Based on the registration codes, 471 companies have been identified. Using the raw data inputs, preliminary direct phone conversations have been carried out to identify the relevance of each company for the data collection process. During this process, the activity type has been verified in order to validate the scope for the future survey. Based on the conversation, 224 companies have been included in the scope of the survey. For each of these companies, a questionnaire has been prepared by Denkstatt and sent by MMSC to collect (if available) data regarding with the utilization of F-gases. The companies list and the questionnaires are presented in Annex 6 Electronic sector. The economic entities, which are of interest, are the following:

- Producers of semiconductors;
- Producers of photovoltaic panels;

The survey showed that in Romania there are currently no manufacturers of semiconductors and producers of photovoltaic panels (only 3 assembly companies exist – Siliken, Altius Fotovoltaic and Renovatio Trading). There used to be a manufacturing facility IPRS (Întreprinderea de piese radio şi semiconductori) Baneasa, but the production ceased with the transition to market economy and it was subsequently closed down. NF_3 is only used in the electronics industry for the production of semiconductors and TFT displays as a chamber cleaning gas. We did not find any references in the guidelines for using NF_3 for other purposes. The EU study (http://ec.europa.eu/clima/policies/f-gas/docs/2011_study_en.pdf) does not list Romania as a user of NF_3 - only Germany, Ireland, France, Italy, Austria (7%), Netherlands, Great Britain, Finland, and the Czech Republic are mentioned. Most of the NF_3 emissions may occur from 2.E.1, 2.E.2, 2.E.3 categories and there are no other activities where consumption of NF_3 may occur. Since no companies returned any data on F-gases consumption, no further data compilation and processing was done.

A further analysis was performed. Two companies were identified (NXP Semiconductors Romania and Atlas Copco), the activity of one of them focuses on IP software, and the second company offers automated assembly solutions for semiconductor production equipment.

NXP Semiconductors Romania started its activity in April 2000, with 5 employees, and has so far created a center of excellence in software research and development with over 600 employees, engineers and customer service specialists. NXP Semiconductors Romania focuses on IP software (auto, microcontroller and connectivity devices) and board solutions. NXP Romania contributes to the creation of solutions for the automotive, consumer and industrial IoT markets by developing software platforms that integrate NXP components and software from partners. NXP also has dedicated teams focused on IT service management and chip sales and order planning and management operations.

Atlas Copco is a trusted assembly solution provider for major semiconductor equipment manufacturing around the world. In many factories, the manufacture of semiconductor manufacturing equipment currently requires thousands of screws to be placed manually by an operator. Regardless of the purpose of the equipment, every screw is expected to be properly tightened to ensure the proper performance of the production equipment. Atlas Copco offers a comprehensive portfolio of certified clean room clamping tools, from torque controllers, tool positioning systems, torque wrenches to automated screws with collaborative robots and error checking software for product assembly processes. Atlas Copco's portfolio of tools and solutions for clamping and process control reduces the risk of costly downtime caused by poor clamping quality or human error.

Another company was identified in Satu Mare, ***ZES Zollner Electronic SRL***, whose field of activity is the use of solvents containing volatile organic compounds (VOC). Within the activities/facilities that used solvents containing volatile organic compounds, no consumption of fluorinated gases was declared, consequently there are no emissions of these compounds into the atmosphere. Periodic analyzes are made for atmospheric pollutants: CO, NOx, SO_2, Cu, Ni, Cr, Pb, Zn, Sn, Cd, VOC. The company has Chiller York cooling units with glycol-based operation, respectively based on R-134A, R-407C, R-410A, used for cooling components or electronic systems during operation. Evaporation losses do not appear to occur when liquid FCs are contained in closed systems throughout the life of the product or system.

4.6.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG’s do not apply for Romania.

4.6.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 0 %;
- EF: 0 %;
- 0 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006. The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

4.6.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

4.6.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

4.6.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

4.7 Product uses as substitutes for ODS (CRT 2.F)

4.7.1 Category description

Under this F-gases category are considered the following subcategories: Domestic refrigeration (CRT 2.F.1.b), Commercial and industrial refrigeration and air–conditioning (CRT 2.F.1.a, 2.F.1.c, and 2.F.1.f), Transport refrigeration (CRT 2.F.1.d), Mobile air–conditioning (CRT 2.F.1.e), Foam blowing (CRT 2.F.2), Fire protection (CRT 2.F.3), Aerosols/Metered dose inhalers (CRT 2.F.4), Solvents (CRT 2.F.5) and Other applications (CRT 2.F.6). Product uses as substitutes for ODS Subsector is responsible for 23.52% of the total Industrial Processes and Product Use Sector GHG emissions in 2023. In 2023 year, the actual emissions from CRT 2.F category are equal to 1,980.25 kt CO_2 equiv. and are presented in the Table 4.37. Emissions from Solvents (2.F.5) and Other applications (2.F.6) do not occur in Romania.

Figure 4.19 GHG emissions trend in the Product uses as substitutes for ODS Sub–sector for 1989–2023 period

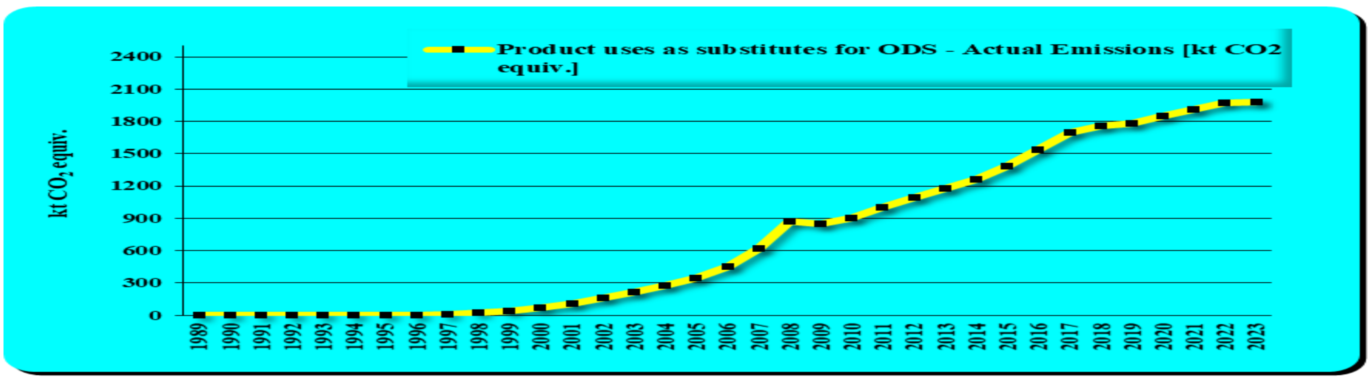


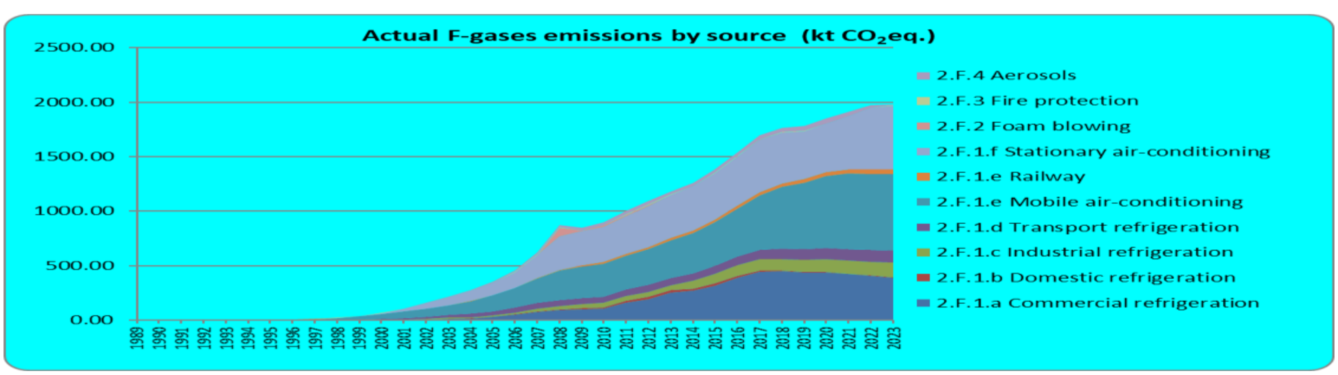
Table 4.37 The Actual emissions in the Product uses as substitutes for ODS Sub–sector for 1989–2023 period

Year	Actual emissions [kt CO_2equiv.]
1989	0.14
1990	0.16
1995	2.47
2000	66.79
2005	348.70
2007	617.51
2008	873.67
2009	850.39
2010	899.30
2011	999.14
2012	1,091.89

Year	Actual emissions [kt CO_2equiv.]
2013	1,181.21
2014	1,260.07
2015	1,381.34
2016	1,538.35
2017	1,696.42
2018	1,761.13
2019	1,780.67
2020	1,847.47
2021	1,908.27
2022	1,972.15
2023	1,980.25

There is a stable increasing trend for F-gases emissions, which is valid also for most of the subcategories (Figure 4.20). The major source of emissions is the refrigeration and air–conditioning sector, from which the most significant are mobile air-conditioning, stationary air–conditioning and commercial refrigeration subcategories. The emission estimates include emissions from manufacturing, operation and decommissioning of equipment containing F-gases. The preferred approach for most of the subcategories is the emission factor approach (Tier 2a method), while the choice of emission factors is mostly based on the default IPCC values or it is based on recent EU studies.

Figure 4.20 Actual F– gases emissions by source for 1989–2023 period



Management of containers has not been estimated separately. It was assumed that emissions from containers are accounted in the proposed EFs for initial charging and servicing of equipment. Related to management of containers, Romania continued the analysis. Of all the economic operators importing fluorinated gases into containers, only one declared the refilling of smaller containers from large containers before placing on the market, and estimated the amount of refrigerant emitted during refilling to be in the range of 0.3–0.5%, range which is much smaller than the range presented in the IPCC 2006 guidelines. The rest of the economic operators stated that the refrigerants are imported in small containers.

Table 4.38 Overview of methods and emission factors used for the current report year in category 2.F.1 – Refrigeration and air-conditioning systems

	QG	Method	Gas	Lifetime	Production	Application	End of life emissions	
			HFC	[years]	Emission factor (%)	Emission factor (%)	Disposal losss factor (%)	Recovery rate (%)
Refrigeration and Air Conditioning Equipment	2.F.1							
Commercial refrigeration	2.F.1a	Tier 2a	HFC PFC	15 (D)	1 (D, NID Germany)	15 (D, EC 2011, NID Germany, Austria and Estonia)	15 (D)	85 (D) (assumption)
Domestic refrigeration	2.F.1b	Tier 2a	HFC	15 (D)	0.6 (D)	0.3 (D, EC 2011)	30 (D) (CS assumption)	70 (D) (CS assumption)
Industrial refrigeration	2.F.1c	Tier 2a	HFC PFC	15 (D)	1 (D) (NID Germany)	10 (EC 2011, NID Germany, Austria and Estonia)	15 (D)	85 (D) (assumption)
Transport refrigeration	2.F.1d							
Vans		Tier 2a	HFC	15 (assumption)	NO	30 (EC 2011)	100 (CS)	0
Trucks				15 (assumption)	NO	20 (EC 2011)	100 (CS)	0
Mobile air conditioning systems	2.F.1e							
Cars		Tier 2a	HFC	20 (based on vehicle fleet)	0.5 (D)	10 (D)	100 (CS)	0
Buses				20 (based on vehicle fleet)	0.5 (D)	15 (D) (EC 2011)	100 (CS)	0
Trucks N1				20 (based on vehicle fleet)	0.5 (D)	10 (D) (EC 2011)	100 (CS)	0
Trucks N2				20 (based on vehicle fleet)	0.5 (D)	15 (D) (EC 2011)	100 (CS)	0
Trucks N3				20 (based on vehicle fleet)	0.5 (D)	15 (D) (EC 2011)	100 (CS)	0
Rail transport				16 (D)	0.5 (D)	20 (D)	100 (CS)	0
Stationary air conditioning	2.F.1f							
Domestic air-conditioners		Tier 2a	HFC	15 (D, EC 2011)	0.6 (D)	5 (EC 2011)	15 (D)	85 (D) (assumption)
Heat pumps				15 (D, EC 2011)	0.6 (D)	3.5 (Ec 2011)	15 (D)	85 (D) (assumption)

4.7.2 Methodological issues

4.7.2.1 Refrigeration and Air Conditioning Equipment (CRT 2.F.1)

Refrigeration and Air Conditioning Equipment (2.F.1) is a key category both level and trend point of view (Tier 1, excluding and including LULUCF).

4.7.2.1.1 Commercial Refrigeration (CRT 2.F.1.a)

Methodology

Commercial refrigeration is an increasingly important source of Greenhouse Gas (GHG) emissions, which started to develop after 2000 with the replacement of R–22. A wide variety of installations is used – from small commercial appliances including refrigerated show-cases and counters, refrigerating furniture to large centralised supermarket refrigeration systems, which could contain from less than 3 kg to several hundred kilograms. Regarding the methodology to estimate the F-gas emissions from commercial, the applied approach is corresponding to Tier 2a (emission factor approach). Even though the primary activity data is represented by the quantities of refrigerant used for servicing and initial charging of equipment (e.g. top-down data), we estimate separately the quantities used for initial charging of new equipment and the banked quantities of refrigerants, and we apply the corresponding emission factors, so in reality this is an emission factor approach. The actual emissions for the period are represented on the Figure 4.21. There is also a variety of HFC species, which are used for this sector, but most predominant are HFC-32, HFC-134a, R-401A, R-404A, R-410A, R-407C, R-407F, R-448A, R-449A and R-452A. Other currently used refrigerants are R-407A, R-420A, R-422D and R-507A. In 2019, compared to 2018, there is a decrease in emissions, this decrease is due to the introduction on the market of a new refrigerant R–744F50 (CO_2). In 2020, F–gas emissions increased is due to the increase in the consumption of refrigerated agents in the service/maintenance activities of refrigeration / air conditioning equipment. In 2021, compared to 2020, respectively in 2022, compared to 2021 there is a decrease in emissions, this decrease is due to the lower consumption of refrigerants in the service/maintenance activities of refrigeration/air conditioning equipment as well as, as a result of the use of R–744F50 refrigerants (CO_2) and R–290 (propane). The aggregated actual emission estimates are equal to of 388.69 kt CO_2 equiv. for 2023 year. The quantity of banked HFCs for this subcategory is estimated at 1,022.61 t in 2023 year and is presented in Table 4.39.

Figure 4.21 Actual emissions of the Commercial Refrigeration for 1989–2023 period

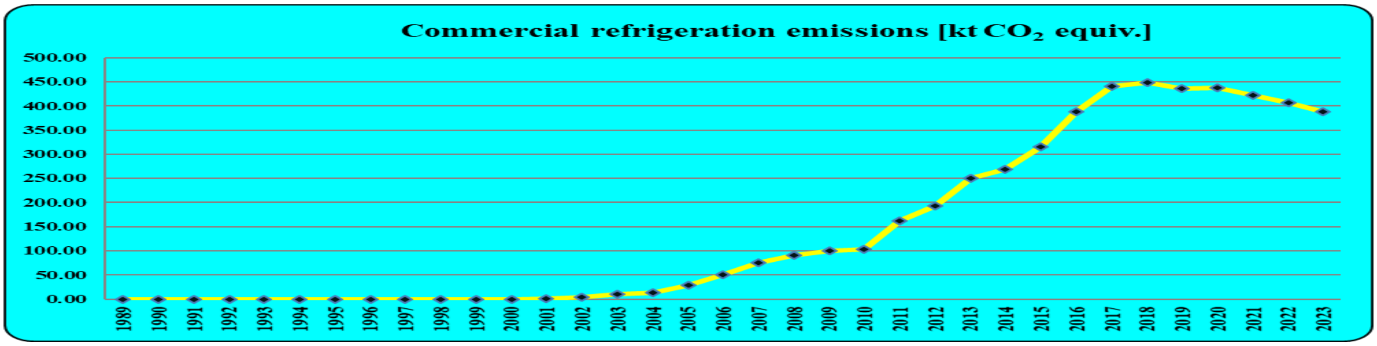


Table 4.39 The quantity of banked HFC of the Commercial Refrigeration for 1989–2023 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [t HFC]	Operation emissions [t HFC]	Disposal emissions [t HFC]	Actual emissions [kt CO_2equiv.]
2001	0.23	0.23	0.00	0.03	0.00	0.15
2005	32.84	54.84	0.29	8.23	0.00	28.88
2007	63.84	144.15	0.50	21.62	0.00	75.58
2008	56.22	178.75	0.35	26.81	0.00	90.98
2009	49.92	201.86	0.23	30.28	0.00	100.24
2010	40.79	212.37	0.11	31.86	0.00	103.85
2011	126.77	307.29	0.95	46.09	0.00	161.95
2012	110.95	372.14	0.65	55.82	0.00	192.70
2013	181.77	498.09	1.26	74.71	0.00	249.52
2014	122.04	545.42	0.47	81.81	0.00	268.26
2015	180.47	644.07	0.99	96.61	0.00	315.17
2016	244.75	791.98	1.48	118.80	0.03	387.90
2017	225.80	892.57	1.01	133.89	0.96	440.55
2018	198.97	947.52	0.62	142.13	1.52	449.20
2019	157.61	953.88	0.27	143.08	1.37	436.76
2020	217.68	999.51	0.78	149.93	4.35	438.24
2021	196.39	1,006.33	0.51	150.95	5.95	421.61
2022	195.69	1,001.40	0.29	150.21	7.45	406.18

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [t HFC]	Operation emissions [t HFC]	Disposal emissions [t HFC]	Actual emissions [kt CO_2equiv.]
2023	206.03	1,022.61	0.43	153.39	5.19	388.69

Activity data

The task to estimate the emissions from this sector is complex because it is more heterogeneous in terms of equipment characteristics: design, size, type of refrigerant, the amount of losses and more. In contrast to household refrigeration equipment or automotive air conditioning systems, systems that are manufactured in batch production are in smaller quantities than those produced on demand. Most of the emissions from this category would result from installations containing more than 3 kg of HFCs. Since those installations are regulated by the Romanian legislation implementing EU Regulation 517/2014, operators of commercial and industrial equipment should maintain records of the quantity and type of fluorinated greenhouse gases installed, any quantities added and the quantity recovered during servicing, maintenance and final disposal. However, according to the current Romanian legislation, operators are not obliged to report on an annual basis, which is the reason why it was not possible to apply a bottom-up methodology for this subsector. In order to obtain the required activity data, was developed a questionnaire, which was sent to all servicing companies licensed to maintain equipment containing more than 3 kg of HFCs. It was assumed, that for the servicing companies it would not be feasible to disaggregate between refrigeration and air-conditioning equipment for the full time series, so it was decided the two subcategories - commercial refrigeration and air-conditioning to be grouped and evaluated together. For the 2023 year the questionnaire has been sent to 516 companies, only 183 responded to the questionnaire. The number of companies is also representative for the amount of substances because those who answer include large operators, which are representative at the national level. In order not to avoid underestimation of the emissions, the reported quantities were increased by the percentage of companies, which did not provide an answer. The companies declared the use of more than 10 different blends of HFCs, which were converted the respective quantity of HFCs according to the information provided in Table 7.8, at page 7.44 from Volume 3 of the 2006 IPCC guidelines. For the estimate of the emissions was developed a special model, similar to the example spreadsheet provided by the IPCC 2006 Guidelines, which estimates the banked quantities of HFCs based on the quantity of used HFCs for a particular year for each particular species of HFCs ($Banks_n = Banks_{n-1} + HFCused_n - Emissions\ from\ operation_{n-1} - Emissions\ from\ Disposal_n/EF_{disposal}$). Emissions from installation were calculated by multiplying the amount of refrigerant charged in new equipment in a particulat year with the emission factor for installation. Emissions from operation were calculated by multiplying the banked quantity with the emission factor for operation. The amount of refrigerant at disposal are estimated with the help of equipment lifetime.

Emission factors

The IPCC 2006 Guidelines provide a very broad range regarding the annual leakage rate – between 10 and 35%. The emissions estimates were prepared by using an annual leakage rate of 15%, based on information provided in various studies (EC 2011, National Inventory Reports of Germany, Austria and Estonia), which is a bit conservative estimate. The installation emissions were estimated with an EF of 1% of the total charge, which is within the proposed default range. Since HFC containing equipment is relatively new and the estimated equipment lifetime of 15 years (EC 2011), emissions from disposal started to occur in 2016 year, but are relatively small. This subcategory is very similar to the industrial refrigeration, since the required data was collected with the same questionnaires and from the same servicing companies. As commercial refrigeration units are serviced and dismantled by the same certified personnel as industrial refrigeration units (all operations are carried out by trained personnel and the implicit recovery assumption of 85% was adopted, as used for industrial refrigeration, which is at the upper end of the range proposed by the IPCC 2006 Guidelines (0-90%).

4.7.2.1.2 Domestic Refrigeration (CRT 2.F.1.b)

Methodology

Domestic refrigeration is an important source of F–gases emissions due to the large number of refrigerators in operation. Unlike other RAC equipment, domestic refrigerators usually contain a very small amount of refrigerants and do not require a regular maintenance or refilling of refrigerant. In order to estimate the emissions from this subcategory was applied a Tier 2a approach, which considers the emissions from manufacturing, operation and disposal of domestic refrigeration equipment. The actual emissions for the period 1989–2023 are represented on the Figure 4.22. The increase of the emissions after 2006 is due to the disposal of old equipment, as the first equipment introduced in the market in 1991 started to be decommissioned. Starting with 2014, there is a decrease in emissions, due to the complete replacement of the HFC–134a refrigerant with isobutane, since 2011. There is also a decrease in emissions from the disposal of the equipment starting with 2014 year. In 2021, compared to 2020, there is an increase in emissions from the disposal of the equipment, this increase is due to the decommissioning of a larger number of equipment in 2021 compared to the previous year. In 2022, compared to 2021, there is an increase in emissions from the disposal of the equipment, this increase is due to the decommissioning of a larger number of equipment in 2022 compared to the previous year. In 2023, compared to 2022, there is an decrease in emissions from the disposal of the equipment, this decrease is due to the decommissioning of a smaller number of equipment in 2023 compared to the previous year. The actual emissions for 2023 year from production, operation and decommissioning are equal to 2.21 kt CO_2equiv., of which operation emissions are equal to 0.038 kt CO_2equiv. The detailed results are presented in the Table 4.40.

Figure 4.22 Actual emissions of the Domestic Refrigeration for 1989–2023 period

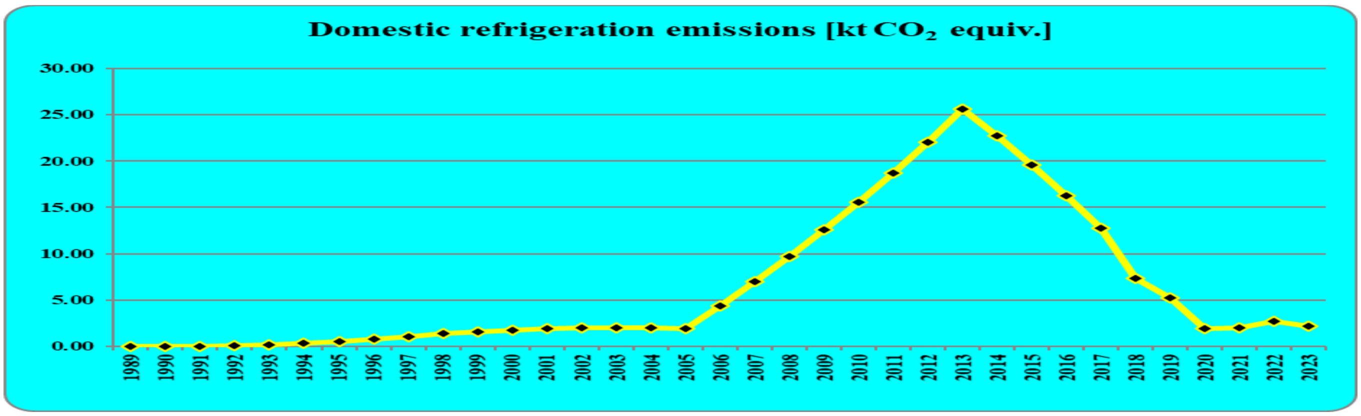


Table 4.40 The result detailed of the Domestic Refrigeration for 1989–2023 period

Year	Produced units	Units placed on the market	HFCs used for production [t]	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFC–134a]	Operation emissions [kg HFC–134a]	Disposal emissions [kg HFC–134a]	Actual emissions [kt CO_2equiv.]
1991	18,181.00	54,428.00	2.18	6.53	6.53	13.09	19.59	0.00	0.04
1995	145,893.00	310,973.00	17.51	37.32	106.88	105.04	320.63	0.00	0.55
2000	305,233.00	425,453.00	36.63	51.05	381.89	219.77	1,145.67	0.00	1.78
2005	43,075.00	40,087.00	5.17	4.81	489.18	31.01	1,467.53	0.00	1.95
2007	67,442.00	59,430.00	8.09	7.13	479.47	48.56	1,438.42	3,882.06	6.98
2008	61,455.00	48,547.00	7.37	5.83	463.79	44.25	1,391.38	6,019.49	9.69
2009	58,843.00	34,436.00	7.06	4.13	438.89	42.37	1,316.68	8,292.26	12.55
2010	68,549.00	50,242.00	8.23	6.03	407.93	49.36	1,223.80	10,701.69	15.57
2011	0.00	0.00	0.00	0.00	362.49	0.00	1,087.46	13,267.54	18.66
2012	0.00	0.00	0.00	0.00	307.97	0.00	923.90	16,029.61	22.04
2013	0.00	0.00	0.00	0.00	243.83	0.00	731.49	18,963.33	25.60
2014	0.00	0.00	0.00	0.00	186.80	0.00	560.40	16,889.50	22.68
2015	0.00	0.00	0.00	0.00	137.44	0.00	412.31	14,641.36	19.57
2016	0.00	0.00	0.00	0.00	96.31	0.00	288.93	12,214.38	16.25
2017	0.00	0.00	0.00	0.00	63.98	0.00	191.93	9,612.92	12.75
2018	0.00	0.00	0.00	0.00	45.30	0.00	135.90	5,545.61	7.39
2019	0.00	0.00	0.00	0.00	32.08	0.00	96.24	3,925.18	5.23

Year	Produced units	Units placed on the market	HFCs used for production [t]	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFC–134a]	Operation emissions [kg HFC–134a]	Disposal emissions [kg HFC–134a]	Actual emissions [kt CO_2equiv.]
2020	0.00	0.00	0.00	0.00	27.39	0.00	82.16	1,379.54	1.90
2021	0.00	0.00	0.00	0.00	22.26	0.00	66.78	1,513.20	2.05
2022	0.00	0.00	0.00	0.00	15.38	0.00	46.13	2,045.20	2.72
2023	0.00	0.00	0.00	0.00	9.76	0.00	29.28	1,670.68	2.21

Activity data

The activity data for this category was received from the National Institute for Statistics (NIS). For some of the equipment types the data was not given in number of units, but instead in tons. In order to estimate the number of units per category was used data for imports in Bulgaria in units and kilograms, according to the assumptions presented in Table 4.41. The values in this table do not represent the amount of refrigerant per unit, but the average weight of the unit itself. For some of the equipment types, import statistics were not available as number of units, but only as total weight of all units in tons. The values in this table were used to calculate the number of units. After determining the number of units, it was possible to calculate the amount of refrigerants imported into those units. The reason why values from the Bulgarian import statistics were taken into account was that both the total weight and the number of units were available for Bulgaria. It was assumed that imported equipment should be similar, so the average weight for Bulgaria should also be applicable for Romania.

Table 4.41 Assumptions on data for imports in Bulgaria for Domestic Refrigeration

CN code	Equipment type	kg/unit
84181020	Combined refrigerator-freezers, of a capacity > 340 l, fitted with separate external doors	77
84181080	Combined refrigerator-freezers, of a capacity <= 340 l, fitted with separate external doors	60
841821	Household refrigerators, compression-type	45
84183020	Freezers of the chest type, of a capacity <= 400 l	50
84183080	Freezers of the chest type, of a capacity > 400 l but <= 800 l	60
84184020	Freezers of the upright type, of a capacity <= 250 l	45
84184080	Freezers of the upright type, of a capacity > 250 l but <= 900 l	67
841869	Refrigerating or freezing equipment (excl. refrigerating and freezing furniture)	31

The number of new units which are introduced on the market in the particular was calculated taking into account production, imports and exports. The provided data for the production of domestic refrigerators was for the period 2003–2023, and for the imports and exports it was for the period 2000–2023. For the rest of the timeseries the number of units was estimated using regression analysis based on the data for the Gross Domestic Product (GDP) of Romania for the period 1989–2012. For the last year the domestic production of refrigerators is around 2 mln. units, but the major part of those is exported. Around 1,250,000 units were placed on the market in 2023. For the 2005–2010 period only a small amount (5%) is assumed to be HFC–containing units, while the rest are supposed to use hydrocarbons (HC–600a or HC-290). In accordance with Regulation 517/2014, since 1 January 2015, was forbidden the use HFCs with GWP of 150 or more in refrigerators and household freezers. After a thorough study we identified that only manufacturer of domestic refrigeration equipment in Romania, since 2011, has replaced completely HFC–134a refrigerant with isobutane. The colleague confirmed that all the refrigerators equipment manufactured and those that was imported uses isobutane. For the 2011–2023 period, for HFC production, import and export equipment units the conservative approach of 0% can be assumed. In order to estimate the quantity of F–gases, contained in domestic refrigeration equipment was assumed an average quantity of 0.12 kg of refrigerant agent per unit (EC 2011). To estimate the quantity of banks in a particular year n, has been used the equation below:

Equation 4.2 The quantity of banks for Domestic Refrigeration

$$Banks_n = Banks_{n-1} + HFC\ in\ new\ units_n - Emissions\ from\ operation_{n-1} - Disposal_n$$

For the calculation of the emissions from manufacturing, the production of units of equipment containing HFC and the quantity of agent per unit was taken into account. Emissions from operation were calculated by multiplying the banked quantity with the emission factor for operation. For the disposal emissions was assumed that the equipment lifetime is 15 y (EC 2011), which is in the range provided by the IPCC 2006 Guidelines. It is possible that the average equipment lifetime is actually higher in Romania, but since this assumption is hard to be verified, a conservative assumption was taken. Effectively, with this assumption the emissions from disposal are calculated as the remaining refrigerant in all the equipment, which was introduced in the market 15 years ago. Disposal emissions start to occur since 2006 year, following the assumption that the first HFC–containing equipment was introduced in the market in 1991 year.

Emission factors

The manufacturing emissions are calculated as a percentage of the initial charge that is released during assembly. The emission factor used for estimating the manufacturing emissions is the default Emission Factor (EF) of 0.6% from the IPCC 2006. The operation emissions are calculated based on the EF for operation of 0.3%, annual leak rate as a percentage of total charge. This is the default EF from the IPCC

2006 and the same EF is also used in various studies as EC 2011, the National Inventory Report (NID) of Austria, Germany and others. Regarding the disposal EF – in order to determine a ***country–specific disposal emission factor***, a further analysis was performed. Additional information on Waste Electrical and Electronic Equipment was requested from the Waste Directorate of NEPA. The information received was for the period 2015-2018 only, for the following types of refrigeration equipment:

a) large refrigerators;

b) refrigerators;

c) freezers;

d) other large devices used for refrigerating, preserving and storing food.

Starting with 2019, a new classification is applied, no distinction was made in the case of WEEE collection between refrigeration equipment waste and air conditioning equipment waste. Taking this into account, starting with 2019, the calculated values were not taken into account for determining a national disposal emission factor value.

The analysis of the received data for the period 2015–2018 was carried out for each type of equipment as well as for all four categories together, as follows:

- **For 2015**, of the total number of waste refrigeration equipment containing HFCs collected for decommissioning (for the types of refrigeration equipment from the points *a – d*, described above), about 70% are sent to treatment to economic operators holding a permit to treat WEEE equipment (treated in the country). Approximately 13% of the total waste refrigeration equipment containing HFCs collected for decommissioning is sent for treatment to foreign countries. The remaining approximately 17% are decommissioned without refrigerant recovery.
- **For 2016**, of the total number of waste refrigeration equipment containing HFCs collected for decommissioning (for the types of refrigeration equipment from the points *a – d*), about 65% are sent to treatment to economic operators holding a permit to treat WEEE equipment (treated in the country), approximately 15% of the total waste refrigeration equipment containing HFCs collected for decommissioning is sent for treatment to foreign countries. The remaining approximately 20% are decommissioned without refrigerant recovery.
- **For 2017**, there was an increase in the number of WEEE treated in the country as well as those exported. Of the total number of waste refrigeration equipment containing HFCs collected for decommissioning (for the types of refrigeration equipment from the points *a – d*), about 73% are sent to treatment to economic operators holding a permit to treat WEEE equipment (treated in the country), approximately 19% of the total waste of electrical and electronic equipment containing HFCs collected for decommissioning is sent for treatment to foreign countries. The remaining approximately 8% are decommissioned without refrigerant

recovery.

- **For 2018**, there was a decrease in the number of WEEE treated in the country as well as those exported. Of the total number of waste refrigeration equipment containing HFCs collected for decommissioning (for the types of refrigeration equipment from the points *a – d*), about 59% are sent to treatment to economic operators holding a permit to treat WEEE equipment (treated in the country), approximately 13% of the total waste refrigeration equipment containing HFCs collected for decommissioning is sent for treatment to foreign countries. The remaining approximately 28% are decommissioned without refrigerant recovery.

Following what was described above, it results that the percentage of equipment that is decommissioned without refrigerant recovery has a fluctuating variation for the period 2015–2018.

About 97% – 98% of these WEEE are sent for treatment to the economic operator GreenWEEE INTERNATIONAL SA. According to the questionnaire submitted by GreenWEEE INTERNATIONAL SA, the efficiency of recovering the amount of fluorinated gases remaining in the equipment in WEEE treatment is approx. 98%. According to the questionnaire sent, GreenWEEE INTERNATIONAL SA began treatment refrigerators activity in 2009. In accordance with the environmental permit provisions of this company, the flow of large household appliances (large refrigerators, refrigerators, other large appliances used for refrigerating, preserving and preserving food, etc.) involves extraction and storage in metal tanks of refrigerants and cyclopentane, without separating them by their types. The process of treating these types of WEEE includes the treatment of polyurethane foam consisting in grinding, pressing and transformation of foam into pellets, but also in the temporary extraction and deposition of residual freon water. This mixture of different types of refrigerants, cyclopentane and residual water have been classified as hazardous waste and are disposed of by authorized companies. Taking into account the fact that the treatment line processes both complete collected WEEE and incomplete WEEE (most often those with a missing engine), so not all waste contained fluorinated gases at the time of treatment.

Separately, the analysis was made for each type of equipment for the 2015–2018 period. Both for category *a*, and for categories *b*, *c* and *d*, it is found that the percentage of equipment that is decommissioned without refrigerant recovery has a fluctuating variation for the 2015–2018 period:

Category/year	**Percentage (%)**				**Weighted average of percentage values for 2015–2018 period**
	2015	**2016**	**2017**	**2018**	
a) large refrigerators	14.74	39.30	7.84	23.20	28.39
b) refrigerators	14.24	14.18	8.62	29.34	21.12
c) freezers	57.58	57.64	-	-	57.61

Category/year	Percentage (%)				Weighted average of percentage values for 2015–2018 period
	2015	2016	2017	2018	
d) other large devices used for refrigerating, preserving and storing food	57.45	33.86	21.87	62.65	50.92
Weighted average	**22.39**	**27.77**	**9.05**	**30.07**	**25.60**

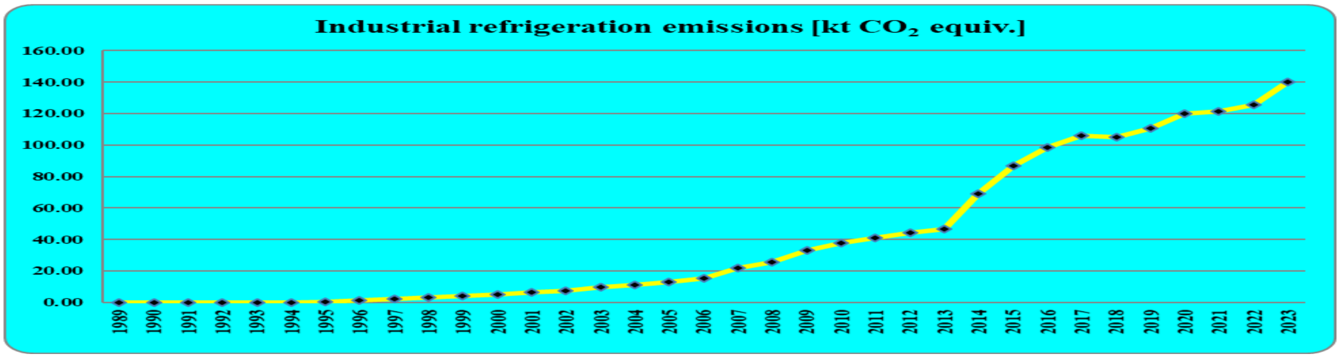
Taking into account the above, as well as the fact that the value of 25.60% is appropriate to the default value from the 2006 IPCC Guidelines (30%), ***it was assumed that the value of 30% can be used as the national value for disposal emission factor.***

4.7.2.1.3 Industrial Refrigeration (CRT 2.F.1.c)

Methodology

Industrial refrigeration is also an important source of HFC emissions. Similar to commercial refrigeration, after the ban on the CFCs use, imposed by the Montreal Protocol, the main substitute on the market became different types of HFCs. The transition seems to have started as early as 1995 for a limited number of installations, but the significant growth did not start until 2005. This subcategory is also characterised by a wide variety of installations in operation and also a variety of HFC species, with the most predominant being HFC-32, HFC-134a, HFC-227ea, R-404A, R-407A, R-407C, R-410A, R-407F and R-449A. Other currently used refrigerants are HFC-23, R-422C, R-507A, R-448A, R-452A and R-513A. Regarding the methodology to estimate the F-gas emissions from industrial refrigeration, the applied approach is corresponding to Tier 2a (emission factor approach). Even though the primary activity data is represented by the quantities of refrigerant used for servicing and initial charging of equipment (e.g. top-down data), we estimate separately the quantities used for initial charging of new equipment and the banked quantities of refrigerants, and we apply the corresponding emission factors, so in reality this is an emission factor approach. The aggregated actual emission estimates are equal to of 139.92 kt CO_2equiv. for 2023 year. The actual emissions for the period 1989–2023 are represented in the Figure 4.23.

Figure 4.23 Actual emissions of the Industrial Refrigeration for 1989–2023 period



The quantity of banked HFCs for this subcategory is estimated at 519.43 t in the 2023 year and is presented in Table 4.42.

Table 4.42 The quantity of banked HFC of the Industrial Refrigeration for 1989–2023 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [t HFC]	Operation emissions [t HFC]	Disposal emissions [t HFC]	Actual emissions [kt CO_2equiv.]
1995	1.22	1.22	0.01	0.12	0.00	0.53
2000	3.73	13.10	0.03	1.31	0.00	5.27
2005	8.28	36.99	0.05	3.70	0.00	13.10
2007	21.27	59.91	0.17	5.99	0.00	21.69
2008	18.63	72.55	0.13	7.25	0.00	25.76
2009	31.81	97.10	0.25	9.71	0.00	33.17
2010	28.44	114.62	0.18	11.46	0.18	38.02
2011	27.22	128.22	0.14	12.82	0.32	40.97
2012	27.48	140.63	0.12	14.06	0.34	44.32
2013	22.61	146.85	0.06	14.68	0.35	46.47
2014	76.67	206.37	0.60	20.64	0.37	69.13
2015	95.11	278.16	0.72	27.82	0.40	86.67
2016	69.48	316.80	0.39	31.68	0.45	98.51
2017	64.66	345.91	0.29	34.59	0.58	105.81
2018	38.08	343.14	0.01	34.31	0.94	105.30

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [t HFC]	Operation emissions [t HFC]	Disposal emissions [t HFC]	Actual emissions [kt CO_2equiv.]
2019	71.46	374.64	0.32	37.46	0.85	110.51
2020	80.81	412.89	0.38	41.29	0.76	120.09
2021	55.43	421.09	0.08	42.11	0.89	121.24
2022	69.74	431.74	0.18	43.17	2.55	125.66
2023	143.53	519.43	0.88	51.94	1.90	139.92

Activity data

This subcategory is very similar to the commercial refrigeration, since the required data was collected with the same questionnaires and from the same servicing companies. In the estimates for this category are also considered both the industrial refrigeration and air-conditioning systems. The quantities reported by the servicing companies were also increased with an appropriate percentage, in order not to avoid underestimation of the emissions due to missing information. The number of companies is also representative for the amount of substances because those who answer include large operators, which are representative at the national level. The companies declared the use of more than 10 different blends of HFCs, which were converted the respective quantity of HFCs according to the information provided in Table 7.8 at page 7.44 from Volume 3 of the 2006 IPCC guidelines. For the estimate of the emissions was used the same model as for the commercial refrigeration, partly based on the example spreadsheet provided with the 2006 IPCC guidelines, which estimates the banked quantities of HFCs based on the quantity of used HFCs for a particular year for each particular species of HFCs ($Banks_n = Banks_{n-1} + HFCused_n - Emissions\ from\ operation_{n-1} - Emissions\ from\ Disposal_n/EF_{disposal}$). Emissions from installation were calculated by multiplying the amount of refrigerant charged in new equipment in a particulat year with the emission factor for installation. Emissions from operation were calculated by multiplying the banked quantity with the emission factor for operation. The amount of refrigerant at disposal are estimated with the help of equipment lifetime. Recovery is calculated with the simplified way of subtracting disposal emissions from the amount of HFC in products at decommissioning.

Emission factors

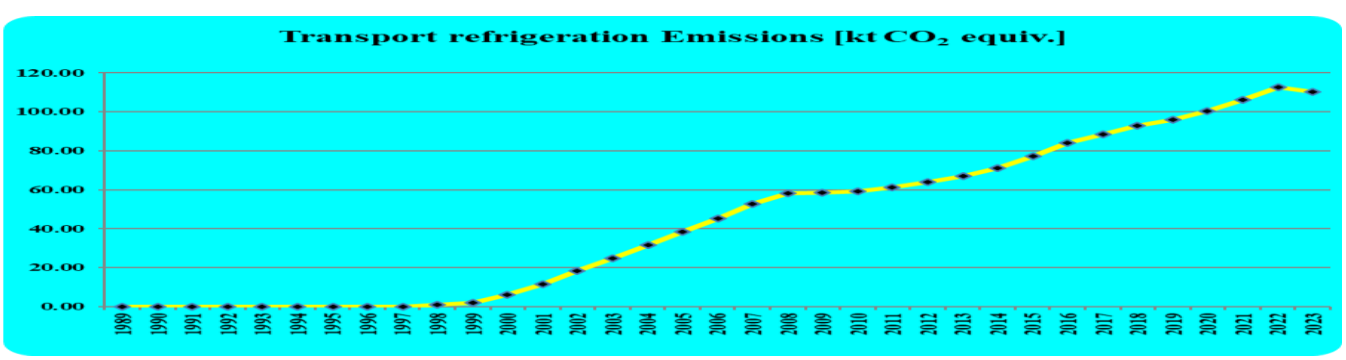
The IPCC 2006 Guidelines provide a very broad range regarding the annual leakage rate – between 7 and 25%. The emissions estimates were prepared by using an annual leakage rate of 10%, based on information provided in various studies (EC 2011, National Inventory Reports of Germany, Austria and Estonia). The installation emissions were estimated with an EF of 1% of the total charge, which is within the proposed default range. For this category the use of HFCs started a bit earlier compared to commercial refrigeration. Although according to the IPCC guidelines the equipment lifetime could be from 10 to 20 years, so an average equipment lifetime of 15 years was assumed. Emissions from disposal started to occur in 2010 year, but are relatively small. Since all operations are carried out by trained personnel, the implicit recovery assumption of 85% was adopted, which is at the upper end of the range proposed by the IPCC 2006 Guidelines (0-90%).

4.7.2.1.4 Transport Refrigeration (CRT 2.F.1.d)

Methodology

Transport refrigeration is usually a minor source of F–gas emissions. According to EC 2011 study, standard refrigerant of vans had been R–12, which was replaced in new systems by HFC–134a after 1995, while common refrigerant of trucks and trailers was R–22; new systems run with R–404A, from 2001 onwards, at the latest. R–410A plays a minor role in refrigerated road vehicles and is not separately considered in the estimate. Following the approach of various studies on the topic, transport refrigeration was divided into two subcategories – vans (corresponding to N1 and N2 vehicle categories) and trucks and trailers (corresponding to N3 vehicle category). The IPCC guidelines do not provide special guidance regarding different subcategories of transport refrigeration and there is no difference in the proposed ranges by the 2000 IPCC GPG and 2006 IPCC Guidelines. Transport refrigeration vehicles are not produced in the country, so no initial emissions were considered. The aggregated emission estimates for the two subcategories result in total actual emissions of 110.07 kt CO_2equiv. for 2023 year, the majority of which are from refrigerated trucks. In order to estimate the emissions from this subcategory was applied a Tier 2a approach, estimating the emissions from operation and disposal of equipment. The actual emissions for the period 1989–2023 are represented on the Figure 4.24.

Figure 4.24 Actual emissions of the Transport Refrigeration for 1989–2023 period



The quantity of banked HFCs for this subcategory is estimated at 149.27 t in 2023 year and is presented in Table 4.43.

Table 4.43 The quantity of banked HFC of the Transport Refrigeration for 1989–2023 period

Year	Number of trucks with HFC units	HFCs placed on the market [t]	Quantity of banks [t]	Operation emissions [kg HFC]	Disposal emissions [kg HFC]	Actual emissions [kt CO_2equiv.]
1995	20.12	0.01	0.03	9.06	0.00	0.01
2000	3,174.22	3.25	9.52	2,237.00	0.00	6.18
2005	13,591.44	2.74	53.91	11,814.86	0.00	38.39
2007	17,902.84	6.14	73.40	15,968.96	0.00	52.74
2008	19,890.03	6.49	81.13	17,669.88	0.00	58.21
2009	20,290.86	0.64	81.76	17,856.63	0.00	58.48
2010	20,522.19	0.81	82.58	18,039.73	1.60	59.04
2011	21,559.41	3.13	85.71	18,774.07	3.79	61.08
2012	23,001.27	4.23	89.94	19,775.12	33.66	63.84
2013	24,400.05	4.18	94.13	20,759.32	209.06	67.04
2014	25,988.16	5.29	99.41	21,967.86	331.31	71.11
2015	27,687.45	5.78	105.19	23,281.50	912.97	77.19
2016	29,953.11	8.55	113.74	25,177.28	1,097.36	83.86
2017	32,198.01	7.41	121.15	26,874.66	1,012.25	88.55
2018	34,742.40	8.18	129.33	28,760.92	745.04	92.93
2019	36,152.10	3.70	133.03	29,665.23	906.71	95.74
2020	38,322.87	7.76	140.79	31,406.97	683.95	100.17
2021	40,202.25	6.50	147.29	32,879.02	1,085.06	106.16
2022	41,663.94	5.09	152.38	34,029.65	1,830.82	112.71
2023	41,441.82	0.50	149.27	33,457.79	1,878.46	110.07

Since the reporting of refrigeration vehicles is not obligated by the Romanian legislation, activity data for this subsector is hard to obtain. Having in mind that the possible large number of transport companies, it is not feasible to identify those companies and to collect activity data by questionnaires. There is no official data on the total number of refrigerated vehicles in the country and there are no separate CN codes for those vehicles, which could be tracked trough national statistics. Questionnaires were sent to railway freight operation companies – neither of the companies reported ownership of refrigerated cars or the usage of F-gases. The emission estimates were prepared based on the total number of trucks in the country, provided by the General Directorate for Driving Licenses and Registrations (GDDLR). As with the mobile air conditioning sector, an attempt to analyse the vehicle sales websites was performed, but the available search filters were very limited in addition to the relatively small number of trucks being sold on most of the websites. Based on this data and on data on the number of refrigerated trucks in other countries (Germany, Bulgaria) was made an assumption, that the refrigerated vehicles are equal to 3% of all vans and 6% of all trucks, which would estimate the vehicle fleet in 2023 as about 24,000 refrigerated vans and 17,422 refrigerated trucks and trailers. As an additional check to confirm this estimate was analysed data about the total number of refrigerated vehicles in Europe, which according to the EU 2011 study consists of 400,000 vans, 200,000 trailers and 220,000 trucks. Based on whether we choose GDP or population, the Romanian share could be estimated between 11,000 and 38,000 refrigerated vehicles. Compared to other subcategories from the refrigeration and air conditioning category, the transition from R-22 to HFCs happened with some delay, which might be even bigger for Romania. In order to estimate the total number of refrigeration trucks with HFC-containing units, was used the available data from the EC 2011 report – the estimated total number of refrigerated vehicles was multiplied by the respective percentage for the particular year. Numbers in bold were provided in the report, while the rest were interpolated (see Table 4.44).

Table 4.44 The total number of Refrigeration trucks with HFC-containing units (%) for 1993–2023 period

Year	% N1 and N2 trucks with HFC units	% N3 trucks with HFC units
1993	0%	0%
1994	0%	0%
1995	**13%**	**0%**
1996	26%	0%
1997	**38%**	**0%**
1998	51%	5%
1999	**63%**	**9%**
2000	76%	20%
2001	**88%**	**31%**

Year	% N1 and N2 trucks with HFC units	% N3 trucks with HFC units
2002	94%	44%
2003	**100%**	**56%**
2004	100%	69%
2005	**100%**	**81%**
2006	**100%**	**91%**
2007	**100%**	**98%**
2008	**100%**	**100%**
2009-2023	100%	100%

For assessing the banked quantities of HFC in refrigerated vehicles were chosen the values of 1.5 kg of refrigerant per refrigerated van and 6.5 kg per truck or trailer (EC 2011). The banked quantities were calculated taking into account the number of refrigeration trucks with HFC-containing units and the average charge. Emissions from operation were calculated by multiplying the banked quantity with the emission factor for operation. For the estimate of the disposal emissions has to be considered the average vehicle lifetime. The 2006 IPCC Guidelines provide a range of 6 to 9 years. However, the analysis of the data about the age distribution of the vehicle fleet in Romania (explained in detail in the mobile air conditioning category) suggests that the expected vehicle lifetime could be much higher, even by using the vehicle as a non-refrigerated vehicle at the end of its lifetime. An average vehicle lifetime of 15 years for both van and trucks was assumed for Romania. This would presume that decommissioning emissions started to occur in 2010. The model also assumes that the vehicle was not maintained (e.g. refrigeration unit has not been refilled) in the last 5 years before decommissioning.

Emission factors

The 2006 IPCC Guidelines provide a very broad range regarding the annual leakage rate – between 15 and 50%. The emissions estimates were prepared by using an annual leakage rate of 30% for vans and 20% for trucks and trailers, as suggested by the EC 2011 study. Since vehicle decommissioning companies in the country have not declared any reclaimed quantities of F-gases from decommissioned vehicles, it was assumed that 100% of the remaining quantities of F-gases are emitted at decommissioning.

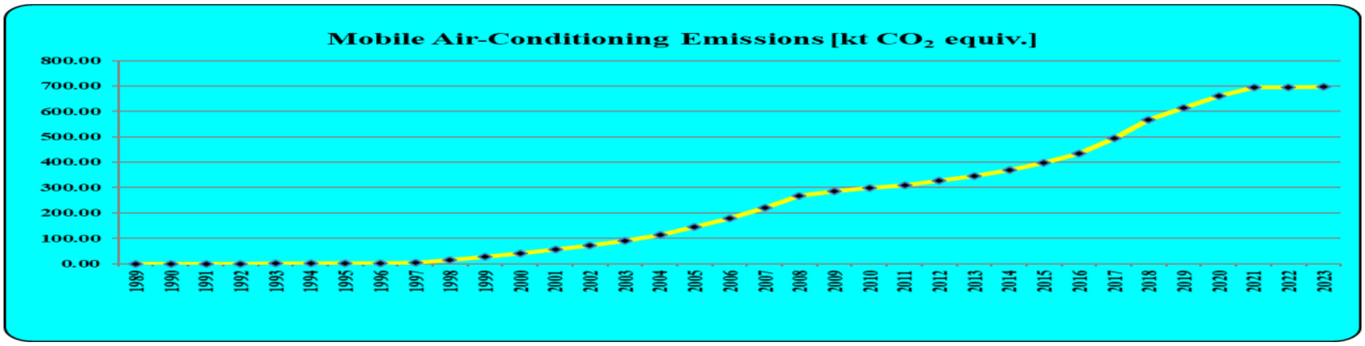
4.7.2.1.5 Mobile Air-Conditioning (CRT 2.F.1.e)

Methodology

In general, the emissions from Mobile Air Conditioning (MAC) units contribute a significant share from the total F-gases emissions due to the large number of vehicles and the relatively high annual leakage rate.

For MAC units there is only one type of HFC, which is used – HFC-134a. According to Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles, starting January 1, 2011, air conditioning systems installed in new vehicle models must contain refrigerants with a low environmental impact. According to Article 6, paragraphs 1-3, subsequent installation and recharge of fluorinated greenhouse gases with a Global Warming Potential (GWP) of more than 150 are prohibited in mobile air conditioning systems. The currently used refrigerant R-134a with a GWP of 1430 is actually banned for new approved vehicles (new models) as from 1 January 2011. From 1 January 2017, this ban will apply to all new vehicles. In Romania, since 2016, HFC–1234yf has also been used in automobile air-conditioning systems. The emissions of HFC–1234yf are not subject to reporting obligations and are not including in the total emissions from Mobile Air Conditioning category. In order to precise the emission estimates, mobile air conditioners were divided into three subcategories – used in cars, trucks and buses, since each of them has its own specifics that need to be addressed, although the IPCC guidelines do not provide special guidance regarding different subcategories of mobile air conditioners. In addition, the IPCC guidelines also do not take into account the quantities of refrigerant over 1.5 kg and therefore offer no default emission factors for such systems, although quantities over 1.5 kg for bus air-conditioners are often used. There are three major automobile producers in the country, so the emission estimates also consider initial emissions from mobile air conditioning production. The aggregated emission estimates for all three subcategories result in total actual emissions of 698.27 kt CO_2equiv. for 2023, the majority of which are from passenger cars. In order to estimate the emissions from the mobile air conditioning subcategory, was applied a Tier 2a approach (emission factor approach), which considers the emissions from manufacturing, operation and disposal of vehicles. This subcategory is a key category. A detailed model for the emissions calculation from each subsector had to be created in order to estimate the Romanian market. The actual emissions for the period 1989–2023 are represented on the Figure 4.25. The initial emissions are estimated to be around 0.083 t of HFC-134a, while the operation emissions are around 508.17 t and the disposal emissions are around 28.9 t. There is a large quantity of banked HFCs, estimated at 4,832.43 t in 2023 year and is presented in Table 4.45.

Figure 4.25 Actual emissions of the Mobile Air-Conditioning for 1989–2023 period



Activity data

In order to assess the manufacturing emissions, questionnaires were sent to the Romanian automobile producers, but since not all companies replied, the collected data was used only for verification purposes. Regarding passenger cars, for the 2016–2023 period was used collected data on the production of cars from the automobile producers. Two major sources of information were used – the NIS provided information regarding the production, import and export of vehicles, concerning 38 different CN codes and 24 PRODCOM codes. The data was available since 2000 regarding the imports and exports and since 2003 regarding the production. The missing data for the rest of the time series was produced using regression analysis based on the data for the GDP of Romania for the period 1989–2012. Regarding passenger cars, for the period 2003–2013 around 30 to 50% of the newly registered vehicles were produced in Romania. For the period 2014–2020 (with the exception of 2017 and 2020), the percentage of cars produced and registered in Romania from the total number of registered cars (including imported cars) is around 45%. For this period, the export of newly produced cars increased a lot. For 2017, the percentage was 10%, and for 2020 around 5%, percentages influenced by the increase in the export of newly produced cars. In the year 2020 from the imported cars around 84% are new cars, with 16% being second hand cars. In the 2022 - 2023 period from the imported cars around 84% are new cars, with 16% being second hand cars. Based on this, we could conclude that regarding newly registered vehicles, the Romanian fleet is not very different from the vehicle fleet in Europe, since the import of second hand passenger cars does not play a significant role.

According to Article 6, paragraphs 1-3 from Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles, subsequent installation and recharge of fluorinated greenhouse gases with a Global Warming Potential (GWP) of more than 150 are prohibited in mobile air conditioning systems. For this purpose, another questionnaire was sent to the Romanian automobile producers asking for data and information on the new refrigerant agent HFO-1234yf to be used in air conditioning units installed on new vehicle models. From the analysis of the questionnaires completed and sent by the two major car manufacturers from Romania, it results that since 2016, HFC-1234yf has begun to be used as a refrigerant for charging air conditioning units on cars. From the data received from the two operators, was calculated a weighted average of the percentage of new air-conditioned cars **"% new cars with AC units"** for **HFC-134a and resulted in a 84% value for 2016**, for **2017 result the value of 15%,** for **2018 result the value of 9%,** for **2019 result the value of 11%**, for **2020 result the value of 6%,** for **2021 result the value of 8%,** for **2022 result the value of 6%,** and for **2023 result the value of 4%.** The situation with the trucks market is different – except for the N1 category trucks, which we believe are very similar to passenger cars, N2 and N3 category trucks are produced in very small numbers in Romania and are mostly imported. The most important information was the data provided by General Directorate for Driving Licenses and Registrations, which was the number of registered passenger cars disaggregated by vehicle age, the number of trucks disaggregated by loading capacity and the number of busses for each year from 1993 to 2019.

Since HFC usage in MAC units starts around 1993, the data for the previous years was not relevant. The estimate on the number of cars with air conditioning units was based on several additional sources of information and data processing.

The first source of information was the EC 2011 study, which provides an estimate of the average percentage of new cars with AC according to the year of production for selected years (for the 1993–2015 period). For the 2016–2023 period was used the weighted average of the percentage of new air–conditioned cars (**84% value for 2016, respectively 15% value for 2017, 9% value for 2018, 11% value for 2019, 6% value for 2020, 8% value for 2021, 6% value for 2022 and 4% value for 2023)**, based on the survey that we did for the shares of HFO–1234yf. For the existing vehicle stock, as only some of the vehicle brands introduced HFO–1234yf in the years before 2016, the impact on the total stock would be much lower than the shares projected in the EC 2011 study. The share of HFO–1234yf of the total vehicle fleet for 2016 and earlier years would be very minor. For Romania the vehicle fleet is much older (e.g. the share of new cars in smaller than the one in Western European countries). Based on this data and the data about the age structure of the vehicle fleet, was calculated the MAC percentage for each year of the time series. The MAC quotas for trucks and busses were taken from the EC 2011 study and interpolated for the years, for which no data is provided (see Table 4.46). For buses and trucks (N1, N2 and N3), based on the very low historical growth rates of their number, it is assumed that no growth will occur until 2050. MAC quotas of new registered vehicles are kept unchanged.

The EC 2011 study provides the values formatted in bold, while the rest of the values were interpolated. The MAC quotas for passenger cars (percentages of MAC–equipped cars from the total cars in the vehicle fleet) are calculated by applying the percentage of cars with MAC units for each particular year – e.g. if N_i is the number of cars from the vehicle fleet in year *y*, which were manufactured in year *i*, and P_i is the percentage of new cars with MAC manufactured in year *i*, then the total number of cars with MAC units in year *y* is equal to Equation 4.3.

Equation 4.3 The total number of cars with Mobile Air-Conditioning units in year y

$$MAC_y = N_y * P_y + N_{y-1} * P_{y-1} + \dots + N_{1993} * P_{1993}$$

In order to confirm some of the assumptions were analysed the 10 largest Romanian websites for trade of new and used cars by performing different searches on the available ads. The total number of vehicles on sale was more than 180,000, but the level of ad details and the available search options were very limited in order to produce any significant results. Some of the websites showed that around 80% of the vehicles have air-conditioning units, while for some of the others the percentage was as low as 30%. To assess the banked quantities of HFCs in MAC units, we need to consider the average quantity of refrigerant per MAC unit and vehicle type. The 2006 IPCC Guidelines provide a range of 0.5 to 1.5 kg per MAC unit. Another important fact is that the quantity of refrigerant decreases significantly during the time series, which leads to different values of refrigerant in new cars introduced in the market during a particular year and a higher average values concerning the whole fleet for the same year.

Table 4.45 The quantity of banked HFC of the Mobile Air-Conditioning for 1989–2023 period

Year	Produced vehicles with MAC units	Total number of vehicles with MAC units	HFCs used for production [t]	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFC–134a]	Operation emissions [kg HFC–134a]	Disposal emissions [kg HFC–134a]	Actual emissions [kt CO_2eq.]
1995	8,577.10	3,240.46	7.76	0.96	4.24	38.79	514.05	0.00	0.72
2000	55,817.14	270,830.27	42.70	85.58	272.11	213.50	31,163.65	0.00	40.79
2005	170,518.75	1,117,593.88	114.09	74.34	982.22	570.45	109,948.21	0.00	143.67
2007	224,741.96	1,927,513.61	145.96	140.22	1,553.42	729.81	168,989.80	0.00	220.64
2008	225,569.36	2,424,280.03	145.63	212.00	1,896.47	728.13	204,861.93	0.00	267.27
2009	274,306.72	2,658,758.51	174.86	87.78	2,026.50	874.28	218,061.11	0.00	284.62
2010	323,104.91	2,871,236.57	204.15	33.95	2,137.56	1,020.76	229,544.64	0.00	299.74
2011	302,850.32	3,013,307.82	191.35	18.99	2,212.32	956.73	237,334.75	0.00	309.78
2012	305,493.25	3,225,001.78	192.16	87.91	2,333.69	960.78	249,975.82	0.00	326.22
2013	369,747.18	3,456,943.15	231.38	108.64	2,465.38	1,156.92	263,680.31	0.00	344.29
2014	344,057.80	3,768,437.39	215.63	118.37	2,647.02	1,078.14	282,614.70	202.04	369.06
2015	332,239.46	4,118,189.35	208.66	141.26	2,850.80	1,043.31	303,949.91	517.50	397.16
2016	301,042.88	4,517,425.09	189.66	185.21	3,116.93	948.30	331,741.81	962.84	433.75
2017	53,502.60	5,080,289.17	34.55	288.89	3,484.93	172.74	369,575.08	10,599.38	494.45
2018	43,637.44	5,578,572.91	28.32	263.84	3,813.92	141.60	403,577.82	32,791.40	567.46
2019	54,331.35	6,032,730.47	35.44	250.80	4,111.38	177.22	434,032.31	37,544.74	613.28
2020	25,982.06	6,449,331.28	17.25	221.10	4,385.10	86.27	462,336.16	46,352.11	661.41
2021	32,271.66	6,832,939.19	21.40	200.76	4,636.19	107.00	488,219.66	45,707.79	694.24
2022	30,866.03	7,005,726.30	20.79	152.12	4,754.03	103.95	500,667.50	33,447.79	694.49
2023	22,516.08	7,130,692.41	16.61	130.65	4,832.43	83.04	508,170.58	28,878.32	698.27

Following the study developed by DENKSTATT in 2014 and taking into account the fact that at that time no data were available at national level regarding the average amount of refrigerant loaded per vehicle, for the selection of an appropriate amount of refrigerant, the values provided in several studies and their use was assumed. A detailed information was found in a British study (AEAT, 2003), in which values are set for an average amount of agent 1.2 kg in 1993 year, declining to 0.8 kg in 2000 year, with expectations of this study for the amount to decrease to 0.6 kg in 2010 year. This is also confirmed by EC 2011 and OR 2003 studies. In order to prepare an accurate estimate, the following values from the EC 2011 study were applied (see Table 4.47). For cars, the average amount of refrigerant charge has varied over the years, dropping from the value of 0.94 kg in 1989 to 0.625 kg in 2023, respectively from 0.94 in 1989 to 0.63 kg in 2023 for new cars. The possibility of developing national parameters is still being analyzed. In this regard, in order to calculate at the national level the average amount of refrigerant HFC-134-a charge per vehicle, for new vehicles, data/information was requested from the major Romanian vehicle manufacturers. One of the operators sent data for the periods 2006–2007, 2009–2019 and for the 2021–2023 period (in 2020 there was no production of cars loaded with HFC-134a), and the second operator sent data for the period 2014–2023. For the period 2006–2013, a national value for the „average new AC charge" cannot be calculated considering the fact that only one operator sent data. For the period 2014–2019, based on the total amount of HFC agents used for the initial filling of the air conditioning units (kg) and the total number of vehicles produced equipped with air conditioning units containing HFC–134a provided by the operators, the average new AC charge was calculated. Average new AC charge values vary depending on the type of car produced. The average new AC charge value increase from 0.54 kg (in 2014) to 0.61 kg (in 2016) and then decrease to 0.58 kg (in 2017-2018) and to 0.54 kg in 2019, then increase to 0.62 kg in 2020 and decrease to 0.56 kg in 2021, to 0.53 kg in 2022, and then increase to 0.54 kg in 2023, but due to the very high fluctuation from year to year, these values were not considered as national values.

The initial emissions were calculated by multiplying the amount of refrigerant from the number of vehicles produced in a given year with corresponding emission factor. The operation emissions were calculated by multiplying the quantity of banks with the corresponding emission factor. For the estimate of the disposal emissions, the average vehicle lifetime in Romania has to be considered.

The 2006 IPCC Guidelines provide a range of 9 to 16 years. However, the data about the age distribution of the vehicle fleet in Romania illustrates different situation – the weighted average vehicle age (not vehicle lifetime) in the country varies between 10 to 13 years for different years and there is no stable trend, since it seems to be influenced by the economic situation. There is also a huge number of vehicles (about 15% in 2012 year) which are above 20 years. The number of vehicles per each year of production was compared to the number of vehicles from the previous year.

The analysis of the data revealed that all vehicles from ages below 17 to 18 years are increasing on an annual basis – e.g. vehicles start to be decommissioned at the age of 17 years, and only a small percentage of all vehicles at that age (2 to 4%) are decommissioned. While it is very hard to calculate the exact average vehicle lifetime from the available data, it could be clearly stated that the average vehicle lifetime is at least 20 years (e.g. most of the vehicles are not decommissioned until they reach at least 20 years).

In order to confirm these observations were contacted licensed vehicle decommissioning companies in the country, which have not declared any reclaimed quantities of F-gases from decommissioned vehicles. Starting with 2016, the emissions from manufacturing began to decrease due to the introduction of the new HFO–1234yf refrigerant. The increase of the total emissions is due to the increase of the emissions from stocks (which take into account the total number of cars) and the emissions from the end of use which started to appear starting with 2014 and which have become much higher during the 2017–2023 period.

Table 4.46 The number of new cars, all cars, trucks and busses with HFC–containing units of MAC for 1993–2023 period

Year	% new cars with AC units produced in that year	% all cars with AC units from the total vehicle fleet	% all N1 trucks with AC units from the total vehicle fleet	% new N1 trucks with AC units produced in that year	% all N2 trucks with AC units from the total vehicle fleet	% new N2 trucks with AC units produced in that year	% all N3 trucks with AC units from the total vehicle fleet	% new N3 trucks with AC units produced in that year	% new busses with AC units produced in that year	% all busses with AC units from the total vehicle fleet
1993	**9%**	0%	**0%**	**1%**	**0%**	**2%**	**1%**	**5%**	**34%**	**3%**
1994	**18%**	1%	**0%**	**3%**	**1%**	**4%**	**3%**	**20%**	**40%**	**7%**
1995	**25%**	3%	**1%**	**4%**	**1%**	**8%**	**6%**	**36%**	**44%**	**12%**
1996	36%	5%	2%	6%	2%	10%	12%	44%	46%	17%
1997	47%	11%	3%	8%	4%	13%	18%	51%	48%	22%
1998	58%	15%	4%	9%	5%	15%	24%	59%	50%	27%
1999	69%	16%	5%	11%	7%	18%	30%	66%	52%	32%
2000	**80%**	16%	**6%**	**13%**	**8%**	**20%**	**36%**	**74%**	**54%**	**37%**
2001	83%	17%	8%	17%	11%	23%	43%	77%	55%	40%
2002	86%	19%	10%	20%	13%	26%	51%	80%	55%	43%
2003	88%	22%	13%	24%	16%	30%	58%	82%	56%	47%
2004	91%	27%	15%	27%	18%	33%	66%	85%	56%	50%
2005	**94%**	34%	**17%**	**31%**	**21%**	**36%**	**73%**	**88%**	**57%**	**53%**
2006	94%	40%	20%	34%	24%	37%	76%	88%	57%	54%
2007	95%	49%	24%	37%	27%	39%	79%	89%	57%	55%
2008	95%	54%	27%	39%	29%	40%	81%	89%	57%	55%
2009	96%	57%	31%	42%	32%	42%	84%	90%	57%	56%
2010	**96%**	**60%**	**34%**	**45%**	**35%**	**43%**	**87%**	**90%**	**57%**	**57%**
2011	94%	63%	36%	45%	36%	43%	88%	90%	57%	57%
2012	92%	65%	38%	45%	38%	43%	88%	90%	57%	57%
2013	90%	66%	40%	45%	39%	43%	89%	90%	57%	57%
2014	88%	69%	42%	45%	41%	43%	89%	90%	57%	57%
2015	86%	72%	44%	45%	42%	43%	90%	90%	57%	57%

Year	% new cars with AC units produced in that year	% all cars with AC units from the total vehicle fleet	% all N1 trucks with AC units from the total vehicle fleet	% new N1 trucks with AC units produced in that year	% all N2 trucks with AC units from the total vehicle fleet	% new N2 trucks with AC units produced in that year	% all N3 trucks with AC units from the total vehicle fleet	% new N3 trucks with AC units produced in that year	% new busses with AC units produced in that year	% all busses with AC units from the total vehicle fleet
2016	84%	74%	44.2%	45%	42.2%	43%	90%	90%	57%	57%
2017	15%	77%	44.4%	45%	42.4%	43%	90%	90%	57%	57%
2018	9%	78%	44.6%	45%	42.6%	43%	90%	90%	57%	57%
2019	11%	79%	44.8%	45%	42.8%	43%	90%	90%	57%	57%
2020	6%	81%	45%	45%	43%	43%	90%	90%	57%	57%
2021	8%	82%	45%	45%	43%	43%	90%	90%	57%	57%
2022	6%	81%	45%	45%	43%	43%	90%	90%	57%	57%
2023	4%	80%	45%	45%	43%	43%	90%	90%	57%	57%

The number of vehicles per each year of production was compared to the number of vehicles from the previous year. The analysis of the data revealed that all vehicles from ages below 17 to 18 years are increasing on an annual basis – e.g. vehicles start to be decommissioned at the age of 17 years, and only a small percentage of all vehicles at that age (2 to 4%) are decommissioned. While it is very hard to calculate the exact average vehicle lifetime from the available data, it could be clearly stated that the average vehicle lifetime is at least 20 years (e.g. most of the vehicles are not decommissioned until they reach at least 20 years). In order to confirm these observations were contacted licensed vehicle decommissioning companies in the country, which have not declared any reclaimed quantities of F–gases from decommissioned vehicles. Starting with 2016, the emissions from manufacturing began to decrease due to the introduction of the new HFO–1234yf refrigerant.

The increase of the total emissions is due to the increase of the emissions from stocks (which take into account the total number of cars) and the emissions from the end of use which started to appear starting with 2014 and which have become much higher during the 2017–2023 period.

Emission factors

Only two vehicle manufacturers provided information regarding the total number of produced vehicles, the nameplate capacity of the air-conditioning units and the amount of HFCs used for initial charge. The provided data was not sufficient in order to calculate a country specific emission factor for the first fill emissions.

The default emission factor of 0.5% which is the upper range according to the 2006 IPCC Guidelines was used in order to estimate the initial emissions from all MAC subcategories (passenger cars, busses and trucks). Regarding the operation emissions, due to the large number of servicing companies of mobile air conditioning units and the necessity to perform significant number of consecutive measurements for a large set of vehicles, it is not feasible to use a country-specific emission factors. The IPCC guidelines provide a very broad range regarding the annual operation emissions. In reality, the actual emission factor is dependent on many conditions, like car make, vehicle age, total quantity of refrigerant contained in the MAC unit, engine size and fuel, number of kilometres driven per year, ambient temperature and so on.

The results of the detailed study on the leakage rates of MAC of passenger cars by Öko-Recherche (OR 2003), prepared for the European Commission, show that on average annual leakage rate is 7.1%. We consider the results of this study to be more accurate than the proposed ranges by the IPCC, having in mind the technological advancements in the MAC units.

Table 4.47 The values from EC 2011 study

Year	Average quantity of refrigerant for all cars	Average quantity of refrigerant in new cars	Average quantity of refrigerant in new N1 trucks	Average quantity of refrigerant for all N1 trucks	Average quantity of refrigerant in new N2 trucks	Average quantity of refrigerant for all N2 trucks	Average quantity of refrigerant in new N3 trucks	Average quantity of refrigerant for all N3 trucks	Average quantity of refrigerant in new busses	Average quantity of refrigerant for all busses
1993	**0.94**	**0.94**	**1.00**	**1.00**	**1.00**	**1.00**	**1.20**	**1.20**	**12.00**	**12.00**
1994	**0.90**	**0.88**	**0.90**	**0.90**	**1.00**	**1.00**	**1.20**	**1.20**	**12.00**	**12.00**
1995	**0.89**	**0.88**	**0.90**	**0.90**	**1.00**	**1.00**	**1.20**	**1.20**	**12.00**	**12.00**
1996	0.87	0.86	0.90	0.90	1.00	1.00	1.20	1.20	12.00	12.00
1997	0.86	0.83	0.90	0.90	1.00	1.00	1.20	1.20	12.00	12.00
1998	0.84	0.81	0.90	0.90	1.00	1.00	1.20	1.20	12.00	12.00
1999	0.83	0.78	0.90	0.90	1.00	1.00	1.20	1.20	12.00	12.00
2000	**0.81**	**0.76**	**0.90**	**0.90**	**1.00**	**1.00**	**1.20**	**1.20**	**12.00**	**12.00**
2001	0.80	0.74	0.90	0.90	1.00	1.00	1.20	1.20	11.80	11.94
2002	0.78	0.72	0.90	0.90	1.00	1.00	1.20	1.20	11.60	11.88
2003	0.77	0.70	0.90	0.90	1.00	1.00	1.20	1.20	11.40	11.82
2004	0.75	0.68	0.90	0.90	1.00	1.00	1.20	1.20	11.20	11.76
2005	**0.74**	**0.66**	**0.90**	**0.90**	**1.00**	**1.00**	**1.20**	**1.20**	**11.00**	**11.70**
2006	0.73	0.65	0.88	0.88	1.00	1.00	1.20	1.20	10.88	11.54
2007	0.71	0.65	0.86	0.86	1.00	1.00	1.20	1.20	10.76	11.38
2008	0.70	0.64	0.84	0.84	1.00	1.00	1.20	1.20	10.64	11.22
2009	0.68	0.63	0.82	0.82	1.00	1.00	1.20	1.20	10.52	11.06
2010	**0.67**	**0.63**	**0.80**	**0.80**	**1.00**	**1.00**	**1.20**	**1.20**	**10.40**	**10.90**
2011	0.66	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.82
2012	0.65	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.74
2013	0.64	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.66
2014	0.63	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.58
2015	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.50
2016	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.48

Year	Average quantity of refrigerant for all cars	Average quantity of refrigerant in new cars	Average quantity of refrigerant in new N1 trucks	Average quantity of refrigerant for all N1 trucks	Average quantity of refrigerant in new N2 trucks	Average quantity of refrigerant for all N2 trucks	Average quantity of refrigerant in new N3 trucks	Average quantity of refrigerant for all N3 trucks	Average quantity of refrigerant in new busses	Average quantity of refrigerant for all busses
2017	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.46
2018	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.44
2019	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.42
2020	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.40
2021	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.40
2022	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.40
2023	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.40

However, to ensure comparability with the GHG inventories of other countries, an annual emission factor of 10% was chosen for the emission estimates from passenger cars. There are similar results from another study by Öko–Recherche for Establishment of Leakage Rates of Mobile Air Conditioners in Heavy Duty Vehicles (OR 2007), which determined an annual leakage rate of 8.3%. However, the original authors produced a subsequent study for the European commission for a review of Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases (EC 2011), which defined slightly higher emission factors for different truck categories – for truck category N1 = 10% and for truck category N2 and N3 = 15%.

This is consistent with the IPCC guidelines, and those emission factors were chosen by a number of other countries, which is the reason for them to be used for the emission estimates. For busses was chosen an annual emission factor of 15%, sourced from the EC 2011 study. This is confirmed by the OR 2007 study, which found annual leakage rates of 13.3% and 13.7% for coaches and busses. Regarding the percentage of HFCs, which are emitted at decommissioning of vehicles, since no company reported any reclaimed quantities of HFCs, we could assume that at the moment the recovery efficiency is 0%.

Rail transport

Methodology and activity data

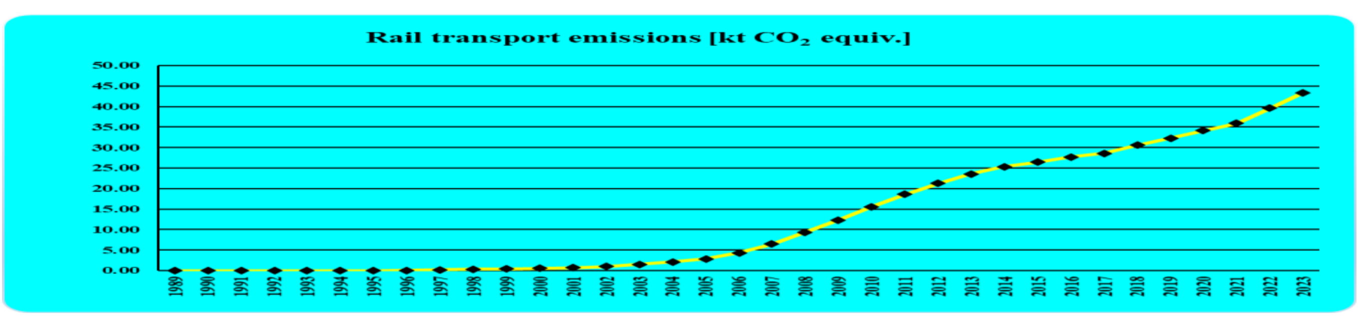
According to a recent study (EU Commission, 2007), most of the emissions from the railway sector are from air-conditioned trains.

According to studies, the F–gases, which are used for this subcategory, are mostly R–134a or R–407C. Starting with 2021 submission, the emissions from the use of refrigerants in rail transport were estimated. Rail transport includes railways and metro. Railway companies have been identified using public information on Romanian Railway Licensing Body OLFR website (http://www.afer.ro/olfr/). A special questionnaire was developed in order to obtain activity data from the railway companies. The questionnaires completed and submitted by the operators of rail passengers and/or cargo and Metrorex, shows that use refrigerants began in 1996 and are used as refrigerants HFC-134a and from 2004, R-407C. From 2021, R-410A is also used. The aggregated actual emission estimates are equal to of 43.41 kt CO_2eq. for 2023 year. The actual emissions for the period 1989–2023 are represented in the Figure 4.26. The quantity of banked HFCs for this subcategory is estimated at 103.51 t in 2023 year. For the estimate of the emissions was developed a special model which estimates the banked quantities of HFCs based on the quantity of used HFCs for a particular year for each particular species of HFCs (*Banksn = Banks$_{n-1}$ + HFCusedn – Emissions from installation$_n$ – Emissions from operation$_{n-1}$ – Emissions from disposal$_n$*). Emissions from installation were calculated by multiplying the amount of refrigerant from equipments / air conditioning installations in use in a particular year with the emission factor for installation. Emissions from operation were calculated by multiplying the banked quantity with the emission factor for operation. The amount of refrigerant at disposal are estimated with the help of equipment lifetime.

Emission factors

Tier 2a method, default emission factor for emissions from operation of 20% and default emission factor for emissions from installation of 0.5% were used, which fully coincide with the given limits of the Guidelines (IPCC, 2006). Equipment lifetime is set to 16 years. Emissions from disposal started to occur in 2012 year, but are relatively small.

Figure 4.26 Actual emissions of the Rail transport for 1989–2023 period



Total actual emissions from Mobile Air-Conditioning (CRT 2.F.1.e category) are presented in the next table.

Table 4.48 Total Actual emissions from Mobile Air Conditioning category

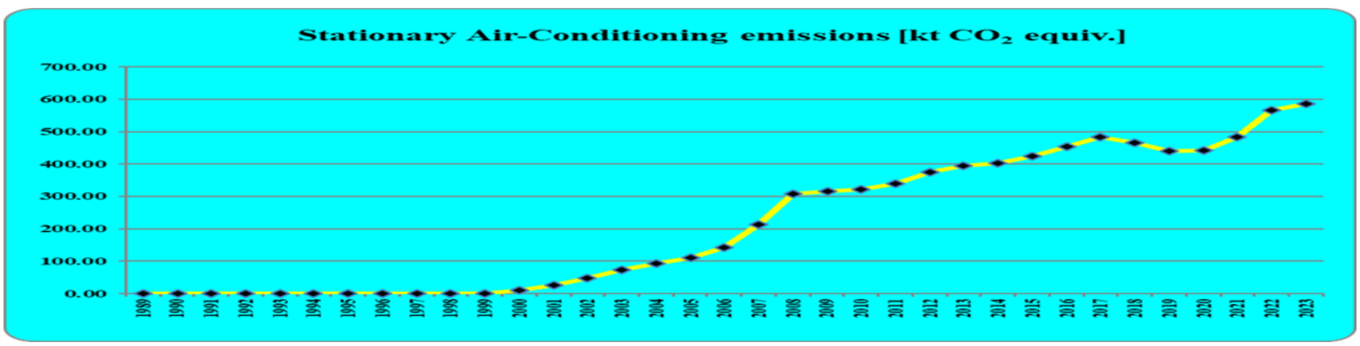
Year	Actual emissions (Mobile AC) kt CO_2 eq.	Actual emissions (Rail transport) kt CO_2 eq.	Total Actual emissions kt CO_2 eq.
1993	0.08	0.00	0.08
1994	0.29	0.00	0.29
1995	0.72	0.00	0.72
1996	1.50	0.05	1.55
1997	5.21	0.17	5.38
1998	15.21	0.32	15.53
1999	26.95	0.44	27.39
2000	40.79	0.58	41.37
2001	56.45	0.70	57.16
2002	72.21	1.03	73.24
2003	89.73	1.52	91.26
2004	114.37	2.12	116.49
2005	143.67	2.88	146.56
2006	177.56	4.34	181.90
2007	220.64	6.50	227.14
2008	267.27	9.35	276.62
2009	284.62	12.33	296.95
2010	299.74	15.57	315.31
2011	309.78	18.61	328.39
2012	326.22	21.29	347.51
2013	344.29	23.59	367.88
2014	369.06	25.31	394.38
2015	397.16	26.47	423.64
2016	433.75	27.69	461.43
2017	494.45	28.61	523.06
2018	567.46	30.56	598.03
2019	613.28	32.32	645.61
2020	661.41	34.14	695.55
2021	694.24	35.95	730.19
2022	694.49	39.62	734.11
2023	698.27	43.41	741.68

4.7.2.1.6 Stationary Air–Conditioning (CRT 2.F.1.f)

Methodology

Stationary air–conditioning is one of the fastest growing subsectors from all F–gas emissions, which is due to the rapidly increasing number of air–conditioning units in operation since 2000. Due to the relatively high annual leakages compared to domestic refrigeration, the units have to be serviced several times during their lifetime. In this subcategory are also considered heat pumps, which contain higher quantity of refrigeration agent, compared to air–conditioners. For this subcategory is followed the same methodological Tier 2a approach, as for the domestic refrigeration. The actual emissions for the period are represented in the Figure 4.27.

Figure 4.27 Actual emissions of the Stationary Air-Conditioning for 1989–2023 period



Compared to domestic refrigeration, although the domestic air-conditioning containing HFCs was introduced later in the market, it contains much higher refrigerant per unit, which leads to rapid build of HFC banks in AC equipment – in 2023 year banked quantities are equal to more than 3,769 tons, with additional 392 tons in heat pump units (see Table 4.49). Combined with a higher operation emission factor (related to domestic refrigeration), this leads to significant emission equal to 564.50 kt CO_2 eq. from AC equipment and 20.92 kt CO_2 eq. from heat pumps, which are result of mostly operation emissions. The emissions from disposal started to produce since 2015 and are quite significant.

Activity data

As with the domestic refrigeration, the activity data for this category was also not given in number of units, but instead in tons. In order to estimate the number of units per category was used data for imports in Bulgaria in units and kilograms, according to the assumptions presented in Table 4.50.

Table 4.49 The quantity of banked HFC of the Domestic Air-Conditioning for 1989–2023 period

Year	Produced units	Units placed on the market	HFCs used for production [t]	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFCs]	Operation emissions [kg HFCs]	Disposal emissions [kg HFCs]	Actual emissions [kt CO_2eq.]
2000	28	63,241	0	109	109	0	4,952	0	9.27
2005	0	151,391	0	244	1,292	0	61,097	0	110.67
2007	5,298	532,436	8	820	2,459	48	117,827	0	213.64
2008	5,835	728,756	9	1,108	3,514	53	170,161	0	307.88
2009	2,991	129,844	4	202	3,607	27	174,605	0	315.85
2010	0	122,350	0	191	3,676	0	177,891	0	321.71
2011	0	199,237	0	309	3,890	0	188,307	0	340.51
2012	0	250,740	0	383	4,267	0	207,011	0	374.23
2013	0	118,350	0	184	4,493	0	218,191	0	394.38
2014	0	169,098	0	261	4,580	0	222,490	0	402.11
2015	0	154,031	0	241	4,555	0	221,449	12,995	424.81
2016	2,243	280,883	3	431	4,685	20	228,240	22,077	453.48
2017	2,256	307,753	3	473	4,795	20	234,119	33,028	484.30
2018	2,406	112,472	4	180	4,547	22	221,971	35,183	465.98
2019	0	96,696	0	156	4,317	0	210,856	33,353	439.32
2020	0	333,155	0	513	4,480	0	219,186	28,749	442.86
2021	0	388,968	0	602	4,657	0	228,243	45,282	484.35
2022	0	430,410	0	674	4,570	0	223,629	95,670	566.38
2023	0	394,758	0	637	4,162	0	202,221	128,968	585.42

Table 4.50 Assumptions on data for imports in Bulgaria for Domestic Air-Conditioning

CN code	Equipment type	kg/unit
841510	Window or wall air conditioning machines, self–contained or "split–system"	44
841581	Air conditioning machines incorporating a refrigerating unit and a valve for reversal of the cooling–heat cycle "reversible heat pumps" (excl. of a kind used for persons in motor vehicles and self–contained or "split–system" window or wall air conditioning	51
841582	Air conditioning machines incorporating a refrigerating unit but without a valve for reversal of the cooling-heat cycle (excl. of a kind used for persons in motor vehicles, and self–contained or "split–system" window or wall air conditioning machines)	51
841861	Heat pumps (excl. air conditioning machines of heading 8415)	64

The values in this table do not represent the amount of refrigerant per unit, but the average weight of the unit itself. For some of the equipment types, import statistics were not available as number of units, but only as total weight of all units in tons. The values in this table were used to calculate the number of units. After determining the number of units, it was possible to calculate the amount of refrigerants imported into those units. The reason why values from the Bulgarian import statistics were taken into account was that both the total weight and the number of units were available for Bulgaria. It was assumed that imported equipment should be similar, so the average weight for Bulgaria should also be applicable for Romania. The same data extrapolations for the period before 2000 year were made regarding the total number of air-conditioning units introduced in the market, although for this category this data is not relevant. According to UNEP report (UNEP 2010), nearly all air conditioners manufactured prior to 2000 year used HCFC–22. The phase–out of HCFC–22 in the manufacturing of new products in the EU was completed in 2004 year. In order to reflect this in the emission estimates a linear growth regarding the new air-conditioning units containing HFCs was assumed from year 2000 to 2004. For heat pumps it is assumed that all units manufactured after 2000 year are HFC-containing. The domestic production has a very unstable trend and there is no production in the last 4 years for AC units and in the last 13 years for heat pumps. In general, the domestic production is insignificant compared to the imports. Around 354,000 AC units and 40,700 heat pumps were placed on the market in 2023 year, with the assumption that all of them are HFC–containing units. In order to estimate the quantity of F–gases, contained in domestic air-conditioning equipment was assumed an average quantity of 1.5 kg of refrigerant agent per AC unit (EC 2011, UK GHG Inventory). For heat pumps the assumed average quantity of refrigerant is 2.6 kg (EC 2011). With the above assumptions it was estimated that for 2023 year around 531 t of refrigerant have been introduced to the market as contained in AC equipment and 106 t in heat pumps. To estimate the quantity of banks in a particular year n, the equation 4.4 has been used.

Equation 4.4 The quantity of banks of the Domestic Air–Conditioning

$$Banks_n = Banks_{n-1} + HFC\ in\ new\ units_n + HFC\ for\ servicing_n - Emissions\ from\ operation_{n-1} - Disposal_n/EF_{disposal}$$

The standard formula was extended in order for the model to reflect in a better way the servicing of equipment and to avoid overestimation of the emissions. Since the air-conditioning equipment needs to be refilled with refrigerant on a regular intervals in order to restore its efficiency, it was assumed that on average every 5 years the equipment has to be topped up to its original capacity, or in other words, in a particular year during servicing are refilled the lost quantities of refrigerant, which were emitted in the last 5 years. The initial emissions were calculated by multiplying the amount of refrigerant from the equipment units produced in a given year with corresponding emission factor. The operation emissions were calculated by multiplying the quantity of banks with the corresponding emission factor. For the disposal emissions was assumed that the equipment lifetime is 15 years, which is the middle range according to the 2006 IPCC GL. This value is higher than the assumed average European AC unit lifetime of 10 years (EC 2011), but it was chosen because of the assumption that the lower living standard in Romania leads to longer equipment lifetime. With this assumption the emissions from disposal are calculated as the remaining refrigerant in all the equipment, which was introduced in the market 15 years ago. Disposal emissions have been on the rise since 2015, when the first HFC-containing equipment expected to be launched was expected to be decommissioned. Domestic air-conditioning equipment containing HFCs is distributed between R–407C and R–410A with assumed ratio 40:60 (AEA 2003). Each of those blends is disaggregated to HFC compounds (HFC–32, HFC–125 and HFC–134a) and total emissions are calculated separately based on the specific GWP of each gas. For heat pumps studies have shown, that the refrigeration agents in use are R–407C, R–410A, R–404A, but their usage changes during the years. From discussions with some of the largest importers of heat pumps in Romania, it turned out that starting from 2019, heat pumps with refrigerant R-32 were also imported, in 2021 their share will reach 80%. The refrigerant split is adopted from the EC 2011 study for the period 2000–2007. For the 2008–2021 period, considering that, at the level of 2021, there are still heat pumps with R–404A refrigerant on the Romanian market, a constant decrease in their share was assumed starting with 2008. For heat pumps with R–410A, an increase was assumed constant until 2018 (up to approximately 69%) and then a decrease to 15% in 2021 as a result of the use of heat pumps with a higher proportion of R–32. For heat pumps with R–407A, a constant decrease was assumed starting with 2008.

The refrigerant split are shown in Table 4.51.

Table 4.51 Refrigerant split for heat pumps, 2000–2023

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
R–407C	80%	77%	75%	70%	60%	55%	50%	45%	40%	39%	38%	37%	36%
R–410A	0%	3%	5%	10%	30%	40%	45%	50%	56%	58%	59%	60%	61%
R–404A	20%	20%	20%	20%	10%	5%	5%	5%	3%	3%	3%	2.5%	2.24%
R–32	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
R–407C	35%	34%	33%	32%	32%	31%	20%	12%	5%	5%	5%
R–410A	63%	64%	65%	66%	68%	69%	60%	48%	15%	15%	15%
R–404A	1.98%	1.72%	1.46%	1.20%	0.94%	0.68%	0.42%	0.16%	0.03%	0.03%	0.03%
R–32	0%	0%	0%	0%	0%	0%	20%	40%	80%	80%	80%

Emission factors

The emission factor used for estimating the manufacturing emissions is the default EF of 0.6% from the 2006 IPCC GL. The operation emissions are calculated based on The EF for operation is 5.0% annual leak rate for AC units and 3.5% for heat pumps as a percentage of total charge (EC 2011). This is within the default EF range from the 2006 IPCC GL.

Regarding the disposal loss factor for 2.F.1.f Stationary air-conditioning category, from the information requested from the Waste Directorate of NEPA regarding the waste of electrical and electronic equipment (data received for 2015), it results that from the total number of waste air conditioners collected for disposal about 83% are sent for treatment economic operators holding an authorization to treat WEEE equipment (in-country treatment). About 2% of all air conditioning waste collected for decommissioning is sent for treatment to foreign countries. The remaining approximately 15% is decommissioned without recovery of the refrigerant. For the 2016–2018 period, the percentage of equipment that is decommissioned without refrigerant recovery has a fluctuating variation: 4% in 2016, 7% in 2017 and 63% in 2018. The treatment line processes both complete collected WEEE and incomplete WEEE (most often those with a missing engine), so not all waste contained fluorinated gases at the time of treatment.

Starting with 2019, a new classification is applied, no distinction was made in the case of WEEE collection between refrigeration equipment waste and air conditioning equipment waste. Following what was described above and taking into account the fact that waste air conditioning systems are treated at an aggregate level (no distinction is made between domestic and commercial/industrial air conditioning systems) and assuming that the domestic air conditioning equipment is maintained and dismantled by the same certified personnel who deal with the refrigeration units and commercial and industrial air conditioning systems, ***the value of the 15% for disposal loss factor can be considered***, value that is also used for the Commercial refrigeration category.

4.7.2.2 Foam Blowing (CRT 2.F.2)

Methodology

Several types of HFCs, CO_2 and/or water could be used in the manufacture of a wide variety of open–cell and closed cell foams (e.g. extruded polystyrene insulation foams, solid polyurethane foams, one component foams, etc.). In Romania, there is only one company, which was identified as a user of HFCs in their production of foams. The company is producing both open–cell (PU flexible) and closed–cell (PU spray) foams and the usage of HFCs (HFC–134a, HFC–365mfc and HFC–227ea) started in 2008. Separate emission estimates were prepared for open–cell and closed–cell foams, since the two applications differ from methodological point of view – the emissions from open-cell foam production are considered prompt and they occur in the country of manufacture, while for closed-cell foams only part of the emissions occur during the production. In order to present the confidentiality of the producer, only aggregate data on the HFC use is provided. There is an unstable trend in the emissions, since the quantities of used HFCs very significantly on a yearly basis, following the market demand. In order to estimate the emissions from the foam blowing subcategory, was applied a Tier 2a approach, which considers the emissions from manufacturing and usage of foams. Disposal emissions are not considered, since the product life is estimated to range from 20 to 50 years. This subcategory is a key category according to previous estimates. A detailed model for the emissions calculation from each type of foam (open-cell flexible foam and closed-cell spray foam) was created. Starting with 2014 year the company is producing closed-cell (PU spray) foams with HFC–152a. The products manufactured with HFC-152a in the 2014-2016 period were exported. In the 2021 year, the actual emissions from foam blowing were 0.58 kt CO_2eq. (89.78% from the products manufactured were exported). In the 2022 year, the actual emissions from foam blowing were 0.54 kt CO_2eq. (87.81% from the products manufactured were exported). In the 2023 year, the actual emissions from foam blowing were 0.52 kt CO_2eq. (see Figure 4.28). The banked quantities of HFCs are estimated to be around 232.54 t in 2023 year and are shown in Table 4.52.

Figure 4.28 Actual emissions of the Foam Blowing for 1989–2023 period

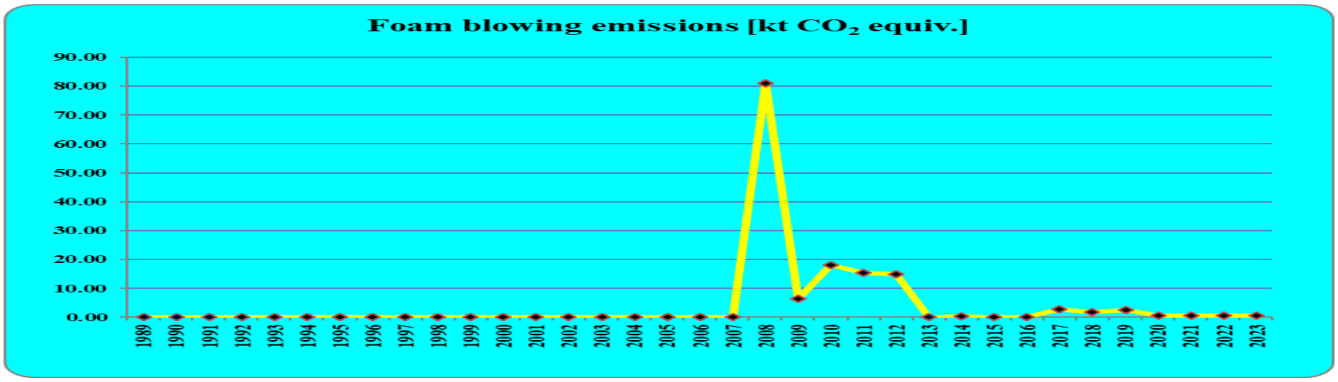


Table 4.52 The quantity of banked HFC of the Foam Blowing for 1989–2023 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFCs]	Operation emissions [kg HFCs]	Actual emissions [kt CO_2eq.]
2008	62.30	0.00	62,299.00	0.00	80.99
2009	4.87	0.00	4,874.80	0.00	6.34
2010	13.90	0.02	13,874.33	0.35	18.04
2011	12.21	0.43	11,795.84	6.50	15.32
2012	12.20	1.10	11,527.90	16.43	14.97
2013	0.62	1.61	93.73	24.15	0.12
2014	1.97	3.26	294.95	48.86	0.35
2015	0.00	3.21	0.00	48.12	0.05
2016	0.00	3.16	0.00	47.40	0.05
2017	124.16	108.65	18,623.57	1,629.69	2.84
2018	71.50	167.80	10,725.65	2,516.93	1.87
2019	90.83	242.48	13,624.02	3,637.22	2.42
2020	2.09	240.62	313.12	3,609.27	0.5801
2021	2.27	238.93	339.84	3,584.02	0.5797
2022	0.86	236.08	128.47	3,541.18	0.5441
2023	0.00	232.54	0.00	3,488.06	0.5184

Activity data

Only one company declared the use of F-gases, which was also the observation from previously collected data by the Ministry of Environment and Climate Change and the Regional Environmental Agencies. Three types of HFCs are used in the production – HFC–134a for producing open-cell flexible foam and HFC–227ea and HFC–365mfc for producing closed-cell spray foam. The amount of HFC–134a used in the production of open-cell flexible foam was very high in the first year and in the following year there was a sharp decrease in the amount of HFC–134a used for the production of open–cell flexible foam. In 2010 the amount of HFC–134a used increases slightly, then it has a constant variation until 2012. Starting with 2013, the production of this type of foam was stopped. Starting with 2010, HFC-227ea closed-cell spray foams come into production, this quantity being much smaller compared to the one used for the production of open-cell foams. Starting with 2014 year the company is producing closed-cell (PU spray) foams with HFC–152a. In 2017 the total amount of HFC–152a used in the production process increased with 10,800% compared to 2016 (total manufactured products in 2017 increased with 10,800% compared to 2016). In 2018 the total amount of HFC–152a used in the production process decreased by 35.29% compared to 2017 and only 86% of the manufactured products were exported. In 2019 the total amount of HFC–152a used in the production process increased with 15.43% compared to 2018 and only 84.33% of the manufactured products were exported. The stock are calculated based on the following formula: $Stock_n = Stock_{n-1}$ + Total quantity of HFC_n – Emissions from $operation_{n-1}$ – Emissions from $production_n$. The total amount of agent depends on the total amount of HFC-152a used in the production process per type of foam used and the % of products made and exported containing HFC-152a. The increase in stock is determined by the increase in the number of manufactured products, respectively the total amount of HFC–152a used to fill these foams. The stock increase for the year 2018, respectively 2019 is considerable because the value of the stock from the previous year is also taken into account, a value that is quite large. In 2020 the total amount of HFC–152a used in the production process decreased by 96.20% compared to 2019 and 90.52% of the manufactured products were exported. In 2021 the total amount of HFC–152a used in the production process increased with 0,67% compared to 2020 and 89.78% of the manufactured products were exported. In 2022 the total amount of HFC–152a used in the production process decreased by 68.31% compared to 2021 and 87.81% of the manufactured products were exported. In 2023, HFC-152a was no longer used in the technological process. In the current production process of single-component polyurethane foam, the following types of gases are used: propane, isobutane, dimethyl ether (fluorinated gases are no longer used).

For the open-cell foam the emissions are considered prompt – e.g. all the used F-gases are considered to be emitted during the production. All occurring emissions are considered to be occurring in Romania, regardless that some of the production is being exported. A different approach is applied for the closed-cell foam – as occurring in Romania are considered only the emissions from the production, which have been placed on the Romanian market. In order to clear the situation about the other possible use of F-gases in the foams sector as insulation materials, was contacted the Romanian Association of Construction Materials Producers (APMCR). No other producers of insulation materials containing F–gases were identified. There is no official statistics on the quantities of various types of foaming materials imported in the country and no estimate could be produced by the experts from APMCR. Additional complication is the fact that very often the importers/distributors of some foam materials used in the construction lack the knowledge if their products contain F–gases or not. Data about the reported emissions from other economies in transition in Central and Eastern Europe was analysed, which showed large differences in emission estimate per capita or per GDP. This could be explained by the fact that the large majority or emissions from the foaming sector occur from the production of foams, and not from the usage, and only a limited number of countries are producers of HFC–containing foams. Thus, we've concluded that it is not feasible to prepare an estimate of the imported foams, since it cannot be determined whether they contain F-gases or not and no reliable import data exists.

Emission factors

The emission estimates were prepared using the default emission factors from the 2006 IPCC Guidelines. For open-cell flexible foam was applied a 100% loss in the first year, while for closed-cell spray foam is assumed 15% loss for the first year (default value from the 2006 IPCC Guidelines for Polyurethane – Spray, table 7.7, page 7.37, chapter 7, volume 3) and 1.5% per annum thereafter.

4.7.2.3 Fire Protection (CRT 2.F.3)

Methodology

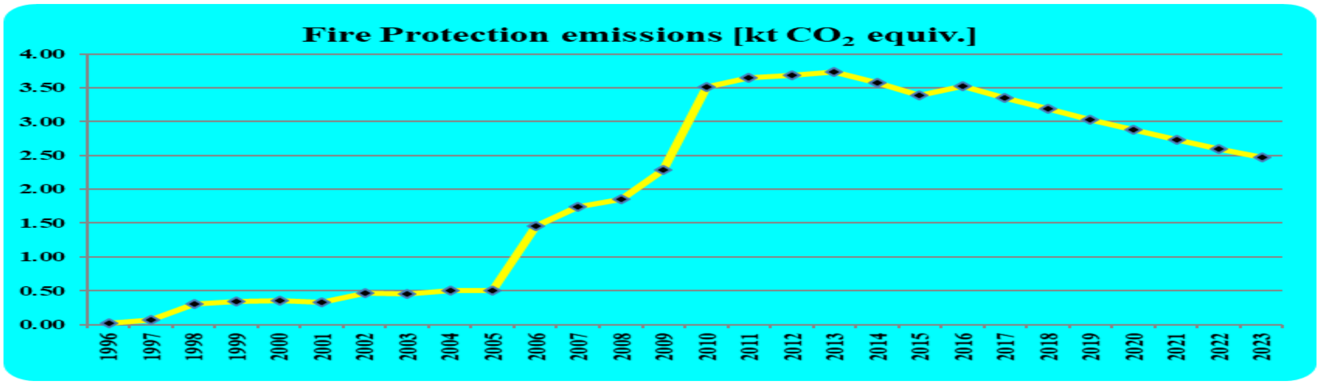
HFC use in fire protection equipment is relatively limited – its main area of application is mostly in flooding systems in datacenters, server and computer rooms, where equipment protection is of extreme importance and this could justify the higher equipment cost. There is no production of such equipment in Romania and usually the pre–filled bottles containing F–gases are directly imported from the manufacturers and connected to the piping, thus manufacturing emissions does not occur. The same procedure is followed at decommissioning – the bottles are simply removed from the piping and returned to manufacturing for off-site reclamation. In addition, the equipment lifetime is estimated to be more than 20 years, thus no emissions from decommissioning are occurring. The banked quantities of HFCs used in fire protection equipment are 14.75 t in 2023 year and while its usage in Romania started in 1996 year, the market started to grow significantly after 2006 year. Since 2017, a decrease in the banked quantities of HFCs has been observed as a result of the replacement of fire protection equipment with other equipment containing gases of type NOVEC – 1230 or by the uninstallation of certain systems (see Table 4.53). In order to estimate the emissions from fire protection equipment subcategory, was applied a Tier 2a approach, although this subcategory is not a key category and the use of a higher tier methodology is not required. The choice of method was taken for practical reasons – the proposed Tier 1 approach would either demand data both on chemical sales particularly for fire protection sector and data on the imports of equipment, which is not possible to obtain, since there are no customs codes, which would allow differentiation between equipment containing HFCs substitutes and other compounds.

Table 4.53 The quantity of banked HFC of the Fire Protection for 1989–2023 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Operation emissions [kg HFC]	Actual emissions [kt CO_2eq.]
1996	0.09	0.09	4.55	0.02
2000	0.15	2.09	104.69	0.35
2005	0.19	3.02	151.05	0.51
2007	2.13	10.42	520.90	1.75
2008	1.18	11.08	553.99	1.86
2009	3.12	13.64	682.07	2.28
2010	8.01	20.97	1,048.40	3.51
2011	1.90	21.81	1,090.73	3.65
2012	1.32	22.04	1,102.20	3.69
2013	1.34	22.28	1,113.88	3.73
2014	0.17	21.34	1,066.78	3.57
2015	0.00	20.27	1,013.45	3.40
2016	1.78	21.03	1,051.74	3.52
2017	0.00	19.98	999.16	3.35
2018	0.08	19.07	953.30	3.19
2019	0.00	18.11	905.63	3.03
2020	0.00	17.21	860.35	2.88
2021	0.00	16.35	817.34	2.74
2022	0.00	15.53	776.47	2.60
2023	0.00	14.75	737.65	2.47

The actual emissions in 2023 year are estimated to be about 2.47 kt CO_2 eq (Figure 4.29).

Figure 4.29 Actual emissions of the Fire Protection for 1989–2023 period



Activity data

For the estimate of this subcategory was used data from the Ministry of Interior Affairs regarding all fire protection installations containing F-gases. Only the use of HFC–227ea (FM–200) was reported, while the reported quantities vary from 18 kg to 6,500 kg per installation. For each installation was provided the nameplate capacity and the year of installation. In some cases the installation capacity was provided in liters – in order to calculate the mass of the F-gas was used a density of 1.3886 kg/l[1]. The stock is calculated based on the new quantity of refrigerant and also takes into account the emissions from operation. In 2019, no fire extinguishing systems containing fluorinated gases were installed. Also, a 41 kg container of HFC–227ea (FM–200) put into operation in 2005 was replaced with 1 bottle of 40 liters containing gases of type NOVEC – 1230, which has a global warming potential of 1 (with a lifetime of 80 years), equivalent to the to CO_2. In 2020, no fire extinguishing systems containing fluorinated gases were installed. In 2021, the installation consisting of 20 cylinders with the quantity FM 200–900 liters (year of installation 2013) was uninstalled, which caused a decrease in emissions compared to 2020. In 2022, 3 cylinders of 60 liters each (year of installation 2002), one cylinder of 75 kg (year of installation 1996), 31 cylinders of 17 kg and 2 cylinders of 26.8 kg (year of installation 2008) were uninstalled, which caused a decrease in emissions compared to 2021. In 2023, the system containing 485 l (put into operation in 1998) was not in working condition.

Emission factors

The 2006 IPCC Guidelines provide an updated range of 2 to 6% annual leakage. However, in order to ensure comparability of the results, the estimates were prepared with the default EF of 5%, which is within the range proposed by the IPCC 2006 Guidelines (2–6%). Emissions from decommissioning are not considered, since the expected equipment lifetime of 20 years has not yet passed since the first installations were

[1]http://www2.dupont.com/FE/en_US/assets/downloads/pdf_fm/k17649_FM-200_physical_properties_si.pdf

introduced in the country. For fire extinguishers containing fluorinated greenhouse gases EF from .decommissioning is NA (the bottles used are returned to the manufacturer).

4.7.2.4 Aerosols/Metered Dose Inhalers (CRT 2.F.4)

Methodology

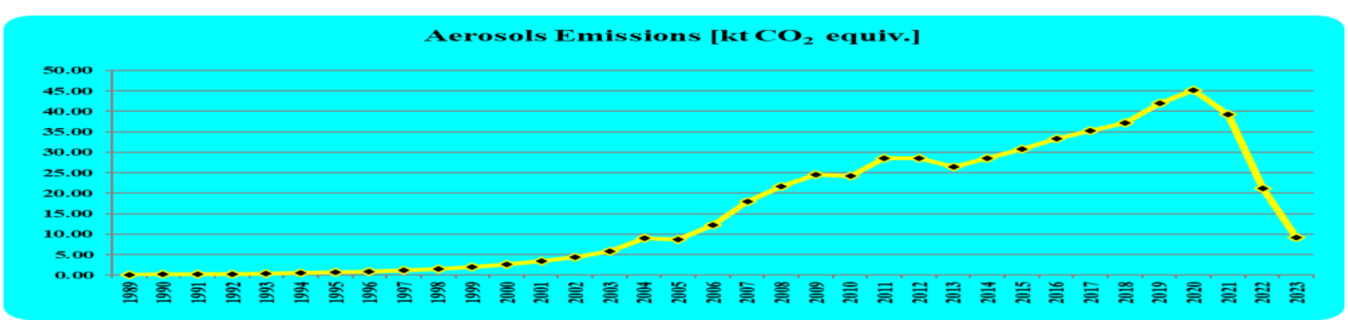
The research did not reveal any aerosol producers from Romania. This was confirmed by reviewing international sources (list of members of the European Aerosol Federation[2], FEA Statistics Report for 2008–2012[3], Aerosol Europe Market survey of European producers[4]). According to information from European Aerosol Federation, the European aerosol industry has primarily shifted to flammable liquefied propellants (hydrocarbons and dimethyl ether), although there are still some use of HFCs, where the use of non-flammable liquefied propellant is required, but this usually excludes the most widespread aerosol types like personal care products and household products. Since the research did not identify any evidence for the existence of Romanian aerosols producers, emissions from manufacturing are not occurring. In Romania, HFCs are mostly used as propellants in aerosol sprays for drug application in asthma therapy (e.g. metered dose inhalers). Generally, HFC–134a and HFC–227ea could be used as propellants, although the research showed only the use of HFC–134a for the 1989–2017 period, and for 2018–2023 period the research showed the use of HFC–134a and HFC–227ea. The emissions from use of MDIs were estimated based on questionnaires provided by pharmaceutical companies – for 2023 more than 0.65 mln. MDIs were sold on the market, the emissions from which amount to 9.26 kt CO_2 eq (see Table 4.54). Since for this subsector the accumulation of banks is limited to one year after the production of the aerosol, there are no large banked quantities accumulated. In the 2006 IPCC Guidelines, two approaches are defined, Tier 1a and Tier 2a, and both are based on the quantities of chemicals contained in aerosols. In order to estimate the emissions from the aerosols subcategory, was applied a Tier 2a approach, which considers the aerosol use emissions. This subcategory is a not a key category.

[2] http://www.aerosol.org/about-fea/members
[3] http://www.aerosol.org/publications-news/publications/statistics/statistics-2
[4] http://www.aerosoleurope.de/wp-content/uploads/MarketSurvey_AE0211.pdf

Table 4.54 The quantity of banked HFC of the Aerosols/Metered Dose Inhalers for 1989–2023 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFC]	Operation emissions [kg HFC]	Actual emissions [kt CO_2eq.]
1989	0.11	0.05	54.59	54.59	0.14
1990	0.14	0.07	72.11	54.59	0.16
1995	0.57	0.29	285.74	218.10	0.65
2000	2.25	1.13	1,127.38	858.22	2.58
2005	4.56	2.28	2,279.06	4,374.64	8.65
2007	13.33	6.66	6,663.40	7,175.09	17.99
2008	20.03	10.02	10,016.62	6,663.40	21.68
2009	17.71	8.86	8,855.65	10,016.62	24.53
2010	19.60	9.80	9,798.32	8,855.65	24.25
2011	24.41	12.20	12,203.56	9,798.32	28.60
2012	19.56	9.78	9,779.65	12,203.56	28.58
2013	21.16	10.58	10,579.09	9,779.65	26.47
2014	22.66	11.33	11,328.28	10,579.09	28.48
2015	24.82	12.41	12,410.87	11,328.28	30.86
2016	26.47	13.23	13,233.36	12,410.87	33.34
2017	27.71	13.85	13,854.37	13,2 33.36	35.21
2018	29.26	14.63	14,629.03	13,854.37	37.26
2019	33.27	16.64	16,635.58	14,629.03	42.06
2020	32.18	16.09	16,088.73	16,635.58	45.19
2021	23.94	11.97	11,972.40	16,088.73	39.35
2022	4.02	2.01	2,007.59	11,972.40	21.25
2023	5.22	2.61	2,609.27	2,007.59	9.26

Figure 4.30 Actual emissions of the Aerosols/Metered Dose Inhalers for 1989–2023 period



Activity data

In order to identify all importers of MDIs in the country was requested a list of all registered drugs, which contain HFCs from the National Agency for Medicines and Medical Devices (ANMDM). The Agency provided a list of 24 different drugs from 7 pharmaceutical companies, registered on the Romanian market from 2004 on. All companies were sent questionnaires requesting them to provide the number of MDIs sold on the Romanian market and the quantities of HFCs per container. The available data about the number of MDIs sold on the market was for the period 2004–2013 – the data for the beginning of the timeseries was estimated using regression analysis based on the data for the GDP of Romania for the period 1989–2012. For the 2016 year 6 pharmaceutical companies sent completed questionnaires and in the 2017 and 2018 years 4 pharmaceutical companies sent completed questionnaires. In 2019, three of the pharmaceutical companies sent the completed questionnaires and two companies stated that the respective drugs are no longer sold in Romania. In 2020, three of the pharmaceutical companies sent the completed questionnaires and one company stated that the respective drugs are no longer sold in Romania. The number of units sold in 2021 decreased by 22.65% compared to 2020. The pharmaceutical companies also provided information on the quantity of propellant per individual drug, which ranges from 5.6 to 17.9 grams per MDI. With this data, it was possible to calculate the exact quantity of HFCs introduced in the market for each year. The annual sales volumes per individual drug vary during the years, since new drugs are introduced or very often the same drug is offered in various packaging (e.g. concentration of the active substance or number of doses per MDI), but in general there is a strong increasing trend in the consumption of drugs. In 2022, two of the pharmaceutical companies sent the completed questionnaires and one of the operators stated that the company did not register sales in 2022 in Romania. The number of units sold in 2022 decreased by 67.08% compared to 2021. The number of units sold in 2023 increased with 20.33% compared to 2022. Even if the number of units sold increased in 2023 compared to 2022, emissions decreased due to the fact that emissions from operation are calculated based on the quantity of refrigerant placed on the market in the previous year (which was lower in 2022 compared to year 2021).

Emission factors

According to the IPCC Guidelines, aerosol emissions are considered prompt, because all the initial charge escapes within the first year or two after the sale. Equation 7.6 from the 2006 IPCC Guidelines was applied with a default emission factor of 50% of the HFCs released in the first year, and the rest released on the following year.

4.7.2.5 Solvents (CRT 2.F.5)

HFC/PFC solvent uses could occur in four main areas: precision cleaning, electronics cleaning, metal cleaning or deposition applications. PFCs have little use in cleaning, as they are essentially inert, have very high GWPs and have very little power to dissolve oils. The pure material does not have the cleaning power of CFC–113, since no chlorine atoms are present in the molecule. In general, based on information provided by Umweltbundesamt in Germany, the share of this subsector is insignificant. The national statistics cannot provide any type of information regarding this application in Romania. Various companies identified by their activity and NACE code (electronics producers, etc.) were contacted in order to asses if they use of F–gases in their operations, neither of which confirmed the application – thus the emissions from this category are considered not occurring.

4.7.2.6 Other Applications (CRT 2.F.6)

Based on information collected through the years both with questionnaires from the Ministry of environment and Climate Change and the Regional Environmental Agencies, not other applications were identified in the country.

4.7.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

4.7.4 Uncertainty assessment and time-series consistency

The uncertainty related values collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study (additional information are included in Annex V.10), by the Austrian Environment Agency–University of Graz consortium, in 2012, were updated in the context of the implementation in 2013 of the study "Elaboration and documentation of the parameters values relevant to the National Greenhouse Gas Inventory Industrial Processes Sector values to allow for the greenhouse gas emissions calculation methods, higher Tier methods, for the categories: Production of halocarbons and sulphur hexafluoride (HFCs, PFCs and SF_6), Consumption of halocarbons and sulphur hexafluoride (actual emissions), Consumption of halocarbons and sulphur hexafluoride (potential emissions)”; the values elaborated in 2013 are presented in the current section and were used in the uncertainty analysis and in the key category analysis. Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2022.

4.7.4.1 Commercial Refrigeration (CRT 2.F.1.a)

Because not all companies provided data about their HFC usage, the activity data had to be adjusted, which could lead to uncertainty close to 20%. Unlike other subsectors from the refrigeration and air conditioning sector, in this subsector there are no further assumptions regarding the quantity of refrigerant per unit, percentage of HFC-containing units, etc. However, the calculation of the banked quantities of HFCs based on the HFC usage reported by the companies could lead to an estimated additional uncertainty of 15%, depending on the actual operational emission factor. As a result, we estimate the total uncertainty of the activity data for this sector at 25%. Considering the available studies regarding the commercial refrigeration sector, it is possible that the used emission factors have an uncertainty of 25%. This leads to a combined uncertainty of the emission estimates of 35%.

4.7.4.2 Domestic Refrigeration (CRT 2.F.1.b)

Due to the large number of assumptions regarding this category, the uncertainty is assumed to be rather high. As sources on uncertainty in the activity data could be noted the primary activity data, which in some cases was not provided in number of units, but in kilograms. This might lead to uncertainty of the data of 20%. For the periods before 2000, where the activity data is extrapolated the uncertainty could increase with additional 20%, although there is a good correlation between the GDP and refrigeration manufacturing. Another source of uncertainty is the assumption about the percentage of HFC-containing equipment, especially for the beginning of the time-series. This could lead to an uncertainty of the activity data of 50 to 150%. The average quantity of refrigerant is also a source of uncertainty, although it should not be more than 20%. As a result, we estimate the total uncertainty of the activity data for this sector at 100%. The uncertainty of the EF is equal to the default uncertainty in the 2000 IPCC GL. The proposed ranges of the EF presume an uncertainty of 200%. This leads to a combined uncertainty of the emission estimates of 224%.

4.7.4.3 Industrial Refrigeration (CRT 2.F.1.c)

The same uncertainty regarding the activity data as in the commercial refrigeration sector is applied–20% because of the missing data from servicing companies with an additional uncertainty of 15% originating from the model for estimating the banked quantities. The total uncertainty of the activity data for this sector is estimated at 25%. Considering the available information about the emission factors for the industrial refrigeration sector, it is assumed an uncertainty of 25%. This leads to a combined uncertainty of the emission estimates of 35%.

4.7.4.4 Transport Refrigeration (CRT 2.F.1.d)

The data regarding the number of vehicles should have a relatively low uncertainty (around 2%), since it should be based on official vehicle registration data. The assumption about the percentage of refrigerated vehicles from all vehicles could lead to uncertainty of 30%. The assumption about the percentage of HFC-containing refrigerated vehicles could lead to uncertainty of additional 15%. The average quantity of refrigerant is also a source of uncertainty, although it should not be more than 15%. As a result, we estimate the total uncertainty of the activity data for this sector at 37%. Considering the available studies regarding the mobile air conditioning sector, it is possible that the used emission factors have an uncertainty of 25%. This leads to a combined uncertainty of the emission estimates of 44%.

4.7.4.5 Mobile Air-Conditioning (CRT 2.F.1.e)

The uncertainty of this category is dependent on several factors. The primary activity data regarding the number of vehicles is provided by the National Statistics and it should have a relatively low uncertainty (around 2%), the same should be valid for the age structure of the vehicle fleet, which should be based on official registration data. The assumption about the percentage of MAC–equipped vehicles is based on average European data, which could lead to uncertainty of 20%. The average quantity of refrigerant is also a source of uncertainty, although it should not be more than 15%. As a result, we estimate the total uncertainty of the activity data for this sector at 25%. Considering the studies by Öko-Recherche, it could be seen that the currently used emission factors are higher by as much as 25%. This leads to a combined uncertainty of the emission estimates of 36%.

4.7.4.6 Stationary Air-Conditioning (CRT 2.F.1.f)

This category has lower uncertainty than the Domestic refrigeration, but shares most of the uncertainty sources. The primary activity data is again not provided in number of units, but in kilograms, which might lead to uncertainty of the data of 20%.The assumption about the percentage of HFC-containing equipment, does not lead to high uncertainties, since for this subcategory there are no major technological alternatives regarding refrigeration agents. Nevertheless, different HFC blends used in this subcategory have different GWP, which could lead to an uncertainty of the activity data of 20 to 50%. The average quantity of refrigerant is also a source of uncertainty, although it should not be more than 20%. As a result, we estimate the total uncertainty of the activity data for this sector at 50%. The uncertainty of the EF is equal to the default uncertainty in the 2000 IPCC GL. The proposed ranges of the EF presume an uncertainty of 200%. This leads to a combined uncertainty of the emission estimates of 206%.

4.7.4.7 Foam Blowing (CRT 2.F.2)

The uncertainty of the activity data is estimated to be low (5%), since data is obtained directly from producers and it is disaggregated by activity type. The uncertainty of the default emission factor is higher judging by the revised estimates provided in the 2006 IPCC Guidelines – it is estimated at 33%. The combined uncertainty of this sector is 33%.

4.7.4.8 Fire Protection (CRT 2.F.3)

The uncertainty of the activity data is estimated to be relatively low (15%), since the fire protection installations have to be registered with the Ministry of Interior Affairs and because of the specific applications for HFC containing equipment. On the other hand, the uncertainty of the default emission factor is rather high – it is estimated at 100% based on information, which suggests that the default EF is probably twice bigger that current estimates. The combined uncertainty of this sector is 101%.

4.7.4.9 Aerosols/Metered Dose Inhalers (CRT 2.F.4)

The uncertainty of the activity data (number of sold MDIs) is estimated to be 10%, since the number of companies is not very large and data was obtained directly from them. Additional source of uncertainty is the data about the quantity of HFC per MDI, but since the data was provided with very high precision (in milligrams), we estimate the uncertainty at 5%. The used methodological approach, which distributes the emissions in two consecutive years might lead to some uncertainty for a particular year compared to the next one does not presume any uncertainty in the long term, since all F-gas emissions are eventually accounted. Thus, we believe that for this particular case the used emission factor does not introduce uncertainty in the emission estimates. The combined uncertainty of this sector is 11%.

4.7.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013. No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

4.7.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the emissions estimates quality some important recalculations were made:

- ***Activity data and emissions:***
    - Fire Protection (CRT 2.F.3)

Table 4.55 The effects of recalculations in Product uses as substitutes for ODS Subsector

The effects of recalculations in Product uses as substitutes for ODS Sector			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	HFC emissions [kt CO_2 equivalent]		
1999	37.62	37.65	0.08
2000	66.76	66.79	0.06
2001	106.08	106.12	0.03
2002	158.46	158.48	0.01
2003	216.02	216.04	0.01
2004	277.58	277.60	0.01
2005	348.68	348.70	0.01
2006	452.43	452.47	0.01
2007	617.48	617.51	0.01
2008	873.64	873.67	0.004
2009	850.36	850.39	0.004
2010	899.27	899.30	0.003
2011	999.11	999.14	0.003
2012	1,091.86	1,091.89	0.003
2013	1,181.18	1,181.21	0.002
2014	1,260.04	1,260.07	0.002
2015	1,381.32	1,381.34	0.002
2016	1,538.33	1,538.35	0.001
2017	1,696.40	1,696.42	0.001
2018	1,761.11	1,761.13	0.001
2019	1,780.65	1,780.67	0.001
2020	1,847.45	1,847.47	0.001
2021	1,908.26	1,908.27	0.001
2022	1,972.13	1,972.15	0.001
2023		1,980.25	

Fire protection (2.F.3)

Recalculations have been made for the 1999-2022 period as a result of updating activity data on the total quantity of agent in fire protection equipments for the years 1999, 2000, 2002 and 2006.

4.7.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

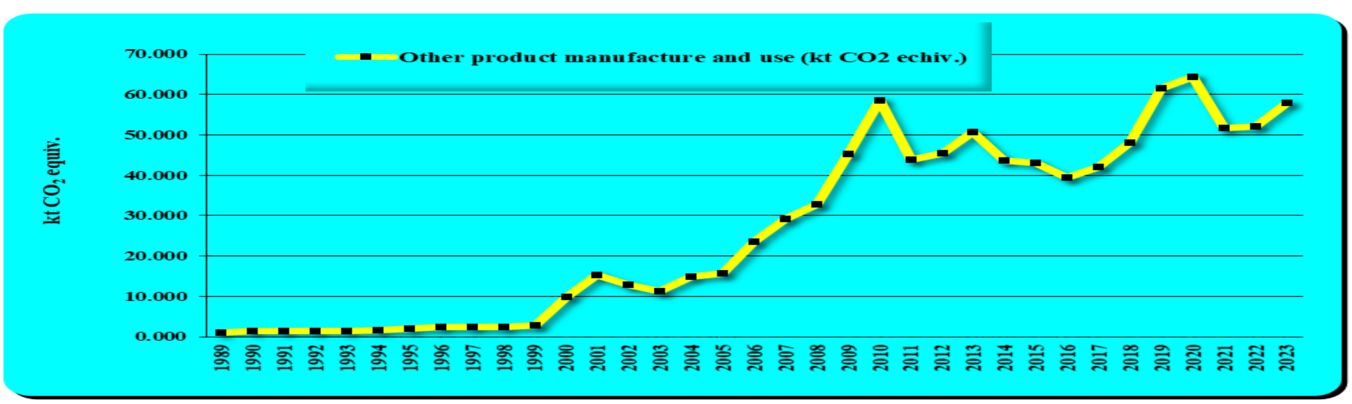
More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

4.8 Other product manufacture and use (CRT 2.G)

4.8.1 Category description

Under this F–gases category are considered the following subcategories: Electrical equipment (CRT 2.G.1), SF_6 and PFCs from other product use (CRT 2.G.2), N_2O from product uses (CRT 2.G.3) and Other (CRT 2.G.4). Other product manufacture and use contributes with 0.69% to the total GHG emissions from Industrial Processes and Product Use Sector in 2023.

Figure 4.31 GHG emissions trend in the Other product manufacture and use Sub–sector for 1989–2023 period



4.8.2 Methodological issues

4.8.2.1 Electrical Equipment (CRT 2.G.1)

Methodology

Sulphur hexafluoride (SF_6) is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity. Emissions could occur during manufacturing, installation, servicing and disposal of the equipment. For the preparation of the emission estimates, this category was divided in two subcategories – sealed pressure equipment and closed pressure equipment. According to the collected data, SF_6 has been used from the beginning of the time series, but the usage started to grow significantly after 2000 year. In the 2011–2016 period the installation of new equipment has been slowing down, which leads to a decreasing trend in emissions. In the 2017–2020 period, the installation of new equipment increased, which led to an increasing trend in emissions. In 2021 the installation of new equipment decreased which led to a decrease in emissions. Most of the banked quantities of SF_6 are contained in closed pressure equipment (around 62.5% of the total quantity or 70 t in 2023 year), while the rest is banked in sealed pressure equipment (around 37.5% of the total quantity or 42 t in 2023 year). There is a clear trend though for the percentage of closed pressure equipment to decrease and the sealed pressure equipment to increase. In terms of emissions, almost all of the emissions are generated by closed pressure equipment, since it generates both installation, operation and disposal emissions. For the sealed pressure equipment no installation emissions are occurring and the operation emissions are much lower. The total emissions from electrical equipment are equal to 55.80 kt CO_2eq. in 2023 year (see Table 4.56). Emissions from the electrical equipment subcategory were estimated using a bottom-up approach (Tier 1 method from the 2006 IPCC guidelines).

Figure 4.32 Actual emissions of the Electrical Equipment for 1989–2023 period

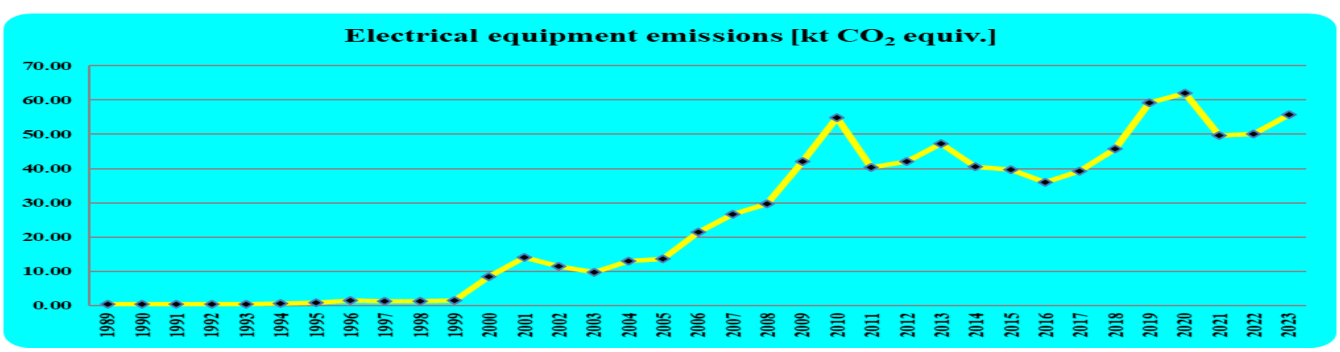


Table 4.56 The quantity of banked HFC of the Electrical Equipment for 1989–2023 period

Year	SF_6 placed on the market [t]	Quantity of banks [t]	Initial emissions [kg SF_6]	Operation emissions [kg SF_6]	Disposal emissions [kg SF_6]	Actual emissions [kt CO_2eq.]
1989	0.00	0.80	0.00	20.83	0.00	0.49
1990	0.00	0.78	0.00	20.29	0.00	0.48
1995	0.17	0.96	14.28	24.72	0.00	0.92
2000	3.06	4.78	249.26	114.44	0.00	8.55
2005	2.32	16.33	171.09	362.97	49.20	13.71
2007	7.98	27.48	532.22	584.63	14.70	26.59
2008	9.17	35.12	529.97	712.89	21.15	29.70
2009	13.72	46.83	842.95	926.51	22.65	42.11
2010	21.35	66.05	1,105.44	1,226.77	4.45	54.91
2011	8.20	71.98	386.93	1,294.21	33.14	40.29
2012	8.03	77.77	393.48	1,364.25	27.68	41.96
2013	7.53	83.16	528.10	1,474.21	12.15	47.34
2014	5.38	86.48	212.75	1,492.94	18.48	40.52
2015	4.36	88.61	165.95	1,492.02	28.61	39.63
2016	2.51	89.09	46.56	1,459.20	24.24	35.95
2017	3.54	90.51	181.28	1,464.18	23.72	39.23
2018	5.99	93.80	383.64	1,515.90	42.94	45.65
2019	11.01	101.49	793.80	1,677.52	50.63	59.27
2020	11.08	109.31	766.68	1,833.19	41.04	62.06
2021	2.79	108.99	236.82	1,826.88	51.83	49.71
2022	3.11	109.47	264.38	1,841.47	26.77	50.12
2023	5.19	111.56	436.80	1,896.69	40.90	55.80

Activity data

A special questionnaire was developed and sent to all electricity producers and distribution companies in the country, which were licensed by the Romanian Energy Regulatory Authority (ANRE). The aim of the questionnaire was to gather historical data on electrical equipment installations and to obtain the required activity data for the development of country-specific emission factors, so a higher tier methodology could be applied. While the companies were able to provide data regarding the nameplate capacity of the new and used equipment, the collected data about the used quantities of SF_6 for installation and maintenance was not complete. Some of the companies were able to provide the total nameplate capacity of their equipment, but not a split between sealed and closed pressure systems (around 1% of the total nameplate capacity of equipment). For those companies was used the average split from all reporting companies for that particular year. Sealed pressure equipment usually has a capacity of less than 5 kg per functional unit and it is used at a voltage below 52 kV. It does not require any maintenance during the period of operation and its operation emission factor is much lower. Systems capable of charge (closed pressure systems) are used in more than 52 kV tension and may contain amounts of 5 to several hundred kg. Although closed pressure system annual emission factor is higher, it could still have more than 10 years between its servicing intervals. Since the electrical equipment is not manufactured in Romania, no manufacturing emissions are occurring. However, there are installation emissions from the closed pressure equipment, but not from the sealed pressure. The stock is calculated based on the new quantity of refrigerant and also takes into account the emissions from charging new equipment, emissions from operation and emissions from disposal.

Emission factors

Since the equipment stock is growing relatively rapidly and due to the lack of sufficient data from the questionnaires, it was not possible to calculate country–specific EF. For equipment installation emissions of closed pressure equipment was used a default EF of 8.5%, given by the 2006 IPCC Guidelines. Regarding the operation emissions, the 2006 IPCC Guidelines provides a default EF of 2.6%. For sealed pressure equipment is used the default emission factor from the 2006 IPCC Guidelines, equal to 0.2% per year.

4.8.2.2 SF_6 and PFCs from other product use (CRT 2.G.2)

4.8.2.2.1 Accelerators (CRT 2.G.2.b)

Methodology

SF_6 is used as an insulating gas in two types of industrial particle accelerators (low and high voltage) and also in medical (cancer therapy) particle accelerators. The survey of other uses of SF_6 was undertaken for 2023 submission. Category 2.G.2.b Accelerators has been added to this submission. In Romania, particle accelerators are used in radiotherapy centers. The Accelerators category is not a key category. The method for calculating of SF_6 emissions from medical particle accelerators is in line with the 2006 IPCC Guidelines (Tier 2 method) considering the “Decision tree for industrial and medical particle accelerators” – page 8.29 (Figure 8.4) and the Equation 8.18 – page 8.30 from 2006 IPCC Guidelines for National Greenhouse Gas

Inventories methodology.

Activity data

Data about the total number of accelerators used for radiotherapy treatment is obtained from the National Commission for the Control of Nuclear Activities of Romania. The data regarding the year of putting into operation of these accelerators, respectively, the average SF_6 charge in a particle accelerator were obtained, through the National Agency of Medicines and Medical Devices in Romania (ANMDMR), from the economic operators who have an issued operating permit by ANMDMR for the installation and maintenance activities of these linear accelerators (see the table below). The values of the average SF_6 charge are between 0.033 and 0.200 kg, depending on the model and manufacturer.

Table 4.57 Number of particle accelerators and the average SF_6 charge for the period 2007–2023

Year	The number of particle accelerators in operation	The average SF_6 charge in the particle accelerator, kg
2007	1	0.033
2008	1	0.033
2009	1	0.033
	1	0.200
2010	1	0.033
	2	0.200
2011	1	0.033
	2	0.200
2012	2	0.033
	5	0.200
2013	2	0.033
	9	0.200
2014	2	0.033
	10	0.200
	1	0.100
2015	2	0.033
	12	0.200
	1	0.100
2016	2	0.033
	16	0.200
	1	0.100
2017	2	0.033

Year	The number of particle accelerators in operation	The average SF_6 charge in the particle accelerator, kg
	18	0.200
	1	0.100
2018	2	0.033
	26	0.200
	1	0.100
2019	2	0.033
	36	0.200
	1	0.100
2020	2	0.033
	40	0.200
	1	0.100
2021	2	0.033
	47	0.200
	2	0.100
2022	2	0.033
	58	0.200
	3	0.100
2023	2	0.033
	64	0.200
	3	0.100

Emission factors

Emissions are calculated according to Tier 2 methodology, Equation 8.18 with available data on the average SF_6 charge in each medical accelerator and default emission factor 2 kg/kg SF_6 from Table 8.10, page 8.30, vol. 3, chapter 8, 2006 IPCC Guidelines. The total SF_6 emissions for category 2.G.2.b Accelerators were calculated as the sum of the emissions generated by each individual accelerator, depending on the average SF_6 charge. The resulting emissions in 2023 correspond to 0.619 kt CO_2-eq.

Table 4.58 SF_6 emissions for category 2.G.2.b Accelerators for the period 2007–2023

Year	SF_6 emissions [kt CO_2eq.]
2007	0.002
2008	0.002
2009	0.011
2010	0.020

Year	SF_6 emissions [kt CO_2eq.]
2011	0.020
2012	0.050
2013	0.088
2014	0.102
2015	0.121
2016	0.158
2017	0.177
2018	0.252
2019	0.346
2020	0.384
2021	0.454
2022	0.562
2023	0.619

4.8.2.3 N_2O from product uses (CRT 2.G.3)

N_2O from product uses is not a key category. Evaporative emissions of nitrous oxide (N_2O) can arise from various types of product use, including:

- Medical applications (anaesthetic use, analgesic use and veterinary use);
- Use as a propellant in aerosol products, primarily in food industry (pressure-packaged whipped cream, etc);
- Oxidising agent and etchant used in semiconductor manufacturing;
- Oxidising agent used, with acetylene, in atomic absorption spectrometry;
- Production of sodium azide, which is used to inflate airbags;
- Fuel oxidant in auto racing; and
- Oxidising agent in blowtorches used by jewelers and others.

The method for calculating emissions of N_2O from Medical applications is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories, considering the Equation 8.24 at page 8.36 from 2006 IPCC Guidelines.

Activity data

In order to estimate N_2O emissions from N_2O from product uses Sub-sector it was made a questionnaire which it was sent to the Local Environmental Protection Agencies. Each agency manages all economic agents which are in its responsibility (producers and distributors / consumers of products of N_2O, hospitals, chemical analysis using atomic absorption spectrometer) in order to complete the needed data. The completed questionnaire has been sent to NEPA where the data are aggregated. The data on N_2O used in medical applications were collected from the economic operators (hospitals). The data on N_2O used in atomic absorption spectrometry activity have been raported by a single institute which is engaged in chemical analysis using atomic absorption spectrometer. There are no statistics on production, import/export and/or sales of canned whipped cream in Romania. For the data on N_2O use as a propellant in aerosol products, a questionnaire was sent to two of the largest importers of tubes of cream in Romania. Only one sent the data for the 2007–2022 period. The N_2O emissions are calculated based on the total amount of nitrous oxide (N_2O) spray used for loading units (tonnes) which is given by the product of the amount of nitrous oxide used for loading each unit spray (6 g/can) and number of sprays whipped cream sold on market in Romania. For the Production of sodium azide, which is used to inflate airbag (nitrous oxide is used for the production of sodium azide NaN_3, which is then used to fill the airbag; the gas inflates the air bag is nitrogen; it is produced either from a chemical reaction between sodium azide and potassium nitrate KNO_3 or by thermal decomposition of sodium azide in sodium metal and nitrogen), after a thorough study we identified that there are no production of sodium azide in Romania. From discussions with two big operators from the country with primary activity, activity manufacturing of motor vehicles, other car parts and motor vehicles, resulted that the capsules with sodium azide are loaded in airbags outside the country and airbag installation is done in the country. It follows that there are no N_2O emissions from this activity.

Emission factors

N_2O emissions are calculated according to Equation 8.24 at page 8.36 from 2006 IPCC GL. It is assumed that none of the administered N_2O is chemically changed by the body, and all is returned to the atmosphere. It is reasonable to assume an emission factor of 1.0.

4.8.2.4 Other (CRT 2.G.4)

Other emissions are not known to be occurring.

4.8.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG’s do not apply for Romania.

4.8.4 Uncertainty assessment and time-series consistency

4.8.4.1 Electrical Equipment (CRT 2.G.1)

The activity data was obtained directly from operators, thus its uncertainty should be around 175%. The questionnaire specifically asked the companies to provide information since which year they are using electrical equipment in order to confirm the consistency of the provided data for the full time series. Since the emission estimates use the default emission factors, the uncertainty is estimated at 0%. The combined uncertainty is 175%.

4.8.4.2 Accelerators (CRT 2.G.2.b)

The activity data was obtained directly from operators, thus its uncertainty should be around 175%. The questionnaire specifically asked the companies to provide information since which year they are using electrical equipment in order to confirm the consistency of the provided data for the full time series. Since the emission estimates use the default emission factors, the uncertainty is estimated at 0%. The combined uncertainty is 175%.

4.8.4.3 N_2O from product uses (CRT 2.G.3)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 10 %;
- 11.18 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2023.

4.8.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

4.8.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In order to improve the emissions estimates quality some important recalculations were made:

- ***Emissions:***
    - Other (please specify) - Oxidising agent used in atomic absorption spectrometry (CRT 2.G.3.b.ii)

Table 4.59 The effects of recalculations in Other product manufacture and use Subsector

The effects of recalculations in Other product manufacture and use Subsector			
Years	**NIR 2024**	**NIR 2025**	**Differences [%]**
	HFC emissions [kt CO_2 equivalent]		
2017	42.11	42.12	0.01
2023		58.04	

Other - Oxidising agent used in atomic absorption spectrometry (2.G.3.b.ii)

Recalculations were made for 2017 due to an error when importing the excel table into the ETF GHG Inventory Reporting Tool application.

4.8.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

5 Agriculture (CRT Sector 3)

5.1 Overview of the sector and background information

This chapter provides information on the estimation of the greenhouse gas emissions from the Agriculture Sector (being associated with the Common Reporting Format Table 3). The following source categories are quantified and reported:

- CH_4 emissions from enteric fermentation;
- CH_4 and N_2O emissions from manure management;
- CH_4 emissions from rice cultivation;
- N_2O emissions from agricultural soils;
- CH_4, N_2O, NO_x and CO emissions from field burning of agricultural residues;
- CO_2 emissions from Lime application;
- CO_2 emissions from Urea application.

The direct GHGs reported within this sector are CH_4, N_2O and CO_2 while indirect gases comprise NO_x and CO. Domestic livestock are the major source of CH_4 emissions from agriculture, both from enteric fermentation and manure management. Manure management also generates N_2O emissions. Table 5.1 gives an overview of the IPCC categories included in this chapter and provides information on the status of related emissions estimates.

Table 5.1 Status of emissions estimation within the Agriculture Sector

IPCC category	Emissions estimation status		
	CH_4	**N_2O**	**CO_2**
3. A Enteric fermentation			
3.A.1 Cattle	✓	NA	NA
3.A.1.A.1. Dairy cattle	✓	NA	NA
3.A.1.A.2. Non-dairy cattle	✓	NA	NA
3.A.2 Sheep	✓	NA	NA
3.A.3 Swine	✓	NA	NA
3.A.4 Other livestock			
3.A.4.1 Rabbits	NO	NA	NA

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
3.A.4.2 Buffalo	✓	NA	NA
3.A.4.3 Camels	NO	NO	NO
3.A.4.4 Goats	✓	NA	NA
3.A.4.5 Horses	✓	NA	NA
3.A.4.6 Mules and Asses	✓	NA	NA
3.A.4.7 Poultry	✓	NA	NA
3.B Manure management			
3.B.1. CH_4 emissions	✓	NA	NA
3.B.1.1 Cattle	✓	NA	NA
3.B.1.1.A.1. Dairy cattle	✓	NA	NA
3.B.1.1.A.2. Non-dairy cattle	✓	NA	NA
3.B.1.2. Sheep	✓	NA	NA
3.B.1.3. Swine	✓	NA	NA
3.B.1.4 Other livestock	✓	NA	NA
3B.1.4.1. Rabbits	✓	NA	NA
3.B.1.4.2. Buffalo	✓	NA	NA
3.B.1.4.3. Camels	NO	NO	NO
3.B.1.4.4. Goats	✓	NA	NA
3.B.1.4.5. Horses	✓	NA	NA
3.B.1.4.6. Mules and Asses	✓	NA	NA
3.B.1.4.7. Poultry	✓	NA	NA
3.B.2. N_2O and NMVOC emissions	NA	✓	NA
3.B.2.1 Cattle	NA	✓	NA
3B.2.1.A.1. Dairy cattle	NA	✓	NA
3B.2.1.A.2. Non - dairy cattle	NA	✓	NA
3.B.2.2. Sheep	NA	✓	NA
3.B.2.3. Swine	NA	✓	NA
3.B.2.4. Other livestock	NA	✓	NA
3.B.2.4.1. Rabbits	NA	✓	NA
3.B.2.4.2. Buffalo	NA	✓	NA

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
3.B.2.4.3. Camels	NA	NO	NA
3.B.2.4.4.Goats	NA	✓	NA
3.B.2.4.5. Horses	NA	✓	NA
3.B.2.4.6.Mules and Asses	NA	✓	NA
3.B.2.4.7.Poultry	NA	✓	NA
3.B.2.5. Indirect N_2O Emissions	NA	✓	NA
3.B.2.6. Emissions per MMS	NA	✓	NA
3.C Rice cultivation			
3.C.1 Irrigated	✓	NA	NA
3.C.1.1 Continuously flooded	NO	NA	NA
3.C.1.2 Intermittently flooded	✓	NA	NA
3.C.1.2.1 Single aeration	NO	NA	NA
3.C.1.2.2 Multiple aeration	✓	NA	NA
3.C.2 Rainfed	NO	NA	NA
3.C.3 Deep water	NO	NA	NA
3.C.3.1. Water Depth 50-100 cm	NO	NA	NA
3.C.3.2. Water Depth >100 cm	NO	NA	NA
3.C.4 Other	NO	NA	NA
3.D Agricultural soils			
3.D.1 Direct soil emissions	NA	✓	NA
3.D.1.1. Inorganic N Fertilizers	NA	✓	NA
3.D.1.2. Organic N Fertilizers	NA	✓	NA
3.D.1.2.a. Animal Manure Applied to Soils	NA	✓	NA
3.D.1.2.b.Sewage Sludge Applied to Soils	NA	✓	NA
3.D.1.2.c.Other Organic Fertilizers Applied to Soils	NA	✓	NA
3.D.1.3 Urine and Dung Deposited by Grazing Animals	NA	✓	NA
3.D.1.4 Crop Residues	NA	✓	NA
3.D.1.5.Mineralization/Immobilization Associated with Loss/Gain of Soil Organic	NA	✓ , NO	NA
3.D.1.6 Cultivation of Organic Soils	NA	✓	NA
3.D.1.7.Other	NA	✓ , NO	NA

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
3.D.2. Indirect N_2O Emissions from Managed Soils	NA	✓	NA
3.D.2.1.Atmospheric Deposition	NA	✓	NA
3.D.2.2. Nitrogen Leaching and Run-off	NA	✓	NA
3.E Prescribed burning of savannas	NO	NO	NO
3.F Field burning of agricultural residues	✓	✓	NA
3.G. Liming	NA	NA	✓
3.H. Urea Application	NA	NA	✓
3.I. Other Carbon-containing Fertilizers	NA	NA	✓

Observations

1) In respect to the IPCC 2006 provisions, N_2O emissions from Pasture range and paddock AWMS are reported under 3D – Agricultural soils (see Chapter 5.5).

Figure 5.1 Total GHG emissions trend in Agriculture for 1989–2023 period

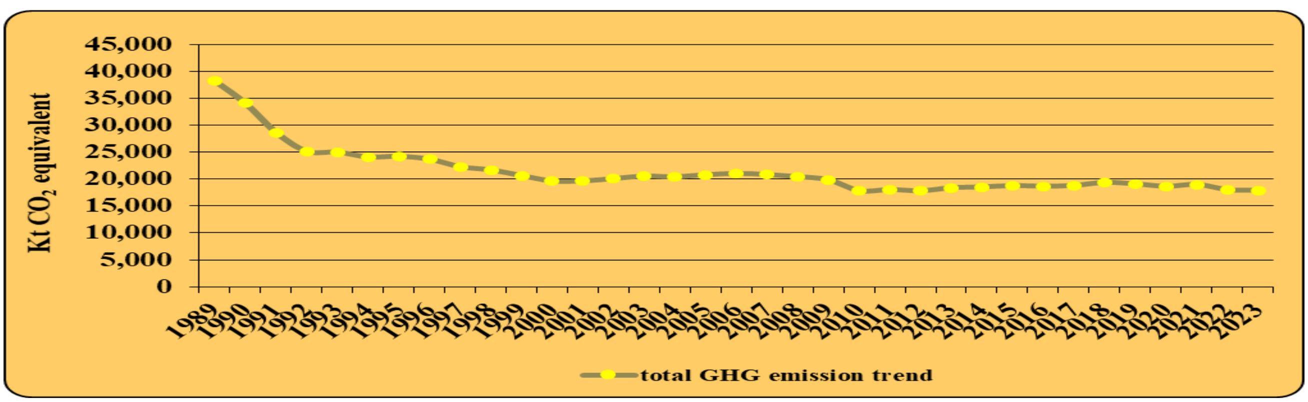
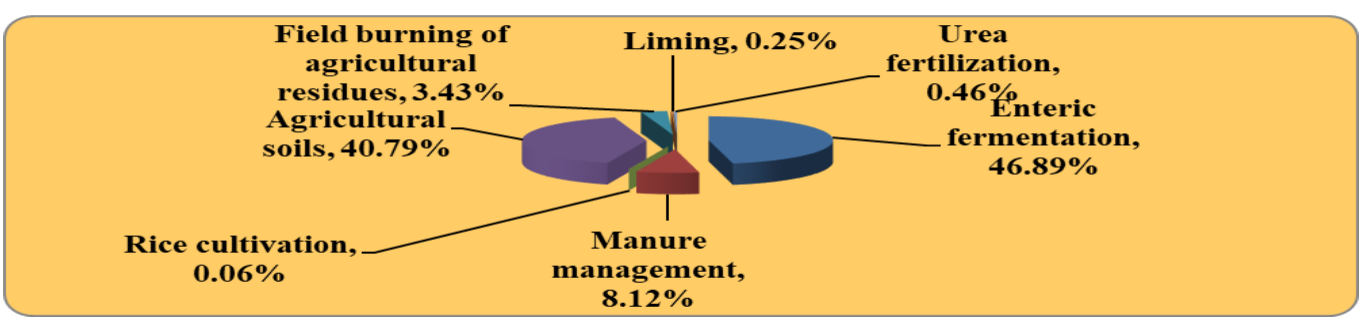


Figure 5.2 Contribution of the sub-sectors in the total GHG emissions from Agriculture, in 2023 year



Another source of methane is represented by anaerobic decomposition of organic material in flooded rice fields. Microbiological processes in soil lead to N_2O emissions. Two N_2O sources are distinguished:

- ❖ direct soil emissions from agricultural soils (sources: Inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues, mineralization/ immobilization associated with loss/ gain of soil organic matter and cultivation of organic soils);
- ❖ indirect soil emissions (atmospheric deposition, leaching and run off).

Burning of agricultural residues is a net source of CH_4, CO, N_2O and NO_x emissions for 1989–2023 period. Emissions from prescribed burning of savannas do not occur in Romania. The Agriculture Sector accounted for 16.31% of the total GHG emissions in 2023, reaching 109667.26 kt CO_2 equivalent (Table 5.2). Within the GHG emissions from the agriculture sector, the CH_4 emissions have the largest contribution (in 2023, CH_4 emissions contribution is 52.64 to the total Agriculture Sector's CO_2 equivalent emissions), followed by the N_2O emissions (that account for the remaining 46.61). Over the period 1989–2023, the GHG emissions resulted from Agriculture Sector decreased by 53.30% (Figure 5.1). The number of animals decreased in this period whatever of the species and type of operation. After a slight recovery of national livestock situation, another dramatic regression occured, result of economic situation extremely difficult Romania passed in the period 1997–2000. After the period 2001–2002 and in present, for the livestock species of interest there are recorded fluctuations in the livestock number influenced by the economic context, the emergence of various associative forms that have acquired economic power and by the interest shown by farmers for increasing the genetic value of the animals. After 1989 the livestock from most Agricultural Production Cooperatives (C.A.P.) were attributed to rural population they being sacrificed in large numbers for meat. On the other hand, in most rural areas, a significant number of farmers have lost the interest in animal husbandry. In case of emissions resulted from enteric fermentation and manure management, the descending trend reflects the decrease in animal population over the period. The number of all cattle categories decreased in the analyzed period. Buffalo population was subject to the same reduction, the animals being privately owned both in subsistence farms and individual households. The lack of interest for these species is also due to the lack of associated governmental incentives. After 1989 swine number decreased, from 1,023,000 heads breeding sows in 1989, to 335,000 heads in 2003; the number recorded a slight increase in years with high economic growth, 2004–2007, then decreased again, registering in 2010, 355,000 heads; in 2023 there were registered 272,647 heads Annex V.5.1 (sheet – Data obtained through the study). The reducing of the swine number was due to (Dinu I. – Swiniculture, Ed. Coral Sanivet, Bucharest, 2002, pages. 28–29):

- ❖ the overgrowth of prices from upstream area, prices associated to the energy, to materials and services, while the price of meat has registered insignificant increases;

- significant mistakes in the restructuring and the liquidation of companies owned in majority by state;
- the liquidation almost entirely of the forms of financial farmers's support;
- the import of meat and meat products made an unfair competition to the local producers, on the internal market.

The sheeps's growth is characterized in some regions through extensivity, using primitive or slightly improved races and through the practice of transhumance. After 1990, during the C.A.P, the sheep number have decreased continuously. After 2004, the livestock begin to grow slowly, due to investors's foreign in exploiting this species and, also due to the increased interest for sheep's milk products. In the 1989–2003 period, goats were represented, especially through White Goat of Banat and Carpathian races. The horses number has increased from 1989, constant until 2003, because has changed the orientation in the horses's growth of traction, are abandons the species heavier of horses, less viable considering the economic criteria, and are used intermediary horses with mixed aptitude, wich moves and are easy maintenance (Creta V, Morar M., Culea C. – *General and special animal husbandry*, E.D.P., Bucharest, 1995). From 2007 to present, horse number is decreasing due to the biological disappearance of population employed in agriculture and due to, the increased mechanization degree in agriculture. On the other, the number of horses used to sport purposes and, in the people therapy and development increased. The number of mules and asses varied over the period with maximum 8,000 heads. Mules and asses are found only in households, not being growth in farms. Poultry for meat number decreased from 1989 to 1994, after which they slightly increased, the egg poultry decreased sharply in 1994, then begin to grow, due to the foreign investments. The sector is developed in Romania and there is in present concerns of development of the modern technologies exploitation of these categories. For the 2004–2023 period, sheep and goats livestock number is only growing slightly; for the rest of species, their downward trend of 1989–2003 period continued. It does not report the CH_4 and N_2O emissions for deer because deer are not relevant to the country; based on the data and information available, including also National Institute for Statistics elements, the activity does not occur. The rice cultivation generated in 2023 a significantly reduced emission compared to the base year 1989 due to the decrease of areas (93.50% decrease comparing with the base year). In case of agricultural soils, the emissions decreased over the period (46.62% decrease in 2023 comparing with 1989), due to the decrease of the amount of the synthetic fertilizer applied, of the livestock populations and of the crop productions level. Starting with the 1999 year, the N_2O emissions from Agricultural Soils fluctuates: decreases until 2000, in 2001 increases and then decreases. This is due variation of quantities of synthetic fertilizers, number of animals and of the crop productions. The Agriculture sector's CH_4 emissions decreased in 2023 with 56.86% compared to basic (see Annex V.5.1 – sheet *Distribution of N_2O and CH_4 emission*). Because the methane emissions are mainly resulted in domestic livestock, the decrease of their level is due to the decline of the domestic livestock. The N_2O emissions from the Agriculture Sector decreased in 2023 with 47.24% comparing with the base year (see Annex V.5.1 – sheet *Distribution of N_2O and CH_4 emission*). The reasons for this decrease are:

- ❖ the decrease of the amount of chemical fertilizers applied to soils;
- ❖ the decline of the domestic livestock (the details are presented above);
- ❖ the decrease of the crop productions level.

In the general context of the transition of the economy to a market based approach, the activity data level decreased substantially in the last years of the characterized period in comparison to the base year. The livestock number decreased in the last years of the characterized period in comparison to 1989 mainly due to:

- ❖ the import of animals;
- ❖ the draught which affected the crop production levels and the crop production prices;
- ❖ state incentives in some periods;
- ❖ closing of the old/opening new facilities due to the restructuration of the economy.

The crop productions level decreased in the late years of the analyzed period in comparison to 1989 mainly due to the change in agricultural land property regime and to the transition to the market economy. Reasons for the inter-annual changes in crop production levels include:

- ❖ existence of draught periods;
- ❖ existence if state incentives for some periods;
- ❖ changes in the land property regime, including the disaggregation of large farms before 1990 and crystallization of new large farms in the late years.

The livestock number was decreased in the 2010 year comparative with the 2009 year due to:

- ❖ the deficiency precipitation that which led to decreased of production needed for feeding;
- ❖ the increases of price per food.

The crop productions of the N fixing for all plants decreased in 2012 compared with 2011 due to drought.

Table 5.2 Contribution of Agriculture sector in total GHG emissions, in 1989–1990, 1995, 2000, 2005, 2007–2023

Year	Total GHG emissions [kt]	GHG emissions from Agriculture [kt]	Contribution of Agriculture in total GHG emissions [%]	Methane emissions from Agriculture [kt]	Contribution of methane emissions in total GHG emissions from Agriculture [%]	Nitrous oxide emissions from Agriculture [kt]	Contribution of nitrous oxide emissions in total GHG emissions from Agriculture [%]
1989	309,563.96	38,316.17	12.38	22,397.98	58.46	15,651.89	40.85
1990	256,636.86	34,124.55	13.30	20,021.23	58.67	13,920.81	40.79
1995	188,315.16	24,235.64	12.86	14,461.14	59.67	9,676.79	39.93
2000	141,841.50	19,620.99	13.83	12,224.93	62.31	7,293.16	37.17
2005	150,375.83	20,799.00	13.83	12,370.26	59.48	8,290.20	39.86
2007	154,891.56	20,821.75	13.44	13,151.63	63.16	7,552.69	36.27
2008	151,566.48	20,433.67	13.48	12,265.69	60.03	8,030.99	39.30
2009	130,229.60	19,838.44	15.23	11,792.04	59.44	7,923.36	39.94
2010	124,812.87	17,799.14	14.26	10,035.78	56.38	7,656.14	43.01
2011	132,250.56	18,020.16	13.63	10,025.04	55.63	7,904.47	43.86
2012	129,239.42	17,797.16	13.77	10,407.41	58.48	7,313.13	41.09
2013	117,865.19	18,365.52	15.58	10,149.96	55.27	8,125.66	44.24
2014	118,110.56	18,519.28	15.68	10,354.29	55.91	8,082.84	43.65
2015	116,802.10	18,765.37	16.07	10,481.67	55.86	8,189.36	43.64
2016	114,839.10	18,648.20	16.24	10,364.59	55.58	8,170.37	43.81
2017	117,804.06	18,792.72	15.95	10,009.77	53.26	8,658.35	46.07
2018	118,545.09	19,361.72	16.33	9,887.24	51.07	9,349.07	48.29
2019	115,311.93	19,088.86	16.55	9,858.44	51.64	9,101.84	47.68
2020	111,521.22	18,630.40	16.71	9,959.83	53.46	8,535.01	45.81
2021	115,375.00	18,985.32	16.46	9,582.62	50.47	9,241.44	48.68
2022	109,667.26	18,000.82	16.41	9,687.49	53.82	8,167.59	45.37
2023	103,862.45	17,891.23	17.23	9,655.20	53.97	8,257.32	46.15

Table 5.2 (continued) Contribution of Agriculture sector in total GHG emissions, in 1989–1990, 1995, 2000, 2005, 2007–2023

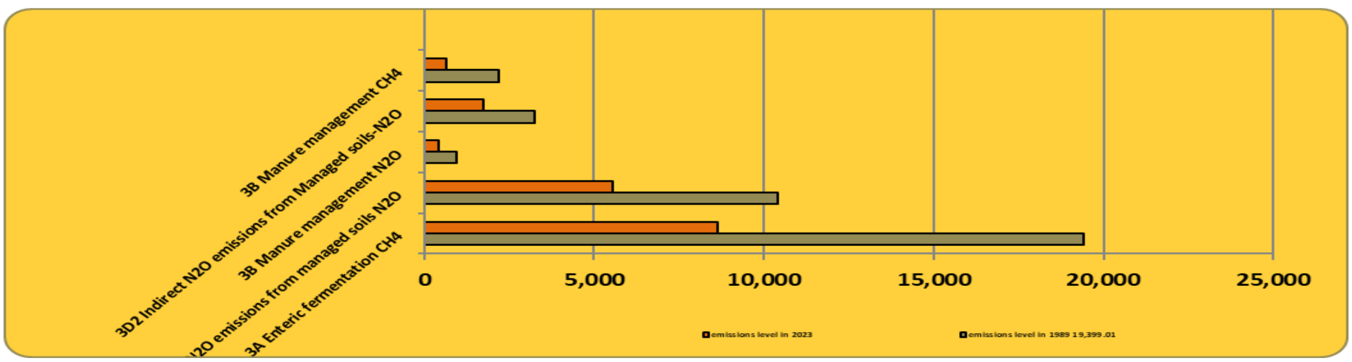
Year	CO_2 emissions from Agriculture [kt]	Contribution of CO_2 emissions in total GHG emissions from Agriculture [%]
1989	266.30	0.69
1990	182.51	0.53
1995	97.71	0.40
2000	102.90	0.52
2005	138.54	0.66
2007	117.43	0.56
2008	136.98	0.67
2009	123.05	0.62
2010	107.22	0.60
2011	90.65	0.50
2012	76.63	0.43
2013	89.90	0.48
2014	82.15	0.44
2015	94.34	0.50
2016	113.24	0.60
2017	124.60	0.66
2018	125.42	0.64
2019	128.58	0.67
2020	135.56	0.72
2021	161.25	0.84
2022	145.75	0.81
2023	127.32	0.71

In 2023 year the CH_4 emissions contribute with 53.97% in total GHG emissions from Agriculture, the N_2O emissions contribute with 46.15% and CO_2 the contribution is 0.71%. Table 5.3 and Figure 5.3 describe Key categories in Agriculture, both from level and trend and including and excluding LULUCF views.

Table 5.3 Key categories overview – Agriculture, 2023

Key categories	GHG	Criteria (L and/or T)	Contribution in total GHG emissions/ removals [%]	Methodological tier used
3A Enteric fermentation CH_4	CH_4	L,T	8.31	Tier 1, Tier 2
3D1 Direct N_2O emissions from Managed soils	N_2O	L,T	5.34	Tier 1
3D2 Indirect N_2O emissions from Managed soils	N_2O	L,T	1.68	Tier 1
3B Manure management CH_4	CH_4	L	0.63	Tier 1, Tier 2
3B Manure management N2O	N_2O	L	0.41	Tier 2

Figure 5.3 Key Categories in Agriculture, both by level and trend



5.2 Enteric Fermentation (CRT 3.A)

5.2.1 Category description

Methane is produced by herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. Although ruminants are the largest source, both ruminant and non-ruminant animals produce CH_4.

Enteric Fermentation:

- ❖ is the source of CH_4 emissions in the Agriculture sector (in 2023, CH_4 emissions from Enteric Fermentation represented 86.88% of total CH_4 emissions in the Agriculture sector);
- ❖ is the source in the Agriculture sector (in 2023, CH_4 emissions from Enteric Fermentation as CO_2

equivalent represented 46.88% from Total Agriculture emissions);

❖ contributed with 8.07% to Total GHG emissions of Romania.

Compared to 1989, total CH_4 emissions from Enteric Fermentation decreased with 51.21% in 2023 (Figure 5.4). The decreasing trend is in direct correlation with the dynamics of livestock. The livestock number for all species of economic interest, except goats, due to increased interest in recent years for this species, declined; the interest for goats's products is a consequence of the consumers's taste refineries, especially for urban consumers, and of the requirements for milk and goat meat for export. The administration of goat livestock is based also on valuable genetic biological material import, especially from breeds specialized in milk production.

Figure 5.4 Methane emission trend due to the Enteric Fermentation

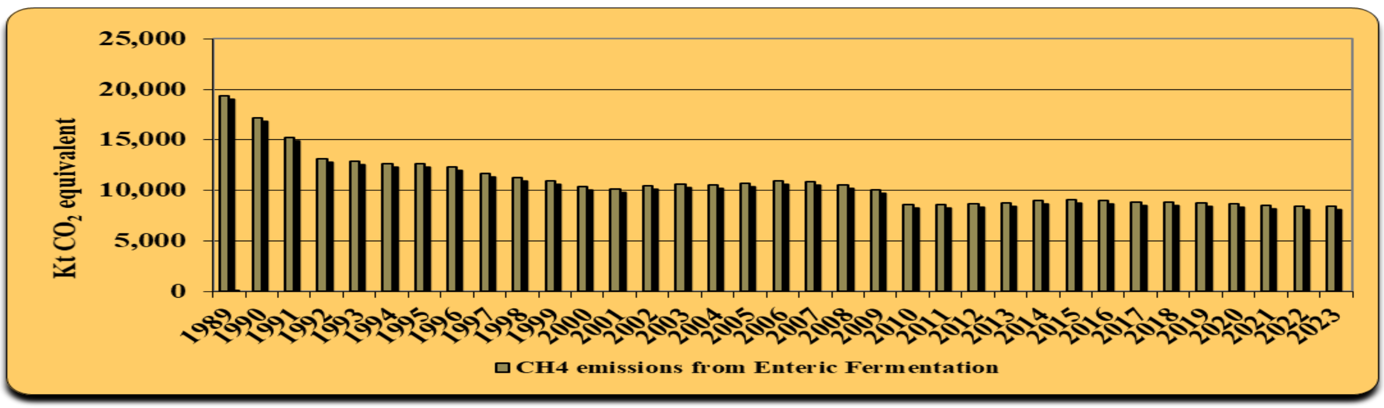


Table 5.4 Observations on source category 3A – "Enteric Fermentation"

Source indicative	Source (livestock) type	Observation	Data source
3.A.1	**Cattle**	Includes livestock data from nine different *cattle* categories: *dairy cows* and *non-dairy cattle*.	AD: NIS and expert judgment, 1989–2003; NIS, 2004–2023 EF: Country specific, expert judgment
3.A.2	**Sheep**	Includes livestock data from three different sheep: *Ewes of milk and fitted*, *reproducers rams* and *other sheep*	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: IPCC 2006, IPCC GPG 2000 Country specific
3A3	**Swine**	Includes livestock data from five different *swine*: *pigs under 20 kg*, *pigs between 20 and 50 kg*, *pigs fattening*, *boars*, *breeding*	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023

Source indicative	Source (livestock) type	Observation	Data source
		sows	EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4.a	**Buffalo**	Includes livestock data from two different *buffalo*: buffalo milk and other buffalo	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: Default -IPCC 2006
3.A.4.d	**Goats**	Includes livestock data from two different *goats*: *Female goats for milk* and *females by first mount* and *other goats*	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: Default -IPCC 2006
3.A.4.e	**Horses**		AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: Default-IPCC 2006
3.A.4.f	**Mules and asses**		AD: FAO, 2011, 2017; EF: Default-IPCC 2006
3.A.4.g	**Poultry**	Includes livestock data from two different poultry: adult poultry for eggs, poultry for meat. Poultry include and the ducks, turckish, geese. Is not possible disaggregation of the livestock poultry because there are no separate data on subcategories.	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023 EF: Default-IPCC 2006
3.A.4.h.i	**Rabbits**		AD: NIS, 1989–2023 EF: Default-IPCC 2006

5.2.2 Methodological issues

Methodology

The amount of methane emitted from enteric fermentation is driven primarily by the number of animals, the type of digestive system, and the type and amount of feed consumed. Emissions of methane from enteric fermentation were calculated using a Tier 2 method, for dairy cattle, non dairy cattle, sheep and swine according to the provisions in the IPCC 2006 decision tree and for goats, buffalo, mules and asses, horses and poultry emissions of methane from enteric fermentation were calculated using a Tier 1 method. There are national data available for species and subcategory of the mentioned livestock for to estimate the methane emission according with the level 2 method. For emissions of methane from enteric fermentation were calculated using equations 10.19, 10.20 and 10.21 in the *IPCC 2006 (pg.10.28 and 10.31).*

Emission factors

According to the provisions in IPCC 2006, to use equation 10.21 have been considered national values for gross energy intake (GE) and default values for developed countries for methane conversion rate which is the fraction of gross energy in feed converted to methane (Y_m), default values provided through IPCC 2006 (Tables 10.12 and 10.13) and IPCC 1996–Reference Manual (Table A–4) for dairy cattle, non dairy cattle, swine and sheep. For category non dairy cattle the calculation of gross energy intake an estimation method depending on the species and the category exploited, respectively based on an average ration, both in summer and in winter, was used. This rations can ensure the necessary of maintenance (allows normal animal organism functioning on basal metabolism level, assuring vital functions), and, respectively, for production in non dairy cattle. For swine was proceeded similarly, taking into account mixed fodder prescriptions specific of categories of exploitation, according to nutritional requirements and standards in force. The values of gross energy ingested were established correlating the nutritional requirements of each species and exploitation category with the food intake brought of through the rations and average prescriptions which were considered for ensuring the production level part of official statistics (elaborated by NIS). For calculation of gross energy caloricity for each prescription or ration were took into account the following:

- ❖ 1g gross protein = 5.72 kcal;
- ❖ 1 g gross fat = 9.5 kcal;
- ❖ 1 g gross pulp = 4.79;
- ❖ 1 g SEN = 4.17 kcal.

The Calculation formula of energy gross is:

Equation 5.1 Calculation of energy gross intake

$$GE\ (kcal/kg) = 5.72 \bullet PB + 9.5 \bullet GB + 4.79 \bullet CelB + 4.17 \bullet SEN$$

(I.Stoica, Nutrition and feedingstuffs, 1997, pg.131)

where:

- ❖ GE = gross energy intake (kcal/kg);
- ❖ PB = gross protein;
- ❖ GB = gross fat;
- ❖ CelB = gross pulp;
- ❖ SEN = Extractable Non-nitrogenous substances.

Rations were made up according of equation above, the protein gross values, gross fat, gross pulp and unnitrous substances extractable were used from the tables with chemical composition of the feeding (I.Stoica, *Nutrition and feedingstuffs*, 1997, pages 513–517) (*Annex V.5.3_Detailed data for estimating CH_4*

and N_2O Agriculture Sector related GHG emissions–livestock food related information). In these tables value of these nutritional principles is expressed as percentage (for 100 grams of exemple), so in the calculation of rations and prescriptions these values were multiplied with 10 for to express caloricity for 1 kg. The total value of ration, expressed in kcal it was divided to 239, to obtain equivalent in MJ (Mega Jouli). The equivalence relations are the following:

- ❖ 1J = 1/41855Kcal, where J = joule and Kcal = kilocalorie;
- ❖ 1KJ = 0,239 Kcal, where KJ = Kilojoule and Kcal = kilocalorie;
- ❖ 1MJ = 239 Kcal, where MJ = Megajoule and Kcal = kilocalorie.

The values of protein gross, gross fat, gross pulp and unnitrous substances extractable were multiply with the specific caloricity of each nutritive principle (5,72 kcal for 1 g of gross protein, and so on). Then was calculated the sum of caloricity of each nutritive principle in order to obtain the caloricity of fodder. This value is multiplied by the number of pounds of fodder which is specified in ration. Digestible energy (DE Mj/day) is used to express the nutritional value of fodder and of rations, mainly for grazing animals. For calculating digestible energy are used mathematical equations considering the nutritive digestible content of nutrients, which multiply with the coefficients of specific digestibility each forage and each species (I.Stoica- *Nutrition and feedingstuffs*, 1997, pages 518–522) (*Annex V.5.3_Detailed data for estimating CH_4 and N_2O Agriculture Sector related GHG emissions-livestock food related information*), then are propagated with the energy equivalents for digestible energy, which are different per species, in the table below (Popa O, Milos M, Halga P, Bunicelul El., EDP., 1980, pages 101– *Livestock feeding*).

Table 5.5 Calculation of feed digestible energy

Specification	**Digestible PB**	**Digestible GB**	**Digestible CelB**	**Digestible SEN**
Symbol	**x_1**	**x_2**	**x_3**	**x_4**
Energy equivalent (e) to:				
Non dairy cattle	5.79	8.15	4.42	4.06
Swine	5.78	9.42	4.4	4.07
Equation for calculating	$x_1 \bullet e_1$	$x_2 \bullet e_2$	$x_3 \bullet e_3$	$x_4 \bullet e_4$

The categories and subcategories for which were the calculated rations are given in Annex V.5.*2_Detailed data for estimating CH_4 and N_2O Agriculture Sector related GHG emissions–rations for livestock.* Mixed fodder is a mixture of concentrates and minerals (salt, dicalcium, phosphate), designed so as to meet the nutritional requirements for producing the produce and that allows to adjust the level of each individual feeding on daily production. For non dairy cattle and swine is considered a combination of forage. Mixed fodder include (for 100 kg mixture): 41.5 kg maize, 20kg barley, 26 kg wheat bran and 8.5 kg soybean meal 2 having an total caloricity/100 of 381382,16 kcal so 3813,82 kcal/kg = 15,95 MJ/kg mixture (Annex V.5.3_*Detailed data for estimating CH_4 and N_2O Agriculture Sector related GHG emissions-livestock food related information*).

For **dairy cattle** and **sheep** gross energy (GE) necessary in the calculation the national emission factor was calculated using the equation 10.16 in IPCC 2006, pg.10.21.

The energyes were calculated so:

- Net energy required by the animal for maintenance (NEm) was calculated with equation 10.3;
- Net energy for animal activity (NEa) was calculated with equation 10.4 and 10.5;
- Net energy for lactation was used equation 10.8 and 10.10;
- Net energy required for pregnancy (NEp) was used equation 10.13;
- Ratio of net energy available in a diet for maintenance to digestible energy consumed (REM) was used equation 10.14;
- Ratio of net energy available for growth in a diet to digestible energy consumed (REG) was used equation 10.15.

For parameters used in above eqations was used the table 10.4, 10.5 and 10.7. In Annex V.5.2_*Detailed data for estimating CH_4 and N_2O Agriculture Sector related GHG emissions-rations for livestock* are found the values all parameters used in the GE calculation (net energy). Was taken the default values for DE (%) = 60 for dairy cattle (default from IPCC 2006, pg. 10.72) and DE (%) = 65 for sheep (IPCC 2006 GL, average of 55–75%, table 10.2 representative feed digestibility for various livestock categories); weight (kg) for dairy cattle and sheep has been developed in the context of the implementation of the 2011 study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“.* In the Table 5.6 are presented the milk productions per year (litre), for the period *1989–1990, 1995, 2000, 2005, 2007–2023* for dairy cows data provided of National Institute of Statistics – Statistical Yearbook of Romania, 1989–2023 (NIS) responding to the annual request made by the National Environmental Protection Agency.

The calculations on ***Milk, l milk/day/dairy cow* are presented** in “Annex V.5.2_Detailed data for estimating CH_4 and N_2O Agriculture Sector related GHG emissions–rations for livestock”.

Table 5.6 Milk production in dairy cows in the period 1989–1990, 1995, 2000, 2005, 2007–2023 (National Institute for Statistics – Statistical Yearbook of Romania, 1989–2023), kg/year

Year	Dairy cattle production (kg/year)
1989	4,167,107.1
1990	4,086,909.1
1995	5,397,771.5
2000	4,961,263.5
2005	5,659,779.2
2007	5,612,525.1
2008	5,431,744.9
2009	4,965,690.3
2010	4,384,125.7
2011	4,501,797.6
2012	4,305,677.8
2013	4,363,123.9
2014	4,500,253.3
2015	4,365,266.0
2016	4,303,480.5
2017	4,157,617.4
2018	4,166,951.2
2019	4,075,422.2
2020	4,088,638.30
2021	4,088,638.30
2022	4,015,957.97
2023	3,970,337.37

For values of ***methane conversion rate (Y_m)*** were used default values from *IPCC 2006 and IPCC 1996–Reference Manual*, because there are no national studies on the rate of conversion of methane from gross energy intake. For cattle were used the value of 0.065 for all subcategories, the value which corresponds to the default value for developed countries. For dairy cattle and sheep–ewes of milk and fitted, reproducers rams, Y_m value is 0.065 for developing countries and for sheep–olther sheep Y_m value is 0.045 (table 10.12 in IPCC2006). For swine was used value of Y_m of 0.6% (0.006), because GE value from our ration is similar to that given in Reference Manual (38 MJ/day for developed countries). For categories where GE value is close to 13 MJ/day (pigs under 20 kg, pigs between 20 and 50 kg) was worked with the value 1.3% (0.013) (Reference Manual, Table A–4). The emission factors used for goats, horses, buffalo, mules and asses and poultry are default. The emission factors used for livestock are presented in Table 5.7, 5.8 , 5.9, 5.10 and 5.11. The gross energy intake is in direct correlation with animal's weight. Weigt animals was established by the expert opinion. Were not calculated the emissions for rabbits due to there not default emission factor.

Table 5.7 The factors emission (kg CH_4/head/year) used for calculation of methane emissions from enteric fermentation of livestock and data necessary for their calculation in the 1989–2023 period

Source indicative	**Livestock (source) type**	**Emission Factors [kg CH_4/head/year]**	**Gross energy intake (GE) (Mj/head/day)**	**Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)**
3.A.1	***CATTLE***			
3.A.1.b	***Non dairy cattle***			
	Calves for slaughter younger than 1 year	60.99	143.07	0.065
	Young cattle of breeding under 1 year	49.24	115.5	0.065
	Young cattle of breeding between 1 and 2 years	62.59	146.83	0.065
	Young cattle of slaughter between 1 and 2 years	94.78	222.33	0.065
	Cattle 2 years and over Breeding bulls	103.03	241.68	0.065
	Cattle 2 years and over Heifers for breeding	90.00	211.12	0.065
	Males and females for sacrificed older than 2 years	71.07	166.72	0.065
	Cattle for work	119.27	303.08	0.065
3.A.3	***SWINE***			
	Pigs under 20 kg	0.69	8.18	0.013
	Pigs between 20 and 50 kg	1.15	13.49	0.013
	Pigs fattening	1.84	46.86	0.006
	Boars	1.78	45.32	0.006
	Breeding sows	1.78	45.34	0.006
3.A.4.a	***BUFFALO***			
	Female buffalo	55	NA	NA
	Other buffalo	55	NA	NA

Source indicative	Livestock (source) type	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3.A.4.d	***GOATS***			
	Female goats for milk and females by first mount	5	NA	NA
	Other goats	5	NA	NA
3.A.4.e	***HORSES***	18	NA	NA
3.A.4.f	***MULES AND ASSES***	10	NA	NA
3.A.4.g	***POULTRY***			
	Adult poultry for eggs	NO	NA	NA
	Poultry for meat	NO	NA	NA

Table 5.8 The factors emission (kg CH_4/head/year) used for calculation of methane emissions from enteric fermentation of dairy cattle and data necessary for their calculation, in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.1.a Dairy cattle			
1989	97.99	229.84	0.065
1990	99.95	234.45	0.065
1995	115.83	271.70	0.065
2000	119.57	280.47	0.065
2005	123.90	290.61	0.065
2007	124.87	292.91	0.065
2008	125.93	295.39	0.065
2009	124.09	291.09	0.065
2010	126.59	296.93	0.065
2011	128.63	301.72	0.065
2012	126.97	297.83	0.065
2013	127.24	298.47	0.065

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.1.a Dairy cattle			
2014	127.89	300.00	0.065
2015	126.49	296.71	0.065
2016	125.04	293.30	0.065
2017	125.05	293.32	0.065
2018	125.74	294.94	0.065
2019	125.49	294.37	0.065
2020	126.29	296.23	0.065
2021	127.82	299.82	0.065
2022	127.26	298.52	0.065
2023	127.50	299.08	0.065

Table 5.9 The emission factors (kg CH_4/head/year) used for calculation of methane emissions from enteric fermentation of sheep- ewes of milk and fitted data necessary for their calculation, in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.2 Sheep ewes of milk and fitted			
1989	9.89	23.19982796	0.065
1990	9.94	23.33808706	0.065
1995	9.89	23.21637158	0.065
2000	9.89	23.21876692	0.065
2005	9.90	23.24039759	0.065
2007	9.91	23.26213065	0.065
2008	9.84	23.10154963	0.065
2009	9.84	23.09509429	0.065
2010	9.86	23.13368984	0.065
2011	9.86	23.13974091	0.065
2012	9.86	23.13849212	0.065

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.2 Sheep ewes of milk and fitted			
2013	9.85	23.11567863	0.065
2014	9.89	23.19969547	0.065
2015	9.88	23.19494358	0.065
2016	9.88	23.18776232	0.065
2017	9.88	23.18395269	0.065
2018	9.89	23.20397753	0.065
2019	9.89	23.20222984	0.065
2020	9.88	23.19082676	0.065
2021	9.90	23.21044923	0.065
2022	9.82	23.03037446	0.065
2023	9.90	23.21825981	0.065

Table 5.10 The emission factors (kg CH_4/head/year) used for calculation of methane emissions from enteric fermentation of sheep- Reproducers rams data necessary for their calculation, in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.2 Sheep Reproducers rams			
1989	8.50	19.95074271	0.065
1990	8.56	20.08900182	0.065
1995	8.51	19.96728633	0.065
2000	8.51	19.96968168	0.065
2005	8.52	19.99131234	0.065
2007	8.53	20.0130454	0.065
2008	8.46	19.85246439	0.065
2009	8.46	19.84600904	0.065
2010	8.47	19.88460459	0.065
2011	8.47	19.89065567	0.065

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.2 Sheep Reproducers rams			
2012	8.47	19.88940687	0.065
2013	8.46	19.86659338	0.065
2014	8.50	19.95061023	0.065
2015	8.50	19.94585834	0.065
2016	8.50	19.93867708	0.065
2017	8.49	19.93486744	0.065
2018	8.50	19.95489228	0.065
2019	8.50	19.9531446	0.065
2020	8.50	19.94174152	0.065
2021	8.51	19.96136398	0.065
2022	8.43	19.78128922	0.065
2023	8.51	19.96917456	0.065

Table 5.11 The emission factors (kg CH_4/head/year) used for calculation of methane emissions from enteric fermentation of sheep- Other sheep data necessary for their calculation, in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.2 Sheep Other sheep			
1989	6.61	22.41621614	0.045
1990	6.65	22.55447524	0.045
1995	6.62	22.43275976	0.045
2000	6.62	22.43515510	0.045
2005	6.62	22.45678577	0.045
2007	6.63	22.47851883	0.045
2008	6.58	22.31793781	0.045
2009	6.58	22.31148247	0.045
2010	6.59	22.35007802	0.045

Years	Emission Factors [kg CH_4/head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Ym fraction)
3A.2 Sheep Other sheep			
2011	6.59	22.35612909	0.045
2012	6.59	22.35488030	0.045
2013	6.59	22.33206681	0.045
2014	6.61	22.41608365	0.045
2015	6.61	22.41133176	0.045
2016	6.61	22.40415050	0.045
2017	6.61	22.40034087	0.045
2018	6.61	22.42036570	0.045
2019	6.61	22.41861802	0.045
2020	6.61	22.40721494	0.045
2021	6.61	22.42683740	0.045
2022	6.57	22.24676264	0.045
2023	6.62	22.43464799	0.045

In the Table 5.12 are summarized the values energy digestible DE (Mj), the percentage of digestible energy DE (%) and the weight for each subcategory. These values were determined in the context of the implementation of the 2011 study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*“ for all livestock excepting dairy cattle and sheep where the value for DE% is default (table 10.2 and 10.A.1 in IPCC2006). In Annex V.5.*2_Detailed data for estimating CH_4 and N_2O Agriculture Sector related GHG emissions-rations for livestock* are found weighted averages of GE, DE and weight values for the non dairy cattle, sheep and pigs categoryes.

Table 5.12 The values energy digestible expressed in Mj/day and percent and weight (kg) for livestock, in the 1989–2023 period

Source indicative	Livestock (source) type	Energy digestible DE (Mj/day)	Percentage of digestible energy DE(%)	Animal weight (kg)
3.A.1	**CATTLE**			
3.A.1.a	*Dairy cattle*	NE	60	650
3.A.1.b	*Non dairy cattle*			
	Calves for slaughter younger than 1 year	81.23	56.77	250
	Young cattle of breeding under 1 year	65.8	56.97	250
	Young cattle of breeding between 1 and 2 years	81.49	55.49	350
	Young cattle of slaughter between 1 and 2 years	152.63	68.65	400
	Cattle 2 years and over Breeding bulls	132.94	55	815
	Cattle 2 years and over Heifers for breeding	124.23	58.84	490
	Males and females for sacrificed older than 2 years	95.15	57	500
	Cattle for work	173.22	57.15	800
3.A.2	***SHEEP***			
	Ewes of milk and fitted	NE	65	60
	Reproducers rams	NE	65	77
	Other sheep	NE	65	48
3.A.3	***SWINE***			
	Pigs under 20 kg	6.7	81.91	14
	Pigs between 20 and 50 kg	11.7	86.75	35
	Pigs fattening	40.66	86.77	110
	Boars	39.3	86.72	270
	Breeding sows	37.7	83.14	125
3.A.4.a	***BUFFALO***			
	Female buffalo	NA	NA	NA
	Other buffalo	NA	NA	NA
3A.4.d	***GOATS***			
	Female goats for milk and females by first mount	NA	NA	NA
	Other goats	NA	NA	NA
3.A.4.e	***HORSES***	NA	NA	NA
3.A.4.f	***MULES AND ASSES***	NA	NA	NA
3.A.4.g	***POULTRY***			
	Adult poultry for eggs	NA	NA	NA
	Poultry for meat	NA	NA	NA

Activity data

Primary livestock data

1989–2003

The primary data on all categories of animals have been provided by NIS through the Statistical Yearbook.

2004–2023

The primary data on all categories of animals have been provided by NIS; they were reported by NIS to EUROSTAT and, published by EUROSTAT, the total number for each livestock was published in the Statistical Yearbook of Romania. In the Annex V.5.1 (sheet *Primary data)* raw data on livestock in the period 1989–2023, are presented. For the all livestock the differences are due to the fact that the values for the year X are allocated by FAO of year X-1, due to methodology used by FAO, and respectively NIS. Following the implementation of a analysis, differences under 4.61% approximatively have been identified between Eurostat and NIR data; the differences are due to specific elements on data manipulation at the National Institute for Statistics (NIR and EUROSTAT data provider) and EUROSTAT level.

Livestock data primary obtained through the dedicated study *„Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“*

1989–2003

The data from the NIS by 2003, presents livestock aggregate per larger categories (the aggregation criterion is the operation production), was necessary an extrapolation in the past (1989–2003), of the subcategories of animals which appear in the Annex V.5.1 (sheet – Data obtained through the study) and for which are official data for 2004–2023. Was considered the reference year for extrapolation, the 2004 year. The extrapolation was made by the contractor, Institute for Studies and Power Engineering in the above study. The categories and subcategories for which reports were made are given in the Annex V.5.1 (sheet – Data obtained through the study).

Cattle

In this year, from total number of cattle were calculated the percentages other categories and subcategories, respectively the percentages of cattle, with all subcategories and the percentages of buffalo, with all subcategories.

Dairy cattle

For the period 1989–2003 was made an extrapolation, yielding the percentage of 55.79% of the total cattle (the expert opinion).

Non dairy cattle

Calves for slaughter younger than 1 year represents 10.03% of the *total bovines* young cattle of breeding under 1 year represents 15.3% of the *total bovines*, young cattle of breeding between 1 and 2 years represents 7.97% of the *total bovines, cattle 2 years and over* - breeding bulls 0.34% of the *total bovines, cattle 2 years and over* - heifers 5.83%, males and females for sacrificed older than 2 years 1%, cattle for work 1.94%. Were kept the same percentage for the entire period, 1989–2003, because are significantly similar, considering that certain subcategories pass quickly from one subset to another. The categories with long operating (*dairy cattle, breeding bulls, cattle for work, female buffalo*) have similar percentages for all–time series; livestock structure does not change drastically during even if the number of livestock decreases. Most of buffalo and cattle for work exists only households, not sacrifice.

Buffalo

Total bovines data are provided by Romanian National Institute for Statistics (NIS) being released through Statistical Yearbook 1989–2023 and other relevant correspondence. Beginning with 2004, NIS provides to Eurostat a more complete set of data, comprising also Buffalo data. The *Buffalo* represents 1.2% of the *total bovines, female buffalo* are represents 0.89% of the *total bovines* and *other buffalo* represents 0.31% of the *total bovines.*

Swine

Similarly extrapolation was done and the number of *swine*, noting that of all the *swine* were decreased the number of breeding sows (are distinct in NIS evidence for the period between 1989 to 2023), and then calculation percentages were applied for the 2004 year. For *pigs under 20 kg* were obtained a percentage of 14.97 from the total swine were reduced breeding sows. For *pigs between 20 and 50 kg* were obtained 23.46%, *pigs fattening* 61.38% and boars 0.19%. Similarly to cattle subcategories of *pigs* pas quickly from one subset to another.

Sheep

For *sheep* and *goats* it was proceeded similar with *swine*, from the *swine total* it was decreased the number *ewes of milk and fitted*, and it was calculated the percentage for *reproducers rams* (15.92%) and *other sheep* (84.08%).

Goats

For *goats* it was decreased from the total number of *goats* the goats number and it was obtained *other goats.* Not applied any extrapolation, because these data were available at NIS.

Mules and asses

Due to impossibility of finding data from Romanian sources we used mules and asses data from FAO databases.

Horses and poultry

The livestock of *horses* and *poultry* (disaggregated in *poultry for eggs* and *poultry for meat*) were taken from

NIS for entire period.

2004–2023

In the Annex V.5.1 (sheet – *Data obtained through the study*) are presented livestock aggregate of the contractor, Institute for Studies and Power engineering in the above study.

Cattle under 1 year

The values for *calves for slaughter* were taken from the Annex V.5.1 (sheet – *Primary data*), the values of *young cattle breeding* is the sum of *males* and *females* from Annex V.5.1 (sheet – *Primary data*).

Cattle between 1 and 2 years

For of *young breeding cattle* the values males were calculated by summing with other from category *cattle between 1 and 2 years* from Annex V.5.1 (sheet – *Primary data*). For *young cattle for slaughter* were used the values from in according with Annex V.5.1 (sheet – *Primary data*). The values for *Dairy cattle* were used from primary data table. For *males and females for sacrificed* were calculated the values summing from *males and females for sacrificed* from primary data table. For *cattle for work* the values represents the sum between *cattle for work* and *other dairy cattle* from primary data table.

Cattle 2 years and over

The values for *breeding bulls* took from the primary data table. For *heifers* were used the values from *breeding heifers* from primary data table. The values for *Dairy cattle* were used from primary data table. For *males and females for sacrificed* were calculated the values summing from *males and females for sacrificed* from primary data table. For *cattle for work* the values represents the sum between *cattle for work* and *other dairy cattle* from primary data table.

Buffalo

The values were used from primary data (NIS).

Swine

For all the subcategories presented in the Annex V.5.1 (sheet - *Data obtained through the study*) are used in according with the Annex V.5.1 (sheet – *Primary data*).

Sheep

The values for *ewes of milk and fitted* were taken from the Annex V.5.1 (sheet – *Primary data*), from the category *Sheep ewes and ewe mounted- total (3+4).* Remaining subcategories were taken from the same table.

Goats

The values for *female goats for milk and females by first mount* were taken from primary data table from *goats which have littered and goats fitted (9+10).* Other goats were taken from the table by primary data.

Poultry

For *adult poultry for eggs* the values were taken from the Annex V.5.1 (sheet – *Primary data).* The values for *poultry for meat* represent the difference between *total poultry* and *adult poultry for eggs*.

The values for *horses* and *mules and asses* were taken from the Annex V.5.1 (sheet – *Primary data*).

5.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

5.2.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 10 %;
- EF: 20%;
- 22.36% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Due to the fact that most of activity data are provided by NIS or FAO and the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“* and were obtained using the same method (the use of one methods for obtaining the livestock data is ensuring the consistency of data series considering the national circumstances; detailed information is provided in Section 5.2.2), emission factors were obtained using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

5.2.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Waste sector*, the results of these being mentioned on the Checklists level. Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NIR was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

The activity data series were also compared to those on FAO and Eurostat, the data being reported at the same level of aggregation and the figures comparable. Further elements are presented within Annex 8.4.

5.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The CH_4 emissions were made recalculations for the following reasons for the 2022 year for swine do to calculation errors.

Table 5.13 The changes impact on activity data for the estimation of the CH_4 emissions from enteric fermentation for swine

Year	**The changes impact on activity data for the estimation of the CH_4 emissions from enteric fermentation– swine**		
	CH_4 emissions (Gg) –NIR 2024	**CH_4 emissions (Gg)– NIR 2025**	**Difference**
2022	4.526521813	5.03425177	0.507729957

5.2.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

Aiming to their incorporation into next inventory submissions, the development of national values for the methane conversion rate (Y_m), for significant categories, is envisaged. The revision of digestible energy (DE%) values is foreseen.

5.3 Manure Management (CRT 3.B)

5.3.1 Category description

Managing a large number of animals in a confined area creates conditions for CH_4 emissions due to the anaerobic decomposition of manure. A part of the nitrogen from manure is converted to N_2O during storage of manure.

Manure Management:

- ❖ in 2023 CH_4 emissions from Manure Management represented 6.88% of total CH_4 emissions while N_2O accounted for 9.55% of total N_2O emissions in the Agriculture sector;
- ❖ CH_4 and N_2O emissions from Manure Management as CO_2 equivalent in 2023 represented 7.66% from Total Agriculture emissions;
- ❖ contributed with 0.63% to Total GHG emissions of Romania.

Emissions from manure management are declining since 1989 due to the decrease of the animal population, on the one hand due to lower number of animals, and on the other hand the switchover any part of it from traditional systems, economic in farms organized, in which is practiced different waste management systems (Figure 5.5). The dynamic of emission of CH_4 from manure management reflect the livestock described situation in Romania. The years 1997–2000 have been of Romania unfavorable, in terms economically, which is found both decrease the number of animals and implicitly the emissions. After 2000, livestock will return with higher share, steps first taken by farmers of especially hens and the emissions increased to 2006, then again begin to fall. The observations on source category 3B – “Manure Management” are presented in the Table 5.14. And the of N_2O emission decreased due to the decrease the effective of livestock including per those them found on farms where it practice manure management system.

Figure 5.5 Overall trends of emissions from Manure Management

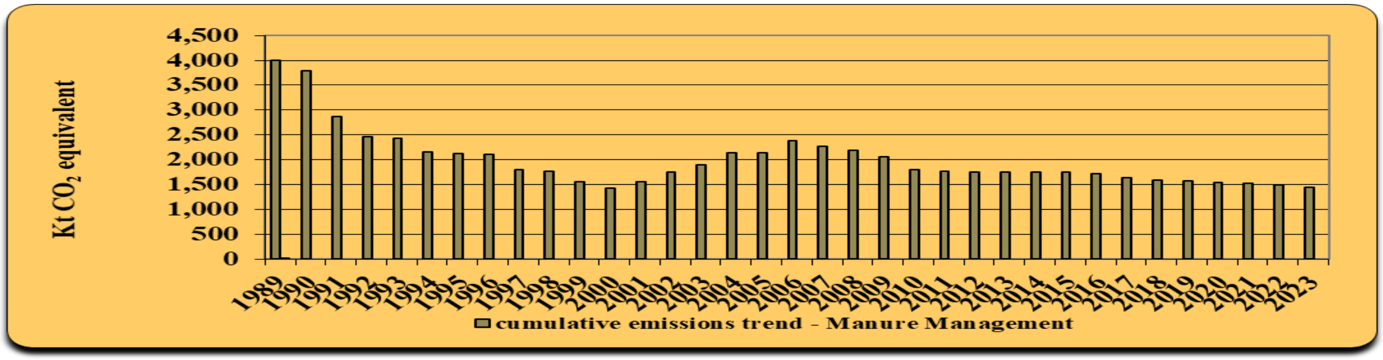


Table 5.14 Observations on source category 3B – "Manure Management"

Source indicative	Source type	Observation		Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"				
3.B.1	**Cattle**		Includes livestock data from nine different cattle categories: dairy cows and non-dairy cattle	AD: NIS and expert judgment, 1989–2003; NIS, 2004–2023 EF: Country specific, expert judgment, IPCC 2006
3.B.2	**Sheep**		Includes livestock data from three different sheep: Ewes of milk and fitted, reproducers rams and other sheep	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: IPCC 2006, country specific
3.B.3	**Swine**		Includes livestock data from five different swine: pigs under 20 kg, pigs between 20 and 50 kg, pigs fattening, boars, breeding sows	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023 EF: IPCC 2006, expert judgment
3B.4.h.i	**Rabbits**			AD: NIS, 1989–2023; EF: IPCC 2006, default
3.B.4.a	**Buffalo**		Includes livestock data from two different buffalo:buffalo milk and other buffalo	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: IPCC 2006, default
3.B.4.d	**Goats**		Includes livestock data from two different goats: Female goats for milk and females by first mount and other goats	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: IPCC 2006, default

Source indicative	Source type	Observation		Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"				
3.B.4.e	**Horses**			AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; EF: IPCC 2006, default
3.B.4.f	**Mules and asses**			AD: FAO, 2017; EF: IPCC 2006, default
3.B.4.g	**Poultry**		Includes livestock data from two different poultry: adult poultry for eggs, poultry for meat. Poultry include and the ducks, turckish, geese	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023 EF: IPCC 2006, default
3.B.(b)1.a	**Cattle**	**Dairy cattle**	Includes following type of systemes of management: - Pasture/range/paddock; - Solid storage; - Liquid/Slurry	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)1.b		**Non dairy cattle**	- Pasture/range/paddock; - Solid storage; - Liquid/Slurry *Cattle 2 years and over-Breeding buls* includes type of systeme of management *Solid storage*	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)2	**Sheep**		Includes following type of systemes of management: - Pasture/range/paddock; - Daily Spread; - Solid storage	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)3	**Swine**		Includes following type of systemes of management: - Solid storage; - Anaerobic Lagoon; - Pit storage *Pigs for breeding-boars* includes type of systeme of management *Solide storage* and *Pit storage*	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment

Source indicative	Source type	Observation		Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"				
3.B.(b)4.a	**Buffalo**		Includes following type of systemes of management: - Pasture/range/paddock; - Solid storage	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)4.d	**Goats**		Includes following type of systemes of management: - Pasture/range/paddock; - Solid storage	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)4.e	**Horses**		Includes following type of systemes of management: - Pasture/range/paddock; - Daily spread; - Solid storage	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)4.f	**Mules and asses**		Includes type of systeme of management -Pasture/range/paddock;	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)4.g	**Poultry**	**Adult poultry for eggs**	Includes type of systemes of management - Daily spread and - Poultry manure without for eggs	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
		Poultry for meat	Includes type of systemes of management - Daily spread and - Poultry manure without beding	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)4.h.i	**Rabbits**			AD: SY, other correspondence, NIS, IPCC 2006 EF: IPCC 2006, expert judgment
3.B.(b)2.5	**Includes the following systems AWMS: Anaerobic Lagoon, Liquid/Slurry, Daily Spread, Solid storage and dry lot, Pasture/range/paddock, Pit storage, Poultry manure with bedding, Poultry manure without bedding**			AD: SY, other correspondence, NIS and expert judgment, IPCC 2006 EF: IPCC 2006, expert judgment

5.3.2 Methodological issues

CH_4 emissions

Methodology

The amount of methane emitted from manure management is driven primarily by the number of animals, the type of digestive system, and the type and amount of feed consumed. Emissions of methane from manure management were calculated using a Tier 2 method, for dairy cattle, non dairy cattle, sheep and swine. For the buffalo, goats, horses, mules and asses, poultry and rabbits categories has been calculated using a Tier 1 method. For dairy cattle, non dairy cattle, sheep and swine are available national data (GE, DE, VS, MS) for each subcategory to estimate methane emissions in according the method 2 using and default values (Bo – maximum CH_4 producing capacity for manure produced by an animal within defined population *i*, m^3/kg of VS and MCF – CH_4 conversion factors for each manure management system *j* by climate region k). Emissions of methane from manure management were calculated using equations: 10.22 of 2006 *IPCC Guidelines for National Greenhouse Gas Inventories.*

Emission factors

According to the provisions of IPCC 2006, to use equation 10.23 and 10.24 have been considered national values for gross energy intake, MJ/head/day (GE), digestible energy (DE), excretion rates (VS), fraction of animal species/category *i*'s manure handled using manure system (MS) and the default values for ASH, Bo, UE (urinary energy expressed) and MCF used from 2006 *IPCC Guidelines for National Greenhouse Gas Inventories.* The GE, DE, VS and MS values for non dairy cattle and swine were calculated in the context of implementing in 2011 the study `*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*`. For dairy cattle and sheep the values GE, DE was presented detail in section 5.2.2 – "Enteric fermentation" and MS values hass been developed in the context of implementing of the mentioned study. In the Annex V.5.1 (sheet– Emission factor manure management) are found weighted average allocation of MMS for all category. The gross energy intake (GE) and digestible energy (DE) calculation was presented detail in section 5.2.2 – "Enteric fermentation" for non dairy cattle and swine. The volatile solid excretion per day (VS) was calculated with equation 10.24 from IPCC 2006. In Annex V.5.1 *"Detailed data for estimating CH_4 and N_2O Agriculture Sector related GHG emissions" are found the weighted average VS values for dairy cattle, shep, non dairy cattle, swine.* The fractions values of ashes (ASH) used in the VS calculation are default, with those in the IPCC 2006 and Reference Manual. For cattle were used for all categories 8%, for swine were chose the specific value of countries developed (2%), because the digestibility calculated (82-88%) is close to that date for developed countries (75%). For sheep was choosing the default value. The coefficient B_0 does not have specific national values, so its value has been used according IPCC 2006 and Reference Manual. Were took the values of Eastern European region, respectively 0.24 for dairy cattle and 0.17 for other category of cattle, 0.29 for swine (value for developing countries, because the value VS calculated is close of the value VS in Manual Reference for countries developing - 0.34). For sheep, it was chose the values Bo specific of developing countries, because this species are grown extensively or household. Not practice intensive growth, industrial to any of the species mentioned. For rabbits was used default emission factor 0.08. In regarding manure management systems, in Romania were used almost all the systems described in 2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, with the exception some exemple of the system "dry lot", which implies the letting for drying manure in refuge and their spread per field after a long time. The distribution of these types of manure management systems were made according expert opinion. The conversion factors of methane for each manure system management (MCF), according to region, were taken from 2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, considering Romania make part of the cold climate. The values urinary energy expressed as fraction of GE were calculated using the default value for UE (urinary energy) from 2006 *IPCC Guidelines for National Greenhouse Gas Inventories* multiplied with the GE value, were presented in the table 5.15. In the Table 5.15 are summarized the values used in the calculation of emissions factors for 1989–2023 period for each livestock (non dairy cattle and swine). In the tables 5.16 and 5.17 are summarized the values used in the calculation of emissions factors for 1989–2023 period for dairy cattle and sheep and the Table 5.19 are summarized the MCF (CH_4 conversion factors for each manure management system *j* by climate region *k*) values for each manure system management. Mention that MCF values are the same for each livestock and each year depending manure system management. The value was chosen because the cold climate in Romania average annual temperature is 10 degrees Celsius. The values for for dairy cattle on Ash content of the manure in percent (%) (ASH) and maximum CH_4 producing capacity for manure produced by an animal within defined population *i*, m^3/kg of VS (B_0) are 8 respectively 0.24. For buffalo, goats, horses, mules and asses, poultry and rabbits has been use the default values for emission factors.

Table 5.15 The values used in the calculation of emissions factors from Manure management for non dairy cattle and swine 1989–2023

Source indicative	**Livestock (source) type**	**Ash content of the manure in percent (%) (ASH)**	**Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)**	**Maximum CH_4 producing capacity for manure produced by an animal within defined population *i*, m^3/kg of VS (B_0)**	**Urinary energy expressed as fraction of GE**
3.B.1	***CATTLE***				
3.B.1.b	***Non dairy cattle***				
	Calves for slaughter younger than 1 year	8	3.37	0.17	5.72
	Young cattle of breeding under 1 year	8	2.71	0.17	4.62
	Young cattle of breeding between 1 and 2 years	8	3.55	0.17	5.87
	Young cattle of slaughter between 1 and 2 years	8	3.92	0.17	8.89
	Cattle 2 years and over -Breeding bulls	8	5.90	0.17	9.66
	Cattle 2 years and over – Heifers for breeding	8	4.75	0.17	8.44
	Males and females for sacrificed older than 2 years	8	3.59	0.17	6.66
	Cattle for work	8	7.08	0.17	12.12
3.B.3	***SWINE***				
	Pigs under 20 kg	2	0.08	0.45	0.16
	Pigs between 20 and 50 kg	2	0.10	0.45	0.26
	Pigs fattening	2	0.37	0.45	0.93
	Boars	2	0.36	0.45	0.90
	Breeding sows	2	0.45	0.45	0.90

Table 5.16 The values used in the calculation of emissions factors from Manure management for 1989–1990, 1995, 2000, 2005, 2007–2023 period for dairy cattle and sheep– Ewes and Ewe mounted

Livestock/ Years	**3.B.1.a Dairy cattle**		**3.B.2 Sheep–Ewes and Ewe mounted**	
	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	**Urinary energy**	**Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)**	**Urinary energy**
1989	5.042784111	0.04	0.451170638	0.04
1990	5.143962425	0.04	0.453859384	0.04
1995	5.961258499	0.04	0.451492364	0.04
2000	6.153662732	0.04	0.451538947	0.04

Livestock/ Years	3.B.1.a Dairy cattle		3.B.2 Sheep–Ewes and Ewe mounted	
	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy
2005	6.376256577	0.04	0.451959602	0.04
2007	6.426663091	0.04	0.452382248	0.04
2008	6.481168988	0.04	0.449259404	0.04
2009	6.386649587	0.04	0.449133866	0.04
2010	6.514825574	0.04	0.449884440	0.04
2011	6.620036484	0.04	0.450002116	0.04
2012	6.534691609	0.04	0.449977830	0.04
2013	6.548719881	0.04	0.449534173	0.04
2014	6.582208184	0.04	0.451168062	0.04
2015	6.509954075	0.04	0.451075651	0.04
2016	6.435177981	0.04	0.450935996	0.04
2017	6.43568879	0.04	0.450861909	0.04
2018	6.471226501	0.04	0.451251335	0.04
2019	6.458636068	0.04	0.451217348	0.04
2020	6.499614094	0.04	0.450995590	0.04
2021	6.578352807	0.04	0.451377191	0.04
2022	6.549723091	0.04	0.447875249	0.04
2023	6.561961962	0.04	0.451529085	0.04

Table 5.17 The values used in the calculation of emissions factors from Manure management for 1989–1990, 1995, 2000, 2005, 2007–2023 period for sheep – Reproducers Rams, Other Sheep

Livestock/ Years	3.B.2 Sheep – Reproducers Rams		3.B.2 Sheep – Other Sheep	
	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy
1989	0.387985175	0.04	0.435931618	0.04
1990	0.390673922	0.04	0.438620364	0.04
1995	0.388306902	0.04	0.436253344	0.04
2000	0.388353484	0.04	0.436299927	0.04
2005	0.388774139	0.04	0.436720582	0.04
2007	0.389196785	0.04	0.437143228	0.04
2008	0.386073942	0.04	0.434020384	0.04
2009	0.385948403	0.04	0.433894846	0.04
2010	0.386698977	0.04	0.434645420	0.04
2011	0.386816653	0.04	0.434763096	0.04

Livestock/ Years	3.B.2 Sheep – Reproducers Rams		3.B.2 Sheep – Other Sheep	
	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy
2012	0.386792368	0.04	0.434738810	0.04
2013	0.386348710	0.04	0.434295153	0.04
2014	0.387982599	0.04	0.435929041	0.04
2015	0.387890188	0.04	0.435836631	0.04
2016	0.387750533	0.04	0.435696976	0.04
2017	0.387676446	0.04	0.435622889	0.04
2018	0.388065873	0.04	0.436012315	0.04
2019	0.388031885	0.04	0.435978328	0.04
2020	0.387810128	0.04	0.435756570	0.04
2021	0.388191729	0.04	0.436138171	0.04
2022	0.384689787	0.04	0.432636229	0.04
2023	0.388343622	0.04	0.436290065	0.04

Table 5.18 The values MCF used in calculation of emissions factor for each manure system management for all livestock in the 1989–2023 period

The period 1989–2023	CH_4 conversion factors for each manure management system (MCF)								
	Anaerobic lagoon	Liquid slurry	Daily spread	Solid Storage	Dry lot	Pasture/ range/ paddock	Pit storage	Poultry manure with bedding	Poultry manure without bedding
	0.66	0.17	0.001	0.02	-	0.01	0.03	0.015	0.015

In the context of the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*“, in the Annex V.5.1 (sheet– *Values MS and Weighted average MS*) are present MS values used in emission factor calculation from manure management for each animal category and subcategory and each AWMS (Animal Waste Management Systems) in the 1989–2023 period, and in the Annex V.5.1 (sheet– *Emission factor manure management*) are found emission factors necessary for calculation of methane emissions from manure management. For swine was used the value 0 for MS in the anaerobic lagoon system. Emission factors of CH_4 for dairy cattle in the 2004–2009 period decrease due to of the MS value in the Liquid/slurry system (in the 2004 year is 0.06, in the 2005 year is 0.02 and in the 2009 year is 0.03), the same for non-dairy cattle EF decrease having the same explanation (in the Liquid/slurry system the values in the 2004 year are between 0.05 – 0.06 and in the 2009 year are between 0–0.02, this the values have been elaborated in the context of implementing in 2011 the study ”Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods”. The time series consistency of emissions trend is very fluctuating in 2004–2006 period, for non-dairy cattle, is due to the fluctuation of the national emission factors values based on the variation of MS values; the emission factors values have been calculated in the context of implementing in 2011 the study mentioned aboved.

Activity data

They were used the same activity data as for calculation of CH_4 emissions from enteric fermentation. Data are presented in Chapter 5.2.2.

N_2O emissions

Direct N_2O emissions

Methodology

Emissions of nitrous oxide from manure management were calculated using a Tier 2 method, for all species, according to the provisions in 2006 *IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). For rabbits were estimated N_2O emissions with the level 1 methode.* For the category buffalo, horses, mules and asses, swine and poultry national data are available for annual average N excretion per head of species/category (kg N/animal/yr) (Nex), fraction of animal species/category *i*’s manure handled using manure system *j* in climate region k (MS) for to estimate the nitrous oxide emissions from manure management in according Tier 2 method, using and default values (EF_3 – the Table 10.21 from 2006 *IPCC Guidelines for National Greenhouse Gas Inventories*). For the category dairy cattle, non dairy cattle, sheep and goats default data are available for annual average N excretion per head of species/category (kg N/animal/yr) (Nex) and national data for fraction of animal species/category *i*’s manure handled using manure system *j* in climate region k (MS). The direct nitrous oxide emissions from manure management were calculated in according with the equation 10.25 from IPCC 2006 (pg.10.54). In respect to the IPCC 2006 provisions, Direct and indirect N_2O emissions from Pasture range and paddock AWMS are reported under 3D – Agricultural soils (see Chapter 11, Section 2).

Emission factors

According to the provisions in IPCC 2006, the calculation methodology took into account national and default the values for annual average N excretion per head of species/category (kg N/animal/yr) (Nex) and national the values for fraction of animal species/category *i*’s manure handled using manure system *j* in climate region k (MS) and default values for emissions factor from IPCC, respectively EF_3 (Table 10. 21 and table 10.30 of IPCC 2006). In the context of the implementation in 2011 of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sector Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“, the values Nitrogen excretion [kg

N/head/year] were calculated for buffalo, horses, mules and asses, swine and poultry according to solid manure and liquid manure using following equation:

Equation 5.2 Nitrogen excretion

$$N_{ex} = \text{the amount of solid manure} \cdot 365 \cdot N\% \text{ from solid manure} /100 + \text{the amount of liquid manure} \cdot 365 \cdot N\% \text{ from liquid manure}/100$$

In the Table 5.19 are presented the values for N_{ex} and the data on the amount of solid manure (kg), N% from solid manure, the amount of liquid manure (l), and N% from liquid manure (Daily quantities of solid manure (S) and liquid (L) of animals and their composition – by various authors, quoted by Dana Sandulescu, PhD Thesis, 2005). The values were implemented through the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sector Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods". In poultry the N_{ex} value is considered sum of solid manure with liquid manure. The phases are not separated physiological.

Table 5.19 Data necessary for calculating of Annual average N excretion per head of species/category Nex (kg N/animal/yr), in the 1989–2023 period

Source indicative	Livestock (source) type	The amount of solid manure (kg)	The amount of liquid manure (l)	N% from solid manure	N% from liquid manure	Annual average N excretion per head of species/category N_{ex} (kg N/animal/yr)
3 B.(b)3	***SWINE***					
	Pigs under 20 kg	1.4	0.94	0.55	1.95	9.5
	Pigs between 20 and 50 kg	2.65	1.75	0.55	1.95	17.8
	Pigs fattening	2.7	1.798	0.55	1.95	18.21
	Boars	3.549	2.5	0.55	1.95	24.91
	Breeding sows	2.7	1.798	0.55	1.95	18.21
3 B.(b) 4a	***BUFFALO***					
	Female buffalo	23.5	9	0.4031	0.58	53.63
	Other buffalo	23.5	9	0.4031	0.58	53.63
3 B.(b)4.e	***HORSES***	16	3.6	0.6	1.55	55.4
3 B.(b).4.f	***MULES AND ASSES***	11	2.2	0.6	1.55	36.53
3 B.(b).4.g	***POULTRY***					
	Adult poultry for eggs	0.175	-	1.7	-	1.08
	Poultry for meat	0.18	-	1.84	-	1.2

For the values on annual average N excretion per head of species/category (kg N/animal/yr) (Nex) for dairy cattle, non dairy catle, rabbits, sheep and goats was used equation 10.30. For default N excretion rate (Nrate) was use table 10.19 from IPCC2006 and the values on typical animal mass for livestock are national. In annex V.5.4 "*Detalied data estimating Nex for livestock*" are found the values and the calculations for Nex for all period and weighted average on Nex. In CRT Report (Common Reporting Format) the nitrogen value of the management system solid manure storage nitrogen was added to value nitrogen management system „*dry lot"* manure, resulting a single value. Also and the nitrogen value from other AWMS in report CRT is the result of sum between of nitrogen value from the manure management system „ *pit storage"* and the nitrogen values of the manure management system „ *poultry manure with bedding*" and „*poultry manure without bedding"*. Considering membership of in Eastern Romania and developing countries, with cold climates the N_2O emission factors used in the calculation the emissions N_2O from manure management are presented in Table 5.20 depending to manure management system.

Table 5.20 N_2O emission factors [kg N_2O-N/kg N excreted] for animal waste per AWMS

AWMS (source) type	Emission factor EF_3 [kg N_2O-N/kg N excreted]
Anaerobic Lagoon	0
Liquid/Slurry	0.005
Daily Spread	0
Solid storage	0.005
Dry lot	0.02
Pit storage	0.002
Poultry manure wit bedding	0.001
Poultry manure without bedding	0.001

Activity data

They were used the same livestock population numbers as for calculation of CH_4 emissions from enteric fermentation. Data are presented in Chapter 5.2.2. The MS values were established by expert opinion in the context of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sector Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods".

<u>Indirect N_2O emissions from Manure management</u> (3B (b).5)

Description of sources of indirect emissions in GHG inventory

N_2O Indirect emissions result from N volatilization in forms of ammonia and NOx and N losses due to leaching and runoff from manure management systems. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature. Simple forms of organic nitrogen such as urea and uric acid are rapidly mineralized to ammonia nitrogen, which is highly volatile and easily diffused into the surrounding air. Nitrogen losses begin at the point of excretion in houses and other animal production areas and continue through on- site management in storage and treatment systems.

Methodological issues

Methodology

Emissions of indirect nitrous oxide from manure management were calculated using the default method of 1 Tier, for all species, according to the provisions in IPCC 2006. The emissions were calculated in accordance with the equation 10.26, 10.27 and 10.28.

Emission factors

In according with IPCC 2006 for the calculating indirect N_2O emissions was used the value default emissions factor from IPCC, respectively EF4 (Table 11.3 - of IPCC 2006).

Activity data

They were used the same livestock population numbers as for calculation of CH_4 emissions from enteric fermentation. Data are presented in Chapter 5.2.2. The values Nitrogen excretion [kg N/head/year] and MS were established are presented in the section direct N_2O emissions. The values for percent of managed manure nitrogen for livestock that volatilises as NH_3 and NOx in the manure management were used from IPCC 2006, the Table 10.22 and for percent of managed manure nitrogen losses for livestock due to runoff and leaching during solid and liquid storage of manure have been used the average within the un between 1-20% (pag. 10.56 in IPCC 2006).

5.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

5.3.4 Uncertainty assessment and time-series consistency

CH_4 emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 10 %;
- EF: 30%;
- 31.62% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Due to the fact that most of activity data are provided by NIS or FAO and the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods" and were obtained using the same method (the use of one methods for obtaining the livestock data is ensuring the consistency of data series considering the national circumstances; detailed information is provided in Section 5.2.2), emission factors were obtained using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

Direct N_2O emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 10 %;
- EF: 30%;
- 31.62% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Due to the fact that most of activity data are provided by NIS or FAO and the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods"* and were obtained using the same method (the use of two methods for obtaining the livestock data is ensuring the consistency of data series considering the national circumstances; detailed information is provided in Section 5.2.2), were used default emission factors using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

Indirect N_2O emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD:25 %;
- EF: 40%;
- 47.17% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation in Chapter 3, Volume 1 of the IPCC 2006.

Due to the fact that most of activity data are provided by NIS or FAO and the study *„Elaboration of national* *emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods"* and were obtained using the same method (the use of two methods for obtaining the livestock data is ensuring the consistency of data series considering the national circumstances; detailed information is provided in Section 5.2.2), were used default emission factors using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

5.3.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Waste sector, the results of these being mentioned on the Checklists level. Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No unconformity has been noted following the UNFCCC review of the NGHGI.

The activity data series were also compared to those on FAO and Eurostat, the data being reported at the same level of aggregation and the figures comparable. Further elements are presented within Annex V.13.

5.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Direct emissions

N_2O

The N_2O emissions were made recalculations for the 1989-2022 period due to N_2O emissions were estimated for rabbits.

In the table below can be found the changes impact on the N_2O emissions from manure management.

Table 5.21 The changes impact on the CH_4 emissions from manure management

Year	The changes impact on the N_2O emissions from manure management		
	N_2O emission from manure management-NIR 2024	N_2O emission from manure management-NIR 2025	Difference
1989	3.541359475	3.541396642	0.0000372
1990	3.285783024	3.285832456	0.0000494
1995	2.228328916	2.228366084	0.0000372
2000	1.541311253	1.541359571	0.0000483
2005	2.10635581	2.106376981	0.0000212
2007	2.165132269	2.16515066	0.0000184
2008	2.147372228	2.147389242	0.0000170
2009	2.036582255	2.036599187	0.0000169
2010	1.807383657	1.807393618	0.0000100
2011	1.792788298	1.792798573	0.0000103
2012	1.801481982	1.801493032	0.0000110
2013	1.816700502	1.816711293	0.0000108
2014	1.835268962	1.835279662	0.0000107
2015	1.851400291	1.851411156	0.0000109
2016	1.830363643	1.830374698	0.0000111
2017	1.779684564	1.779694908	0.0000103
2018	1.739148757	1.739158398	0.0000096
2019	1.731277565	1.73128779	0.0000102
2020	1.709645254	1.709654679	0.0000094
2021	1.670996505	1.671005297	0.0000088
2022	1.651938052	1.651945532	0.0000075

Year	The changes impact on the N_2O emissions from manure management		
	N_2O emission from manure management-NIR 2024	N_2O emission from manure management-NIR 2025	Difference
2023	2.165132269	1.620078423	-0.5450538

5.3.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

Aiming to their incorporation into next inventory submissions, the development of national values for the following parameters, parameters relevant to significant species are envisaged:

- ❖ ash content of the manure (ASH);
- ❖ maximum CH_4 producing capacity for manure produced by an animal within defined population (B_0);
- ❖ CH_4 conversion factors for each manure management system by climate region (MCF).

Indirect N_2O emissions

- ❖ percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NOx in the manure management system S, % (FracGasMS).

5.4 Rice Cultivation (CRT 3.C)

5.4.1 Category description

Anaerobic decomposition of organic material in flooded rice fields produces methane. Methane escapes to the atmosphere primarily by transport through the rice plants and its flux depends upon the input of organic carbon, water regimes, time and duration of drainage, soil type, etc.

Rice Cultivation:

- ❖ is source of CH_4 emissions in the Agriculture sector (in 2023, CH_4 emissions from Rice Cultivation represented 0.11% of total CH_4 emissions in the Agriculture sector);
- ❖ in 2023, CH_4 emissions from Rice Cultivation as CO_2 equivalent represented 0.05% from Total Agriculture emissions);
- ❖ contributed with 0.01% to Total GHG emissions of Romania.

Emissions from rice cultivation are declining since 1989 due to the decrease of rice cultivated area (Figure 5.6). The rice area cultivated with is decreased in 21.6 thousands ha in 1991 by 100 ha in 2003. In 2023 the rice area cultivated is 2.4 thousands ha. The reduction due to areas privatization process and concession of the land from state patrimony, which ended in 2004. Due to natural conditions, Romania dispose a production of rice relatively balanced while the cultivated area and the emissions from rice continue to fall.

Figure 5.6 Methane emission trend due to the Rice Cultivation

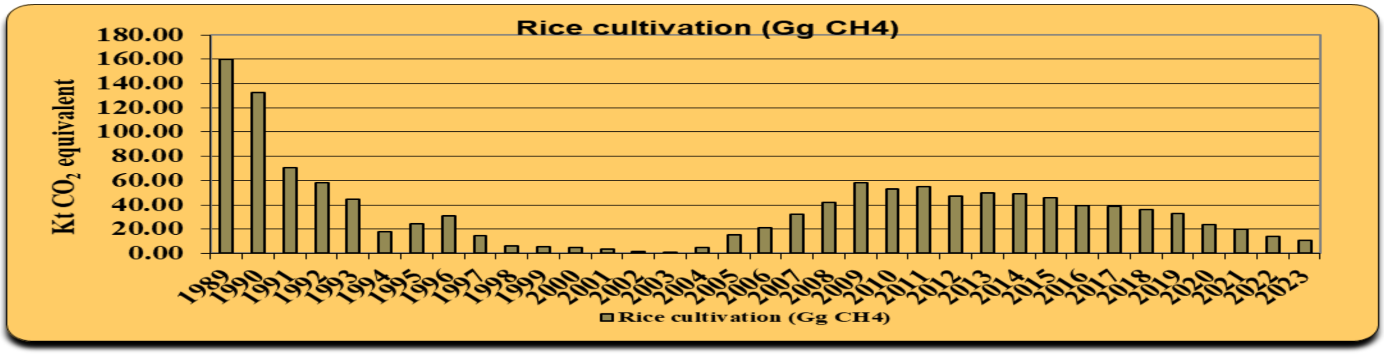


Table 5.22 Observations on source category 3C – "Rice Cultivation"

Source indicative	Source type	Observation	Data source
3.C.1.2	Rice harvested area		AD: SY, NIS, 1989–2023; expert judgment; EF: IPCC 2006

5.4.2 Methodological issues

Methodology

Due to small importance of source category Rice Cultivation into Total GHG emission level (Rice Cultivation does not meet the key category thresholds) a Tier 1 method has been applied. For calculation of methane emissions from rice cultivation, the equations 5.1 and 5.2 of IPCC 2006 were used (pag.5.45 and 5.48).

Emission factors

Considering the provisions in IPCC 2006 and the data provided by the Ministry of Agriculture, the calculation methodology took into account:

- ❖ a seasonally integrated emission factor value for continuously flooded fields without organic amendments (EF_c) of 1.30 kg CH_4 ha^{-1} day^{-1} (from Table 5.11 in IPCC 2006);
- ❖ a default value of 0.52 for the scaling factor to account for the differences in ecosystem and water management regime (SF_W) corresponding to lowland – irrigated – intermittently flooded – multiple aeration water management regime (from Table 5.12 in IPCC 2006);
- ❖ a default value of 1.22 for scaling factor to account for the differences in water regime in the pre-season

before the cultivation period (SFp) (from Table 5.13 in IPCC 2006);

- ❖ yearly default values for the scaling factor to account for both type and amount of amendment applied (SF_O). Was calculated using equation 5.3 from IPCC 2006. Was take application rate of organic amendament in dry weight for straw and fresh weight for others (ROA) which is Rice residues productivity values, conversion factor for organic amendament (CFOA) (Table 5.14);
- ❖ default values to account for the differences in water regime in the pre-season before the cultivation period of 1.22 (Table 5.13);
- ❖ default values of 1 for scaling factor for soil type, rice cultivar;
- ❖ cultivation period of rice of 120 days the value establish of the expert opinion.

In the next table are shown rice residues productivity values, default values for the scaling factor to account for the type and amount of amendment applied (SF_O) and the values of the emission factors for 1989–1990, 1995, 2000, 2005, 2007–2023 period.

Table 5.23 Rice residues productivity values, default values for the scaling factor to account for the type and amount of amendment applied (SF_O) and the values of the emission factors for 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Rice residues productivity (ROA) [tones d.m./ha]	Scaling factor to account for the both type and amount of amendment applied (SF_O)	Emission factor
1989	1.066	1.172	0.966
1990	1.249	1.200	0.989
1995	2.911	1.435	1.183
2000	1.902	1.296	1.068
2005	2.741	1.412	1.164
2007	2.457	1.374	1.132
2008	3.699	1.537	1.267
2009	4.084	1.586	1.307
2010	3.724	1.540	1.270
2011	3.862	1.558	1.284
2012	3.375	1.496	1.233
2013	3.433	1.503	1.239
2014	2.665	1.401	1.156
2015	3.365	1.494	1.232
2016	3.469	1.507	1.243

Year	Rice residues productivity (ROA) [tones d.m./ha]	Scaling factor to account for the both type and amount of amendment applied (SF_O)	Emission factor
2017	3.560	1.519	1.253
2018	3.941	1.567	1.292
2019	4.038	1.579	1.303
2020	3.217	1.475	1.216
2021	2.091	1.323	1.090
2022	3.886	1.561	1.287
2023	3.773	1.547	1.275

Activity data

Total rice cultivated area is provided by Romanian National Institute for Statistics (NIS) being released through Statistical Yearbook 1989–2023. Was used the cultivation period of 120 days. By expert judgment, total harvested area equals total cultivated area (the number of harvests per year equals 1). Harvested area data series are presented in Table 5.24.

Table 5.24 Harvested area data series for 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Harvested area [10^8 m^2]
1989	4.93
1990	3.99
1995	0.62
2000	0.14
2005	0.39
2007	0.84
2008	0.99
2009	1.33
2010	1.24
2011	1.27
2012	1.13
2013	1.19
2014	1.27
2015	1.11
2016	0.94
2017	0.91

Year	Harvested area [10^8 m^2]
2018	0.83
2019	0.74
2020	0.58
2021	0.54
2022	0.03
2023	0.02

5.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG’s do not apply for Romania.

5.4.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 500%;
- 5% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Due to the fact that all activity data are provided by NIS and were obtained using the same method, that default emission factors were used and the same estimation method was used for the whole period, the data series 1989–2023 is consistent

5.4.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating *Waste sector*, the results of these being mentioned on the Checklists level.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the

Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 06/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No unconformity has been noted following the UNFCCC review of the NGHGI.

The activity data series were also compared to those on FAO and Eurostat, the data being reported at the same level of aggregation and the figures comparable. Further elements are presented within Annex V.5.1.

5.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Was made recalculations for 2022 year due to of the surface update.

The impact of emissions can be found below.

Table 5.25 The changes impact on the CH_4 emissions from rice cultivation

Year	The changes impact on the CH_4 emissions from rice cultivation		
	CH_4 emission from rice cultivation-NIR 2024	CH_4 emission from rice cultivation-NIR 2025	Difference
2022	0.55013859	0.50978847	-0.04035012

5.4.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

In respect to the IPCC 2006 provisions, more detailed data on rice cultivation techniques used are proposed to be obtained.

5.5 Managed soils (CRT 3.D)

5.5.1 Category description

Microbial processes of nitrification and denitrification in agricultural soils produce nitrous oxide emissions. There can be distinguished three types of emissions:

❖ direct soils emissions result from the following nitrogen input to soils:
- synthetic fertilizers (F_{SN});
- organic N applied as fertilizer (F_{ON});
- urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP});
- N in crop residues (F_{CR});
- N mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soil (F_{SOM});
- drainage/management of organic soils (F_{OS}).

Direct soil emissions (3D1)

Direct soil emissions:

❖ is the first source of N_2O emissions in the Agriculture sector (in 2023, N_2O Direct soil emissions represented 88.38% of total N_2O emissions in the Agriculture sector);

❖ is the first source in the Agriculture sector (in 2023, N_2O Direct soil emissions as CO_2 equivalent represented 40.79% from Total Agriculture emissions);

❖ contributed with 5.32% to Total GHG emissions of Romania.

Emissions from Agricultural Soils are declining since 1989 (Figures 5.7 and 5.8) due to the decrease of the:

❖ amount of synthetic fertilizer applied;

❖ livestock populations (the details can be found in Chapter 5.1);

❖ crop productions level.

In the 1989–1999 period the N-synthetic fertilizer amount is decreasing due to:

–the transition of economy from a centralized state to the market economy. The centralized economy has associated the existence of large/centralized farms with an appropriate technical management. After 1989 year, the large farms has been splitted/disaggregated in the sense that smaller land areas have been restituted to individuals; there was no appropriate N-synthetic fertilizer management at the individuals level;

- the N-synthetic fertilizer price variation-the prices increased while the newly created individuals administrating smaller farms did not had an adequate financial capacity;
- a significant part of land in the small farms had not been temporarily subject to cultivation (due to limited individuals capacity).

In the 1999–2011 period the N-synthetic fertilizer amount is increasing due to:

- re-establishment of large farms, in a significant manner, now in private property; these have associated an optimal technical and financial management aiming to maximize the crop production level.

The amount of N_2O emissions from application of synthetic fertilizers have decreased from 10.45 kt N_2O in 1989, to 7.29 kt N_2O in 2023. The quantity of synthetic fertilizer has decreased considerably after the 1989 year from 665,300 tonnes/year to 463,657 tonnes/year. This decrease is reflected in the decrease of the nitrogen fraction volatilized into the atmosphere as N_2O. The main cause was a decrease of crop production and the inability of farmers to use the agricultural technology correctly. The amount of N_2O emissions from annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils have decreased from 6.48 kt N_2O in 1989, to 3.14 kt N_2O in 2023. The decrease of crops, for example in 1992 was caused by unfavorable weather conditions, while the situation was completely opposite in 2004. In the 2007 year, the crop was reduced from 2006 due to drought. Cultivated areas were maintained crop except soybeans which recorded significant decreases.

Figure 5.7 Overall emissions trend of Agricultural Soils

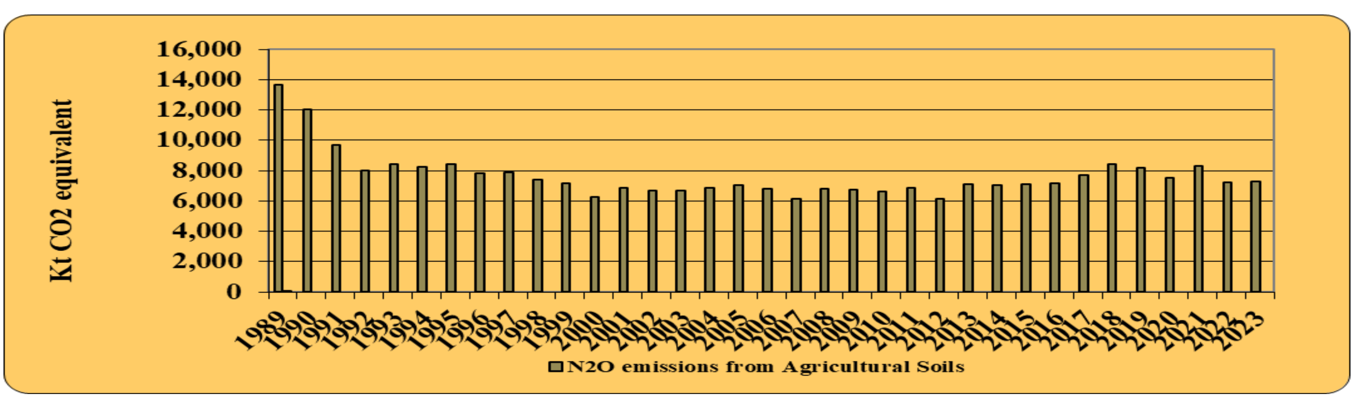


Figure 5.8 Direct N_2O emissions trends – Agricultural Soils

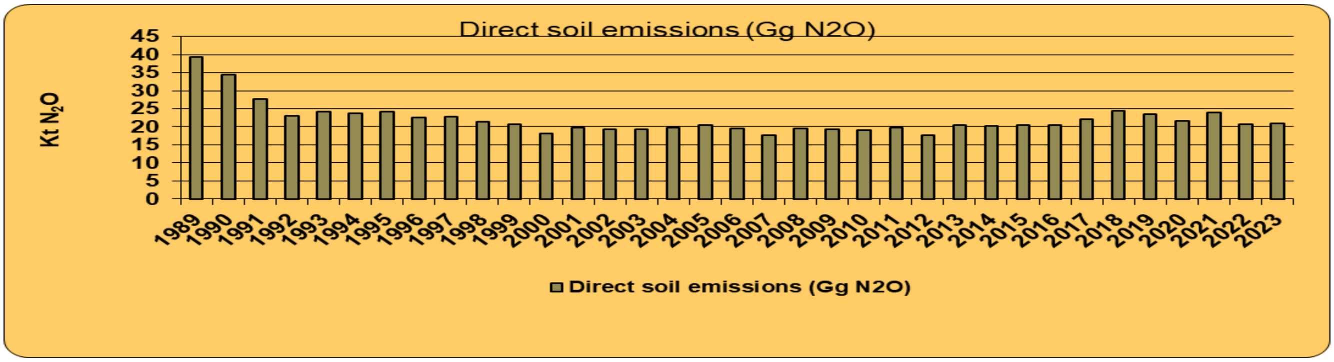


Table 5.26 Observations on source category 3D – "Managed Soils"

Source indicative	Source (livestock) type	Observation	Data source
3.D.1, 3.D.2	**Amount of N synthetic fertilizer used**		AD: SY, NIS, 1989-2023; EF: IPCC 2006
3.D.1.2.a, 3.D.1.3, 3.D.2	**Animals number by livestock**	Includes data on eight different livestock types: cattle (Dairy cattle and Non-dairy cattle), buffalo (buffalo milk and other buffalo), sheep (Ewes of milk and fitted, reproducers rams and other sheep), goats (Female goats for milk and females by first mount and other goats), horses, mules and asses, swine (pigs under 20 kg, pigs between 20 and 50 kg, pigs fattening, boars, breeding sows) and poultry (adult poultry for eggs, poultry for meat).	AD: SY, other correspondence, NIS and expert judgment, 1989–2003; NIS, 2004–2023; The study „*Elaboration of national emission factors /other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*" EF: IPCC 2006, Country specific, expert judgment
3.D.1.4	**Production crops**	Includes following crops: *rye, wheat, barley and two-row barley, oats, maize, sorghum, rice, other grains, rape, sunflower, flax for oil, other oilseed plants (castor), in fiber- textile plants, hemp for fiber - plant textiles, other textile plants – cotton, tobacco, hop, medicinal aromatic plants/spices grown, other industrial crops (sorghum for brooms, potatoes, sugar beet, fodder roots, tomatoes, eggplant, dry onion, dry garlic, cabbage, green peppers, cultivated mushrooms, root vegetables – edible roots, water melons and melons, Green maize for fodder,other vegetables, annual grasses, other perennial grasses,*	AD: SY, other correspondence, NIS, 1989–2023; The study „*Elaboration of national emission factors /other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*".

Source indicative	Source (livestock) type	Observation	Data source
		pea beans, dry bean, other leguminous for dry bean, soybeans, Annual leguminous, lucerne, clover, other perennial leguminous.	EF: IPCC 2006
	Area crop	Includes following crops: *rye, wheat, barley and two-row barley, oats, maize, sorghum, rice, other grains, rape, sunflower, flax for oil, other oilseed plants (castor), in fiber- textile plants, hemp for fiber - plant textiles, other textile plants – cotton, tobacco, hop, medicinal aromatic plants/spices grown, other industrial crops (sorghum for brooms, potatoes, sugar beet, fodder roots, tomatoes, eggplant, dry onion, dry garlic, cabbage, green peppers, cultivated mushrooms, root vegetables – edible roots, water melons and melons, Green maize for fodder, other vegetables, annual grasses, other perennial grasses, pea beans, dry bean, other leguminous for dry bean, soybeans, Annual leguminous, lucerne, clover, other perennial leguminous.*	AD: NIS, 1989–2023; EF: IPCC 2006
	Area burnt	Includes following crops: *rye, wheat, barley and two-row barley, oats, maize, sorghum, rice, other grains, rape, sunflower, flax for oil, other oilseed plants (castor), in fiber- textile plants, hemp for fiber - plant textiles, other textile plants – cotton, tobacco, hop, medicinal aromatic plants/spices grown, other industrial crops (sorghum for brooms, potatoes, sugar beet, fodder roots, tomatoes, eggplant, dry onion, dry garlic, cabbage, green peppers, cultivated mushrooms, root vegetables – edible roots, water melons and melons, other vegetables, annual grasses, other perennial grasses, pea beans, dry bean, other leguminous for dry bean, soybeans, Annual leguminous, lucerne, clover, other perennial leguminous.*	AD: NIS, 1989–2023; expert judgment EF: IPCC 2006
3.D.1.6	**Area of cultivated organic soils**		AD: The Report of National Reasearch Institute for Soil Agrochemical and Environment Protection EF: IPCC 2006

5.5.2 Methodological issues

N_2O Direct soil emissions

Methodology

Despite the fact that Direct soil emissions is a key category, both from level and trend views, Tier 2 method (equation 11.2 from IPCC 2006) could not be applied, due to the lack of national activity data. Therefore, a

Tier 1 method has been applied. For calculation of nitrous oxide Direct soil emissions, the equations 11.1, 11.3, 11.4, 11.5, 11.7 and 11.7A in IPCC 2006.

Emission factors

The calculation methodology took into account IPCC 2006 default emissions factors (Table 11.1 of IPCC 2006):

- ❖ EF_1 = 0.01 (fraction of N-input, kg N_2O-N/kg N);
- ❖ EF_2 = 8 (value specific to Middle-Latitude Organic Soils; kg N_2O-N/ha/year);
- ❖ $EF_{3PRP, CPP}$ for cattle = 0.02 (dairy, non dairy and buffalo);
- ❖ $EF_{3PRP,SO}$ for sheep and other animals = 0.01.

Activity data

Data used for calculation of the annual amount of synthetic fertilizer nitrogen applied to soils (F_{SN})

The amount of synthetic fertilizer applied to soils data are provided by Romanian National Institute for Statistics (NIS) being released through Statistical Yearbook 1989–2023.

Data series are presented in Table 5.27.

Data used for calculation of annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils (F_{ON})

For calculation F_{ON} is necessary of the annual amount of animal manure N applied to soils **(F_{AM})**.

Livestock data are presented in Chapter 5.2.2. Nitrogen excretion per head of animal and fraction of nitrogen excretion produced in different AWMS values used are presented in Chapter 5.3.2. For the calculation amount of managed manure N available for soil application, feed, fuel or construction **(N_{MMS})** were used the parameters presented in Chapter 5.2.2 and 5.3.2.

Annual amount of total sewage N that is applied to soils **(F_{SEW})** is calculated with so:

Equation 5.3 Annual amount of total sewage N that is applied to soils

$$F_{SEW} = SSluN\ (\%) * Ssluagric\ (tonne) * 1000$$

SSluN (%)= nitrogen content in dry matter (in according to the opinion expert is 3.9%);

Ssluagric (tonne)= annual amount of sewage sludge agriculturally applied.

In the table 5.28 are found annual amount of sewage sludge agriculturally applied. The values has been provided in NIS. For the period 1990–2005 there is no available date, because the statistical research has been carried out since 2006.

Annual amount of total compost N applied to soils **(F_{COOMP})** was calculated by the opinion of the expert as follows:

- Is considered 45% in compost total which use in agriculture (data which were provided by Waste Directorate from National Environmental Protection Agency (NEPA)), the dry matter content is 40% from compost total which use in agriculture; is considered 0.3%N from dry matter.

The values on total compost use in agriculture, tonne/year is found in the table 5.29. For the1989–2013 period there are no data on compost total which use in agriculture.

For FOOA (annual amount of other organic amendments used as fertiliser) kg N/y are not available the values. Amount of managed manure nitrogen for livestock category that is lost in the manure management system **($Frac_{LossMS}$)** is used the default value from IPCC 2006 (Table 10.23), and the amount of nitrogen from bedding **(Nbedding)** is used the value 0, it is not known organic bedding. For fractions of managed manure used for feed **($Frac_{FEED}$),** fraction of managed manure used for fuel **($Frac_{FUEL}$)** and fraction of managed manure used for construction **($Frac_{CNST}$)** were used the 0 value, because were not identified sources of national statistical data (the expert opinion). The use or recycling manure by the introduction in manufacturing processes of materials building, although it is known the technique, not was used.

Table 5.27 Activity data series used for calculation of F_{SN}, for 1989–1990, 1995, 2000, 2005, 2007–2023 period (NIS)

Year	Amount of synthetic fertilizer applied to soil [thousands tonnes/year]
1989	665.3
1990	656.0
1995	306.0
2000	239.0
2005	299.0
2007	265.0
2008	279.8
2009	296.0
2010	306.0
2011	313.0
2012	289.9
2013	344.0
2014	303.0
2015	357.0

Year	Amount of synthetic fertilizer applied to soil [thousands tonnes/year]
2016	344.1
2017	381.3
2018	468.6
2019	455.9
2020	468.9
2021	538.6
2022	459.0
2023	463.6

Table 5.28 Activity data series used for calculation of F_{SEW}, for 1989–1990, 1995, 2000, 2005, 2007–2023 period (NIS)

Year	Annual amount of sewage sludge agriculturally applied [t]
1989	NO
1990	NO
1995	NO
2000	NO
2005	NO
2007	20000.04
2008	6000.24
2009	3000.96
2010	9000.63
2011	3000.01
2012	13000.48
2013	25000.05
2014	29000.52
2015	29000.24
2016	30000.8
2017	44000.01
2018	55000.69
2019	50000.85

Year	Annual amount of sewage sludge agriculturally applied [t]
2020	56000
2021	44740
2022	67000
2023	66406

Table 5.29 Total compost use in agriculture, tonne/year, tonne/year for 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Total compost use in agriculture, tonne/year
1989	NO
1990	NO
1995	NO
2000	NO
2005	NO
2007	NO
2008	NO
2009	NO
2010	NO
2011	NO
2012	NO
2013	NO
2014	7717.71
2015	16571.7
2016	22878.45
2017	38754.45
2018	29,245.05
2019	55,077.75
2020	62,901.90
2021	44,074.35
2022	45,338.40
2023	58,563.72

Data used for calculation of annual amount of nitrogen in crops residues (F_{CR})

Primary data for crop production of nitrogen fixing crop

In the calculation annual amount of nitrogen in crop residues **(F_{CR})** has been considered the primary data on Crop production of nitrogen fixing crop and non–N–fixing crop, total annual area harvested of crop and annual area of crop burnt. Primary data on Crop production of nitrogen fixing crop and non–N–fixing crop which has been obtained from the NIS through SY 1989–2023 and data base. Crop production of nitrogen fixing crop are presented in Table 5.30. Based on questionnaire and of the database from NIS *other perennial forage* was obtained decreasing from *total perennial forage* the sum of the values of *lucerne* and *clover*. Until 2003 NIS the data on crop production of *plant used silage* were collected in accordance with the Regulations, and the data were collected in accordance other Regulations according to the requirements EUROSTAT, renouncing at the name of this indicator, resulting the indicator *annual green fooder total* (the sum plant used silage with annual green fooder).

Table 5.30 The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Crop production of nitrogen fixing crop (tonnes/year)							
	Peas beans	Dry Bean	Total Leguminous for dry beans	Soy beans	Annual green fodder	Plant used for silage	Total Annual green fodder	Lucerne in equivalent green fodder
1989	98,500	143,600	255,900	303,900	9,705,200	6,096,600	15,801,800	11,131,700
1990	49,395	57,542	112,116	141,173	6,882,641	7,520,906	14,403,547	8,057,219
1995	54,262	41,769	97,017	107,861	4,127,358	1,892,078	6,019,436	7,081,202
2000	14,159	21,803	36,929	69,473	2,840,370	476,958	3,317,328	5,120,710
2005	39,096	41,733	80,913	312,781	IE	IE	2,454,958	6,274,555
2007	17,748	18,014	36,185	136,094	IE	IE	2,222,483	4,166,344
2008	36,917	25,157	62,466	90,579	IE	IE	2,860,655	5,505,795
2009	30,009	22,348	52,918	84,268	IE	IE	2,898,188	5,642,588
2010	39,677	21,059	61,344	149,940	IE	IE	3,041,978	5,799,305
2011	55,076	21,351	76,830	142,636	IE	IE	3,371,352	6,015,839
2012	45,878	16,603	62,934	104,330	IE	IE	3,043,519	4,836,406
2013	54,600	18,900	74,214	149,900	IE	IE	3,346,435	5,480,516
2014	51,000	19,700	71,400	202,900	IE	IE	3,389,600	6,071,232
2015	55,300	19,900	75,800	262,000	IE	IE	3,032,300	5,653,900

Year	Crop production of nitrogen fixing crop (tonnes/year)							
	Peas beans	Dry Bean	Total Leguminous for dry beans	Soy beans	Annual green fodder	Plant used for silage	Total Annual green fodder	Lucerne in equivalent green fodder
2016	78,808	19,087	99,312	263,380	IE	IE	2,715,401	5,505,202
2017	282,245	16,125	301,680	393,495	IE	IE	3,032,111	5,915,928
2018	172,512	17,298	191,475	465,609	IE	IE	3,467,000	6,971,521
2019	221,572	14,095	236,423	415,942	IE	IE	3,146,401	6,222,965
2020	110,133	11,252	121,679	334,209	IE	IE	2,719,016	5,626,682
2021	161,421	12,027	173,950	347,536	IE	IE	2,873,525	6,511,279
2022	110,600	7,400	118,800	244,325	IE	IE	2,282,500	5,701,700
2023	155,919	7,457	164,033	303,177	IE	IE	2,202,266	5,058,610

Table 5.30 (continued) The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year		Crop production of nitrogen fixing crop (tonnes/year)		
	Green maize for fodder	Clover in equivalent green fodder	Other perennial forage	Perennial forage
1989	3,957,700	2,937,100	3,988,200	18,057,000
1990	6,549,458	1,926,004	2,980,701	12,963,924
1995	1,771,757	2,367,015	2,761,694	12,209,911
2000	444,042	2,018,423	2,072,818	9,211,951
2005	520,686	1,601,385	2,251,574	10,127,514
2007	650,701	1,463,864	1,700,004	7,330,212
2008	775,934	1,751,484	2,016,050	9,273,329
2009	811,283	1,786,509	2,032,409	9,461,506
2010	862,467	1,949,735	2,224,993	9,974,033
2011	1,052,593	2,001,723	2,644,119	10,661,681
2012	930,149	1,598,254	2,047,590	8,482,250
2013	1,259,933	1,873,522	2,345,173	9,699,211
2014	1,351,545	1,888,412	2,534,297	10,493,941

Year	Crop production of nitrogen fixing crop (tonnes/year)			
	Green maize for fodder	Clover in equivalent green fodder	Other perennial forage	Perennial forage
2015	1,239,380	1,633,300	2,400,600	9,687,800
2016	1,205,025	1,521,715	2,328,189	9,355,106
2017	1,387,493	1,731,087	2,523,978	10,170,993
2018	1,467,664	1,841,763	2,834,993	11,648,277
2019	1,467,664	1,514,691	2,069,509	9,807,165
2020	1,163,818	1,462,204	1,752,512	8,841,398
2021	1,351,612	1,344,863	1,721,289	9,577,431
2022	996,231	1,106,000	1,423,800	8,231,500
2023	1,077,136	1,050,464	1,412,755	7,521,829

The data on Crop production of nitrogen fixing crop obtained through the dedicated study *„Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods.“*

In the context of the study above, by expert opinion using the primary data from the Table 5.30 (NIS) for the calculation F_{CR} are used the data on Crop production of nitrogen fixing crop presented in the Table 5.30. The values for pea beans, dry bean, soybeans, lucerne and clover were used in the primary data table (Table 5.31). The values for other leguminous for dry beans were obtained from the difference between total leguminous for dry beans and the sum of the values from pea beans and dry beans. In the context of the study above, by expert opinion were considered that the Annual leguminous were obtained by multiplying annual green fodder with 0.3. In the context of the study above, by expert opinion the values for other perennial leguminous represent 40% from other perennial forage.

Table 5.31 The data on Crop production of nitrogen fixing crop obtained through the dedicated study (tonnes/year), in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Crop production of nitrogen fixing crop (tonnes/year)							
	Peas beans	Dry Bean	Other leguminous for dry beans	Soy beans	Lucerne in equivalent green fodder	Clover in equivalent green fodder	Annual leguminous	Other perennial leguminous
1989	98,500	143,600	13,800	303,900	11,131,700	2,937,100	4,740,540	1,595,280
1990	49,395	57,542	5,179	141,173	8,057,219	1,926,004	4,321,064	1,192,280
1995	54,262	41,769	986	107,861	7,081,202	2,367,015	1,805,831	1,104,678
2000	14,159	21,803	967	69,473	5,120,710	2,018,423	995,198.4	829,127.2
2005	39,096	41,733	84	312,781	6,274,555	1,601,385	736,487.4	900,629.6
2007	17,748	18,014	423	136,094	4,166,344	1,463,864	666,744.9	680,001.6
2008	36,917	25,157	392	90,579	5,505,795	1,751,484	858,196.5	806,420
2009	30,009	22,348	561	84,268	5,642,588	1,786,509	869,456.4	812,963.6
2010	39,677	21,059	608	149,940	5,799,305	1,949,735	912,593.4	889,997.2
2011	55,076	21,351	403	142,636	6,015,839	2,001,723	1,011,406	1,057,648
2012	45,878	16,603	453	104,330	4,836,406	1,598,254	913,056	819,036
2013	54,600	18,900	714	149,900	5,480,516	1,873,522	1,003,930	938,069
2014	51,000	19,700	700	202,900	6,071,232	1,888,412	1,016,880	1,013,719
2015	55,300	19,900	600	262,000	5,653,900	1,633,300	909,690	960,240
2016	78,808	19,087	1,417	263,380	5,505,202	1,521,715	814,620	931,276
2017	282,245	16,125	3,310	393,495	5,915,928	1,731,087	909,633.30	1,009,591
2018	172,512	17,298	1,665	465,609	6,971,521	1,841,763	1,040,100	1,133,997
2019	221,572	14,095	756	415,942	6,222,965	1,514,691	943,920.30	827,804
2020	110,133	11,252	294	334,209	5,626,682	1,462,204	815,704.80	701,005
2021	161,421	12,027	502	347,536	6,511,279	1,344,863	862,057.50	688,516
2022	110,600	7,400	15,600	244,325	5,701,700	1,106,000	684,750.00	569,520
2023	155,919	7,457	657	303,177	5,058,610	1,050,464	660,679.80	565,102

Primary data for crop production of nitrogen non fixing crop

The primary data on Crop production of nitrogen non–N–fixing crop are provided by NIS through SY 1989–

2023 and data base are presented in Table 5.32.

Table 5.32 The primary data on Crop production of non – nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Productions of non–N–fixing crops (tonnes/year)							
	Rye	**Wheat**	**Barley and two-row barley**	**Oats**	**Maize grains**	**Sorghum**	**Rice**	**Total Cereal grains**
1989	0	0	3,436,300	167,800	6,761,800	7,600	70,100	18,379,300
1990	89,678	7,289,344	2,679,558	23,4025	6,809,604	3,500	66,460	17,173,539
1995	42,728	7,666,538	1,816,267	404,428	9,923,132	4,408	24,066	19,882,827
2000	21,802	4,434,438	867,018	243,830	4,897,603	1,479	3,551	10,477,506
2005	48,962	7,340,664	1,079,148	377,456	10,388,499	1,912	14,251	19,345,464
2007	20,583	3,044,465	531,420	251,633	3,853,918	1,193	27,518	7,814,825
2008	31,446	7,180,984	1,209,411	382,030	7,849,083	20,899	48,917	16,826,441
2009	32,959	5,202,526	1,182,062	295,832	7,973,258	14,440	72,418	14,872,952
2010	34,281	5,811,810	1,311,035	304,462	9,042,032	18,677	61,588	1,6712,883
2011	31,382	7,131,590	1,329,692	375,855	11,717,591	39,696	65,261	20,842,160
2012	18,236	5,297,748	986,361	338,998	5,953,352	37,481	50,862	12,824,138
2013	23,812	7,296,400	1,542,200	373,800	11,305,100	49,800	54,600	20,897,100
2014	24,400	7,584,800	1,712,500	381,600	11,988,600	51,500	45,200	22,070,700
2015	24,300	7,962,400	1,623,200	344,200	8,984,700	31,700	49,800	19,286,200
2016	25,931	8,431,131	1,817,269	381,359	10,746,387	24,413	43,635	21,764,816
2017	28,158	10,034,955	1,906,703	407,795	14,326,097	54,282	43,311	27,138,884
2018	28,636	10,143,671	1,870,710	383,722	18,663,939	76,309	43,355	31,553,279
2019	26,182	10,297,107	1,879,947	361,573	17,432,223	60,010	39,991	30,412,426
2020	28,487	6,754,534	1,154,521	196,659	10,942,348	35,399	24,958	19,374,048
2021	35,101	10,433,751	1,981,030	209,845	14,820,693	33,753	15,152	27,791,258
2022	34,900	8,684,200	1,706,650	171,600	8,037,100	14,800	17,100	18,860,670
2023	29,589	9,624,074	1,997,624	155,202	8,743,995	20,777	12,214	20,784,656

Table 5.32 (continued) The primary data on Crop production of non – nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Productions of non–N–fixing crops (tonnes/year)							
	Wheat and rye	Triticale	Rape	Sunflower	Flax for oil	Total Oilseed plants	Soy beans	In fiber-textile plants
1989	7,935,200	0	18,000	655,800	48,900	1,034,300	303,900	127,200
1990	7,379,022	0	10,860	556,242	28,040	739,319	141,173	53,192
1995	7,709,266	0	357	932,932	4,744	1,055,371	107,861	7,246
2000	4,456,240	7,431	76,126	720,871	994	868,531	69,473	881
2005	7,389,626	94,142	147,566	1,340,940	55	1,803,080	312,781	538
2007	3,065,048	81,768	361,500	546,922	394	1,046,558	136,094	72
2008	7,212,430	100,818	673,033	1,169,936	221	1,942,289	90,579	96
2009	5,235,485	97,251	569,611	1,098,047	1,099	1,764,047	84,268	0
2010	5,846,091	123,120	943,033	1,262,926	1,817	2,377,651	149,940	0
2011	7,162,972	144,800	738,971	1,789,326	2,626	2,686,860	142,636	0
2012	5,315,984	133,931	157,511	1,398,203	3,553	1,667,601	104,330	20
2013	7,320,212	245,027	666,100	2,142,100	4,046	2,966,621	149,900	36
2014	7,609,200	275,219	1,059,100	2,189,300	2,600	3,460,600	202,900	0
2015	7,986,700	262,143	919,500	1,785,800	3,600	2,975,200	262,000	241
2016	8,457,062	287,326	1,292,779	2,032,340	3,159	3,596,831	263,380	79
2017	10,063,113	331,567	1,673,327	2,912,743	3,619	4,986,458	393,495	0
2018	10,172,307	337,451	1,610,907	3,062,690	3,196	5,145,625	465,609	119
2019	10,323,289	313,998	798,215	3,569,150	6,197	4,792,420	415,942	0
2020	6,783,021	235,848	780,155	2,198,665	1,806	3,316,685	334,209	36
2021	10,468,852	259,207	1,375,067	2,843,531	3,355	4,574,041	347,536	134
2022	8,719,088	259,207	1,229,532	2,106,600	2,500	3,584,500	244,325	200
2023	9,653,663	197,118	1,789,667	2,015,621	2,887	4,114,946	303,177	487

Table 5.32 (continued) The primary data on Crop production of non– nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Productions of non–N–fixing crops (tonnes/year)								
Year	**Hemp for fiber-Plant textiles**	**Cotton**	**Tobacco**	**Hop**	**Medicinal aromatic plants/spices grown**	**Sorghum for brooms**	**Potatoes**	**Sugar beet**
1989	113,900	0	27,500	0	33,300	12,656	4,420,300	6,771,100
1990	72,105	484	14,168	2,451	20,459	6,505	3,185,624	3,277,705
1995	5,862	21	13,358	1,823	12,114	11,156	3,019,921	2,654,610
2000	1,398	0	10,869	142	1,397	6,300	3,469,805	666,870
2005	4,698	0	3,682	194	3,297	6,712	3,738,594	729,658
2007	479	0	1,128	374	2,857	5,437	3,712,410	748,839
2008	181	0	2,366	257	7,488	3,170	3,649,020	706,660
2009	2	0	1,566	245	7,063	6,006	4,003,980	816,814
2010	45	0	2,971	232	15,828	5,392	3,283,866	837,895
2011	9	0	2,562	117	11,157	7,288	4,076,570	660,497
2012	0	0	1,341	173	4,293	5,793	2,465,150	719,788
2013	31	0	1,357	172	4,397	6,191	3,289,722	1,029,209
2014	2,253	0	1,405	268	4,219	6,290	3,519,329	1,398,570
2015	1,900	0	1,100	224	4,200	11,600	2,625,000	1,040,600
2016	3,673	0	1,656	208	5,627	5,668	2,689,733	1,012,186
2017	2,610	0	1,219	124	4,079	6,179	2,667,453	1,174,502
2018	2,763	0	1,259	219	2,159	7,526	3,022,758	978,266
2019	3,161	0	1,214	218	1,947	4,724	2,626,788	917,163
2020	2,971	0	1,151	213	2,040	5,487	2,698,496	778,299
2021	2,767	0	971	208	3,313	5,639	1,397,835	783,534
2022	1,300	0	200	189	1,900	6,200	1,179,900	281,300
2023	1,160	0	494	184	3062	3,692	1,183,467	403,672

Table 5.32 (continued) The primary data on Crop production of non – nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Year	Productions of non–N–fixing crops (tonnes/year)							
	Fodder roots	Tomatoes	Eggplant	Dry onion	Dry garlic	Cabbage	Green peppers	Cultivated mushrooms
1989	4,094,200	1,011,300	0	412,700	46,600	877,300	253,300	0
1990	2,575,013	813,561	51,951	225,440	30,611	551,914	182,033	0
1995	1,332,449	730,945	88,506	362,969	69,476	824,412	195,648	600
2000	800,587	628,675	94,823	296,297	68,338	731,897	174,836	3
2005	711,939	626,960	97,902	363,625	68,374	1,009,430	203,751	563
2007	594,956	640,785	63,716	324,993	49,948	893,153	184,939	1,083
2008	756,292	814,376	153,677	395,579	72,333	964,625	238,682	1,664
2009	567,499	755,596	168,588	378,106	63,245	1,001,940	245,661	7,317
2010	489,740	768,532	144,391	369,142	67,215	981,219	243,493	9,973
2011	555,341	910,978	160,010	394,305	66,602	1,025,293	253,505	7,661
2012	335,497	683,282	126,005	345,340	59,368	987,900	207,072	9,311
2013	417,182	749,128	123,278	391,837	62,156	1,156,436	227,690	8,785
2014	417,612	706,200	127,578	386,989	62,773	1,123,132	228,576	9,758
2015	393,800	695,200	126,755	353,600	62,400	1,066,300	222,400	10,955
2016	335,811	627,177	116,225	325,074	54,389	992,398	201,881	14,519
2017	292,390	679,807	127,763	352,165	55,673	1,026,575	226,459	15,168
2018	284,126	742,899	137,829	350,159	57,975	1,065,537	229,662	15,511
2019	254,072	689,401	129,013	340,635	54,862	985,842	223,326	13,872
2020	221,624	698,424	123,153	326,740	57,164	973,667	207,395	14,316
2021	150,883	753,377	143,490	357,213	60,601	919,961	248,735	14,493
2022	60,900	509,500	105,672	263,100	50,200	689,700	182,900	14,734
2023	54,956	474,182	103,717	253,072	45,801	643,316	179,659	16,189

Table 5.32 (continued) The primary data on Crop production of non– nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989–1990, 1995, 2000, 2005, 2007–2023 period

Years	Productions of non–N–fixing crops (tonnes/year)						
	Root vegetables – Edible roots	Water melons and melons	Total vegetables	Annual green fodder	Plant used for silage	Annual green fodder new	Total Perennial forage
1989	251,900	215,700	4,195,600	9,705,200	6,096,600	15,801,800	18,057,000
1990	158,554	381,585	3,051,200	6,882,641	7,520,906	14,403,547	12,963,924
1995	281,339	639,352	3,868,500	4,127,358	1,892,078	6,019,436	12,209,911
2000	253,853	531,127	3,381,100	2,840,370	476,958	3,317,328	9,211,951
2005	229,569	691,760	3,624,612	IE	IE	2,454,958	10,127,514
2007	209,029	407,973	3,116,801	IE	IE	2,222,483	7,330,212
2008	265,999	562,260	3,819,890	IE	IE	2,860,655	9,273,329
2009	238,748	652,844	3,901,862	IE	IE	2,898,188	9,461,506
2010	241,578	662,863	3,863,617	IE	IE	3,041,978	9,974,033
2011	275,145	645,486	4,176,298	IE	IE	3,371,352	10,661,681
2012	275,145	554,588	3,535,316	IE	IE	3,043,519	8,482,250
2013	242,265	634,786	3,960,990	IE	IE	3,346,435	9,699,211
2014	251,589	530,677	3,802,494	IE	IE	3,389,600	10,493,941
2015	227,004	506,000	3,629,600	IE	IE	3,032,300	9,687,800
2016	219,232	477,556	3,358,389	IE	IE	2,715,401	9,355,106
2017	217,874	553,515	3,638,447	IE	IE	3,032,111	10,170,993
2018	232,836	583,875	3,797,436	IE	IE	3,467,000	11,648,277
2019	206,775	518,944	3,529,648	IE	IE	3,146,401	9,807,165
2020	208,130	512,302	3,482,943	IE	IE	2,719,016	8,841,398
2021	220,005	382,202	3,495,105	IE	IE	2,873,525	9,577,431
2022	166,756	178,355	2,426,100	IE	IE	2,282,500	8,231,500
2023	160,714	179,107	2,313,038	IE	IE	2,202,266	7,521,829

The data on Crop production of non – nitrogen fixing crop obtained through the dedicated study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“. In the context of the study above, by expert opinion using the primary data from the Table 5.32 (NIS) were considered the data on Crop production of non – nitrogen fixing crop presented in the Annex V.5.1 – sheet Crop production of non N fixing. For the 1989 period the value of production of by rye, wheat, cotton, hop has made an extrapolation with reference year 1990. The data on Crop production of nitrogen fixing crop were considered the presented in the Table 5.32. The crop production values from the these plants (rye, wheat, barley and two–row barley, oats, maize, sorghum, rice, rape, sunflower, flax for oil, in fiber– textile plants, hemp for fiber – plant textiles, tobacco, hop, medicinal aromatic plants/spices grown, potatoes, sugar beet, fodder roots, tomatoes, eggplant, dry onion, dry garlic, cabbage, green peppers, cultivated mushrooms, root vegetables – edible roots, water melons and melons) were used from the primary data table (Table 5.32).

By expert opinion, the values for other grains were obtained from the difference between total cereal grains and the sum wheat and rye, barley and two-row barley, oats, maize, sorghum, rice and triticale. The values for other oilseed plants (castor) were obtained from the difference between total oilseed plants and the sum rape, sunflower, flax for oil and soya beans. By expert opinion, the values of *other textile plants* were taken from *castor*. In the context of the study above, by expert opinion were taken from *sorghum for brooms*. The values for *other vegetable* were obtained from the difference between *total vegetables* and the sum *tomatoes, eggplant, dry onion, dry garlic, cabbage, green peppers, cultivated mushrooms, root vegetables – edible roots, water melons and melons.* In the context of the study above, by expert opinion, were considered that the *annual green fodder new* the values of *annual grasses* represent 70%.

The productions of *annual green fodder new* were obtained from the of sum *annual green fodder* and *plant used for silage*. In the context of the study above, by expert opinion, were considered that the *other perennial forage* the values of *other perennial grasses* represent 60%. The values for *other perennial forage* were obtained from the difference between *total perennial forage* and the sum *the lucerne in equivalent green fodder* and *clover in equivalent green fodder.* The values associated the nitrogen fixing crop used in the calculation $\mathbf{F_{CR}}$ are presented in the Table 5.33. In the 2012 year the production for all plants decreased compared with the 2011 year. *Above-ground residues dry matter* ***(AG_{DM})*** *has calculated with the formula in Table 11.2 in IPCC 2006, pg.11.17 using the default value for* ***$AG_{DMslope}$*** *and* ***AG_{DM}intercept*** in the same table *and for the N content of above-ground residues for crop* **(N_{AG})**, *N content of below-ground residues for crop* **(N_{BG})** and *ratio of below-ground residues above-ground biomass* ***(R_{BG-BIO})***, dry matter has fraction **($Frac_{DM}$)** used the default value in Table 11.2 (IPCC 2006). Data on **Area crops** (ha) and **Area burnt** were presented in Anexe V.5.1. Area burnt was calculated by expert opinion so:

- was estimated percent of area crops divided area crops cereals to total area crops cereals multiplied with 100;

- area burnt was estimed dividing the percent of area crop cereals to 100 and multiplied with total area of cereals;
- total area of cereals was estimated divided the data from Food and Agriculture Organization of the United Nations (FAO) on amount biomass burned to the data from National Institute of Statistics (NIS) on average production.

Table 5.33 The values associated the nitrogen fixing crop used in the calculation F_{CR} (AG_{DM} slope, AG_{DM} intercept, R_{BG-BIO}, N_{AG}, N_{BG}, $Frac_{Remove}$, $Frac_{DM}$, $Frac_{RENEW}$), in the 1989–2023 period

Parameters	The values associated the nitrogen fixing crop in the calculation F_{CR}								
	Peas beans	Dry Bean	Other leguminous for dry beans	Soy beans	Lucerne in equivalent green fodder	Clover in equivalent green fodder	Annual leguminous	Other perennial leguminous	Green maize for fodder
AG_{DM} slope	1.13	1.13	1.13	0.93	0.29	0.3	1.13	0.3	1.03
AG_{DM} intercept	0.85	0.85	0.85	1.35	0	0	0.85	0	0.61
R_{BG-BIO} (kg d. m.)	0.19	0.19	0.19	0.19	0.4	0.8	0.4	0.4	0.22
N_{AG} (kg d.m.)	0.008	0.01	0.008	0.008	0.027	0.025	0.027	0.027	0.006
N_{BG}	0.008	0.008	0.008	0.008	0.019	0.016	0.022	0.022	0.007
$Frac_{Remove}$	0	0	0	0	1	1	1	1	1
$Frac_{DM}$	0.91	0.91	0.91	0.91	0.90	0.90	0.90	0.90	0.3
$Frac_{RENEW}$	1	1	1	1	0.2	0.5	1	0.5	1

In the Table 5.34 are presented the values associated the nitrogen non fixing crop used in the calculation **F_{CR}**.

Table 5.34 The values associated the nitrogen non fixing crop used in the calculation F_{CR} (AG_{DM} slope, AG_{DM} intercept, R_{BG-BIO}, N_{AG}, N_{BG}, $Frac_{Remove}$, $Frac_{DM}$, $Frac_{RENEW}$), in the 1989–2023 period

Parameters	*The values associated the nitrogen non fixing crop in the calculation F_{CR}*							
	Rye	**Wheat**	**Barley and two-row barley**	**Oats**	**Maize grains**	**Sorghum**	**Rice**	**Other cereals**
AG_{DM} slope	1.09	1.09	0.98	0.91	1.03	0.88	0.95	1.43
AG_{DM} intercept	0.88	0.88	0.59	0.89	0.61	1.33	2.46	0.14
R_{BG-BIO} (kg d. m.)	0.22	0.22	0.22	0.25	0.22	0.22	0.16	0.22
N_{AG} (kg d.m.)	0.005	0.006	0.007	0.007	0.006	0.007	0.007	0.007
N_{BG}	0.011	0.009	0.014	0.008	0.007	0.006	0.009	0.009
$Frac_{Remove}$	0	0.025	0.025	0	0	0.10	0	0
$Frac_{DM}$	0.88	0.88	0.89	0.89	0.87	0.89	0.89	0.9
$Frac_{RENEW}$	1	1	1	1	1	1	1	1

Table 5.34 (continued) The values associated the nitrogen non fixing crop used in the calculation F_{CR} (AG_{DM} slope, AG_{DM} intercept, R_{BG-BIO}, N_{AG}, N_{BG}, $Frac_{Remove}$, $Frac_{DM}$, $Frac_{RENEW}$), in the 1989–2023 period

Parameters	*The values associated the nitrogen non fixing crop in the calculation F_{CR}*							
	Rape	**Sunflower**	**Flax for oil**	**Other oilseed plants castor**	**In fiber-textile plants**	**Hemp for fiber-Plant textiles**	**Other textile plants-cotton**	**Tobacco**
AG_{DM} slope	0.93	0.93	0.93	0.93	1.07	1.07	1.07	1.07
AG_{DM} intercept	1.35	1.35	1.35	1.35	1.54	1.54	1.54	1.54
R_{BG-BIO} (kg d. m.)	0.19	0.19	0.19	0.19	0.2	0.2	0.2	0.2
N_{AG} (kg d.m.)	0.008	0.008	0.008	0.008	0.016	0.016	0.016	0.016
N_{BG}	0.008	0.008	0.008	0.008	0.014	0.014	0.014	0.014
$Frac_{Remove}$	0.10	0.10	0	0	0.30	0.30	0.10	0
$Frac_{DM}$	0.91	0.91	0.91	0.91	0.94	0.85	0.85	0.85
$Frac_{RENEW}$	1	1	1	1	1	1	1	1

Table 5.34 (continued) The values associated the nitrogen non fixing crop used in the calculation F_{CR} (AG_{DM} slope, AG_{DM} intercept, R_{BG-BIO}, N_{AG}, N_{BG}, $Frac_{Remove}$, $Frac_{DM}$, $Frac_{RENEW}$), in the 1989–2023 period

Parameters	The values associated the nitrogen non fixing crop in the calculation F_{CR}								
	Hop	Medicinal aromatic plants/spices grown	Other industrial crops-sorghum for brooms	Potatoes	Sugar beet	Fodder roots	Tomatoes	Eggplant	Dry onion
AG_{DM} slope	1.07	1.07	1.09	0.1	1.07	1.07	0.1	0.1	1.07
AG_{DM} intercept	1.54	1.54	0.88	1.06	1.54	1.54	1.06	1.06	1.54
R_{BG-BIO} (kg d. m.)	0.2	0.2	0.22	0.2	0.2	0.2	0.2	0.2	0.2
N_{AG} (kg d.m.)	0.016	0.016	0.006	0.019	0.016	0.016	0.019	0.019	0.016
N_{BG}	0.014	0.014	0.009	0.014	0.014	0.014	0.014	0.014	0.014
$Frac_{Remove}$	0	0	0.10	0	0	0	0	0	0
$Frac_{DM}$	0.85	0.85	0.88	0.22	0.94	0.94	0.85	0.22	0.94
$Frac_{RENEW}$	1	1	1	1	1	1	1	1	1

Table 5.34 (continued) The values associated the nitrogen non fixing crop used in the calculation F_{CR} (AG_{DM} slope, AG_{DM} intercept, R_{BG-BIO}, N_{AG}, N_{BG}, $Frac_{Remove}$, $Frac_{DM}$, $Frac_{RENEW}$), in the 1989–2023 period

Parameters	The values associated the nitrogen non fixing crop in the calculation F_{CR}								
	Dry garlic	Cabbage	Green peppers	Cultivated mushrooms	Root vegetables –Edible roots	Water melons and melons	Other vegetables	Annual grasses	Other perennial grasses
AG_{DM} slope	1.07	1.07	0.1	0	1.07	1.07	0.1	0.3	0.3
AG_{DM} intercept	1.54	1.54	1.06	0	1.54	1.54	1.06	0	0

Parameters	*The values associated the nitrogen non fixing crop in the calculation F_{CR}*								
	Dry garlic	**Cabbage**	**Green peppers**	**Cultivated mushrooms**	**Root vegetables –Edible roots**	**Water melons and melons**	**Other vegetables**	**Annual grasses**	**Other perennial grasses**
R_{BG-BIO} (kg d. m.)	0.2	0.2	0.2	0	0.2	0.2	0.2	0.8	0.8
N_{AG} (kg d.m.)	0.016	0.016	0.019	0	0.016	0.016	0.019	0.015	0.015
N_{BG}	0.014	0.014	0.014	0	0.014	0.014	0.014	0.012	0.012
$Frac_{Remove}$	0	0	0	0	0	0	0	0	0
$Frac_{DM}$	0.94	0.94	0.22	0.85	0.94	0.94	0.22	0.90	0.90
$Frac_{RENEW}$	1	1	1	1	1	1	1	1	0.5

Combustion factor (C_f)

The value for combustion factor **(C_f)** for following plants wheat, rice, maize was used in Volume 4, Chapter 2, table 2.6, pg.2.49. Combustion factor for *rye, barley and two–row barley* have been taken at wheat, for *oats, other cereals* have been taken from *rice* and for other remaining plants have been taken from *sugarcane*.

$Frac_{Remove}$

In the context implementing of the study, by expert opinion „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*“ was estimated *for $Frac_{Remove}$* (fraction construction and feed) for the 1989–2023 period the national values for some plants: *wheat, oats, maize, peas beans, dry bean, other leguminous for dry beans, rape, sunflower, flax for oil, in fiber-textile plants, hemp for fiber-plant textiles, other textile plants-cotton, other industrial crop, sugar beet, root vegetables*.

$Frac_{DM}$

Were used the default values from the Table 11.2 (IPCC 2006) and the national values based on data presented in national bibliography.

$Frac_{Renew}$

By expert opinion, fraction of total area under crop thatis renewed annually was considered for the annual plants the value 1 and for lucerne was divided 1 to 5 year and for clover, other perennial grasses and other perennial leguminous 1 to 2 year.

Data used for calculation of nitrogen mineralized in mineral soils as a results of loss of soil C throught

chance in land use or management (F_{SOM})

In Romania activity data on nitrogen mineralized in mineral soils as a results of loss of soil C throught chance in land use or management not there is.

<u>Area of organic soils cultivated</u>

Area of organic soils cultivated is 4662.27 ha for all period 1989–2023. The methodologie used in the determination this value is described in the LULUCF sector, the subsection 6.3.

Annual direct N_2O emissions from urine and dung inputs to grazed soils

Annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock and by grazing animals (FracPRP)

Methodology

A Tier 1 method has been applied using equation 11.5 from IPCC 2006.

Emissions factors

It was used default emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals from table 11.1 in IPCC 2006.

Activity data

For the calculating **($Frac_{PRP}$)** were used the same livestock population numbers as for calculation of CH_4 emissions from enteric fermentation and annual average N excretion per head and fraction of total annual N excretion for ech livestock as for calculation of N_2O emissions from manure management. Data are presented in Chapter 5.2.2. and 5.3.2.

<u>Indirect N_2O emissions from Managed soils</u> ***(3D2)***

Description of sources of indirect emissions in GHG inventory

Emissions of N_2O also take place through two indirect pathways:

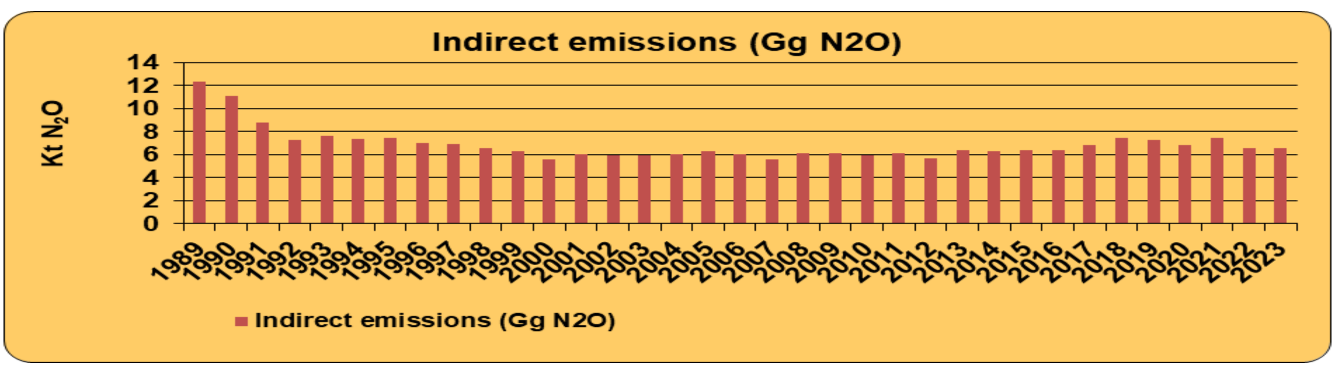
- The first of these pathways is the volatilisation of N as NH_3 and oxides of N (NOx), and the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters. The sources of N as NH_3 and NOx are not confined to agricultural fertilisers and manures, but also include fossil fuel combustion, biomass burning, and processes in the chemical industry. Thus, these processes cause N_2O emissions in an exactly analogous way to those resulting from deposition of agriculturally derived NH_3 and NOx, following the application of synthetic and organic N fertilisers and/or urine and dung deposition from grazing animals.
- The second pathway is the leaching and runoff from land of N from synthetic and organic fertiliser additions, crop residues, mineralisation of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, and urine and dung deposition from grazing animals.

Microbial processes of nitrification and denitrification in agricultural soils produce indirect nitrous oxide emissions. Indirect soils emissions result from the following nitrogen input to soils:

- synthetic fertilizers (F_{SN});
- organic N applied as fertilizer (F_{ON})
- urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP});
- N in crop residues (F_{CR});
- N mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soil (F_{SOM});
- drainage/management of organic soils (F_{OS}).

- in 2023, N_2O Indirect soil emissions represented 21.12 % of total N_2O emissions in the Agriculture sector;
- N_2O Indirect soil emissions as CO_2 equivalent in 2023 represented 9.74 % from Total Agriculture emissions;
- contributed with 1.67 % to Total GHG emissions of Romania.

Figure 5.9 Indirect N_2O emissions trends – Agricultural Soils



Methodological issues

Methodology

Despite the fact that Indirect soil emissions is a key category, from level view, Tier 2 method could not be applied, due to the lack of detailed data needed. Therefore, a Tier 1 method has been applied. For calculation of indirect nitrous oxide soil emissions, the equation 11.9 and 11.10 from IPCC 2006 were used.

Emission factors

The calculation methodology took into account IPCC 2006 default emissions factors (Table 11.3 from IPCC 2006):

- EF_4 = 0.010 [kg N_2O-N/kg NH_3-N and NO_x-N volatilised];
- EF_5 = 0.0075 (kg N_2O-N/kg N leaching/runoff)$^{-1}$ [23]

Activity data

For the $Frac_{GASF}$ fraction was used the 0.1 value, $Frac_{GASM}$ was used 0.2 and $Frac_{LEACH-(H)}$ from the Table 11.3 (IPCC 2006). The all activity data are presented in the relevant Direct soil emissions section and Chapter 5.3.2.

5.5.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

5.5.4 Uncertainty assessment and time-series consistency

Direct soil emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 20 %;
- EF: 300%;
- 300.67% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

Due to the fact that most of activity data are provided by NIS or FAO and the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*" were obtained using the same method (the use of two methods for obtaining the livestock data is ensuring the consistency of data series considering the national circumstances; the use of both national and default values associated to amount of nitrogen in crop residues (kg N/year) (F_{CR}); detailed information is provided in Section 5.2.2 and 5.5.2, default emission factors were used using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

Indirect soil emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 20 %;
- EF: 300%;
- 300.67% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation in Chapter 3, Volume 1 of the IPCC 2006.

Due to the fact that all activity data are provided by NIS, FAO, MADR or ICPA and the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“,* default emission factors were used using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

5.5.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Waste sector*, the results of these being mentioned on the Checklists level.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No unconformity has been noted following the UNFCCC review of the NGHGI.

The activity data series were also compared to those on FAO and Eurostat, the data being reported at the same level of aggregation and the figures comparable. Further elements are presented within Annex V.13.

5.5.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made

5.5.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

Direct N_2O emissions

Aiming to their incorporation into next inventory submissions, the development of national values for the following parameters:

- national values for activity data in totality;
- national emission factors

Indirect N_2O emissions

Aiming to their incorporation into next inventory submissions, the development of national values for the following parameters, parameters relevant to significant species, are envisaged:

- ❖ fraction that volatilizes as NH_3 and NO_x, specific to synthetic fertilizers nitrogen adjusted for volatilization ($Frac_{GASF}$);
- ❖ fraction that volatilizes as NH_3 and NO_x, specific to animal manure nitrogen used as fertilizer, adjusted for volatilization ($Frac_{GASM}$);
- ❖ national values for activity data in totality;
- ❖ fraction of N input that is last through leaching and runoff ($Frac_{LEACH}$).

5.6 Prescribed Burning of Savannas (CRT 3.E)

Prescribed Burning of Savannas does not occur in Romania.

5.7 Field Burning of Agricultural Residues (CRT 3.F)

5.7.1 Category description

Burning of agricultural crop residues is a significant source of emissions of methane, carbon monoxide, nitrous oxide and nitrogen oxides. However, the burning of crop residues is not thought to be a net source of carbon dioxide because the carbon released to the atmosphere is reabsorbed during the next growing season. Considering legislation which prohibits the burning of crop, were concluded that this the activity happening on a small scale, in the case of crop production (the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*". Emissions from field burning of agricultural residues in 2023 are lower than emissions in 1989 with 25.19%, due to the lower agricultural yields.

Figure 5.10 Cumulative emissions trend – Field Burning of Agricultural Residues

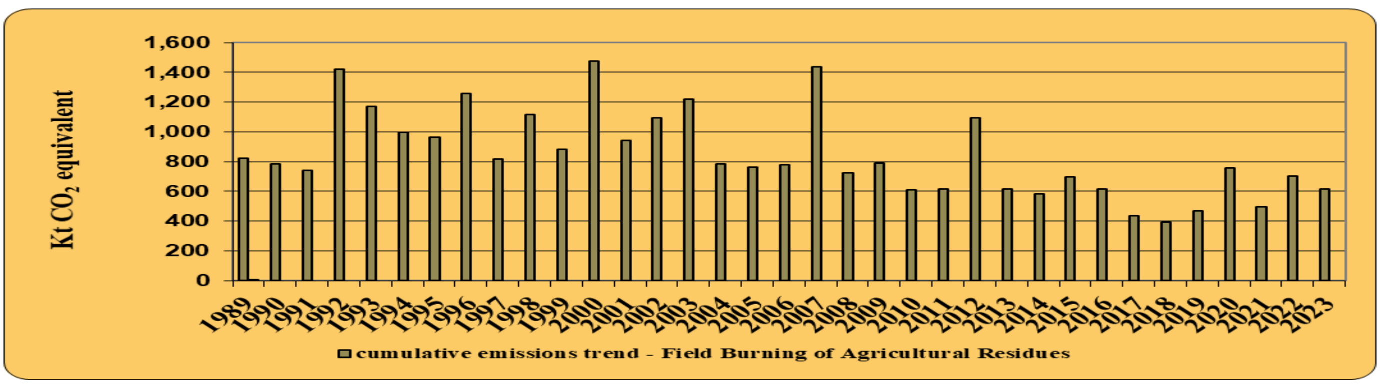


Table 5.35 Observations on source category 3F – "Field Burning of Agricultural Residues"

Source indicative	Source (livestock) type	Observation	Data source
3.F	Crop productions	Includes data on 6 types of crops productions: rye, wheat, barley and two-row barley, maize grains, sorghum, other cereals	AD: SY, other correspondence NIS, 1989–2023; the study „*Elaboration of national emission factors/ other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the*

Source indicative	Source (livestock) type	Observation	Data source
			higher tier calculation methods“. EF: IPCC 2006.

5.7.2 Methodological issues

Methodology

Due to the fact that CH_4 and N_2O emissions from field burning of agricultural residues are not key categories, neither from level nor from trend views, a Tier 1 method has been applied. For calculation of methane and nitrogen oxides emissions, the equation on page 2.42 of IPCC 2006, Volume 4, Chapter 2, was used.

Emission factors

According to the provisions in IPCC 2006 was used default emission factors for various of burning in table 2.5, pg.2.47, Volume 4, Chapter 2. Was used default combustion factor from IPCC 2006, table 2.6, Volume 4, Chapter 2. of 0.9 for rye, wheat and 0.8 for barley and two-row barley, maize grains, sorghum, other cereals.

Table 5.36 Default emission ratios for agricultural residue burning of residues calculations

Gas	Default IPCC 1996 emission ratios
Methane (CH_4)	2.7
Nitrous oxide (N_2O)	0.07

Activity data

Data on Area burnt described in Chapter 5.5.2.

The data on total biomass burned (kt dm) is calculated so: area burned multiplied mass of fuel available for combustion (from IPCC 2006, table 2.4) using equation 2.27 from IPCC 2006.

5.7.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG’s do not apply for Romania.

5.7.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 20 %;
- EF: 50%;
- 53.85% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10.

N_2O emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 20 %;
- EF: 50%;
- 53.85% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. Due to the fact that most of activity data are provided by NIS and the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*“ were obtained using the same method, is ensuring the consistency of data series considering the national circumstances (detailed information is provided in Section 5.5.2), default emission factors were used using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

5.7.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Waste sector*, the results of these being mentioned on the Checklists level.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the

Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No unconformity has been noted following the UNFCCC review of the NGHGI.

The activity data series were also compared to those on FAO and Eurostat, the data being reported at the same level of aggregation and the figures comparable.

Further elements are presented within Annex V.13.

5.7.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made.

5.7.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

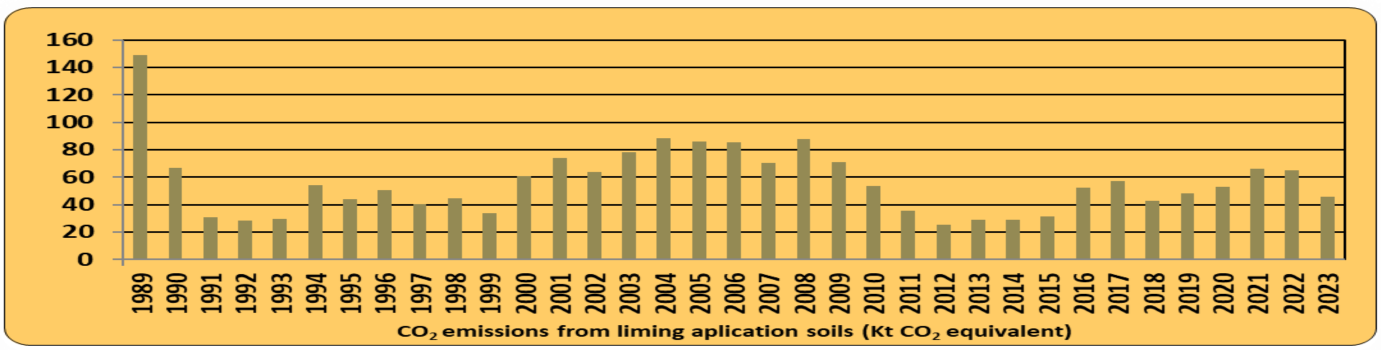
Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality, for to significant species, is envisaged.

5.8 Liming (CRT 3G)

5.8.1 Category description

Liming is used to reduce soil acidity and improve plant growth in managed systems, partilulary agricultural lands and managed forests. Adding carbonates to soils in the form of lime (calcil limestone $CaCO_3$ or dolomite $CaMg(CO_3)_2$ leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3$), which evolves into CO_2 and water (H_2O). The emissions decreasing until 1993 then begin to fluctuate in according with the decreasing and increasing of annual amount of calcic limestone $CaCO_3$.

Figure 5.11 CO_2 emissions from liming application soils



5.8.2 Methodological issues

Methodology

Was apllied the method of tier 1 applying the equation 11.12 from IPCC 2006, pg.11.27.

Emission factor

Were used default emissions factors from IPCC 2006 of 0.12 for limestone and 0.13 for dolomite.

Activity data

Annual amount of calcic limestone or dolomite have been provided by Ministry of Agriculture and Rural Development.

5.8.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

5.8.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 25 %;
- EF: 40 %;

Uncertainties were taken from IPCC 2006.

- 47.17 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

5.8.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Waste sector*, the results of these being mentioned on the Checklists level. No unconformity has been noted following the UNFCCC review of the NGHGI.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

5.8.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations/recalculations/several recalculations/improvements were implemented following the QA activities mentioned in the previous two paragraphs.

5.8.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

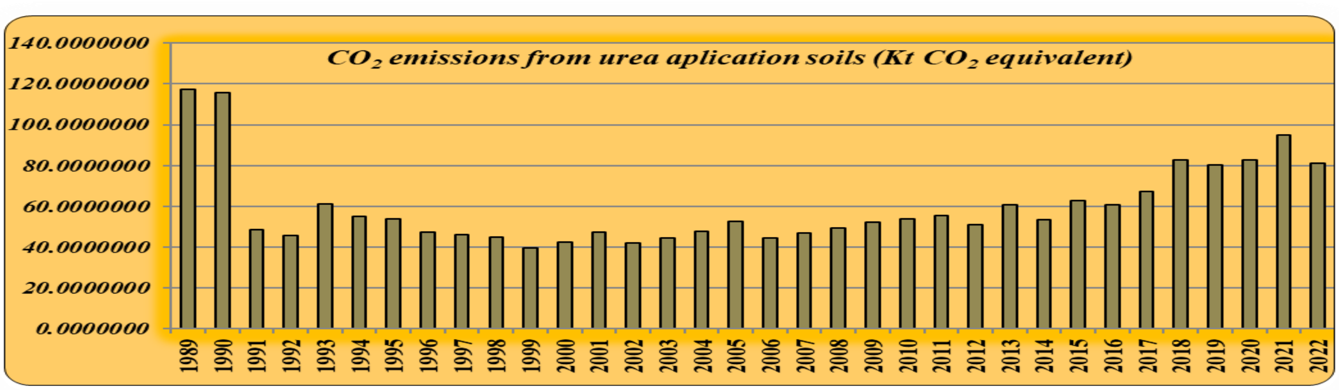
Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality.

5.9 Urea fertilization (CRT 3H)

5.9.1 Category description

Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. Urea is converted into ammonium (NH_4), hydroxyl in and bicarbonate that is formed evolves into CO_2 and water. This source is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector). The emissions were decreased until 1992 then begin to fluctuate in according with the decreasing and increasing of annual amount of urea fertilisation.

Figure 5.12 CO_2 emissions from Urea fertilization



5.9.2 Methodological issues

Methodology

Was apllied the method of Tier 1 applying the equation 11.13 from IPCC 2006, pg.11.32.

Emission factor

Was used default emissions factor of 0.20 from IPCC 2006.

Activity data

Annual amount of urea fertilization

Was estimated by the expert opinion as 11.06% of annual amount of synthetic fertilizer N applied to soils presented in Chapter 5.5.2. Annual amount of urea fertilization divided by 0.46 being the percentage of N in uree.

5.9.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

5.9.4 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 25 %;
- EF: 40 %;
- 47.17 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

5.9.5 Category–specific QA/QC and verification, if aplicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Waste sector*, the results of these being mentioned on the Checklists level. No unconformity has been noted following the UNFCCC review of the NGHGI.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the

Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

5.9.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations/recalculations/several recalculations/improvements were implemented following the QA activities mentioned in the previous two paragraphs.

5.9.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality.

6 Land use, land-use change and forestry (CRT sector 4)

6.1 Overview of the sector and background information

The LULUCF sector is integral to mitigating climate change and achieving the European Union's climate goals for 2030 and beyond. As part of the Fit for 55 package, the European Commission has proposed key revisions to the regulation governing GHG E/R in this sector.

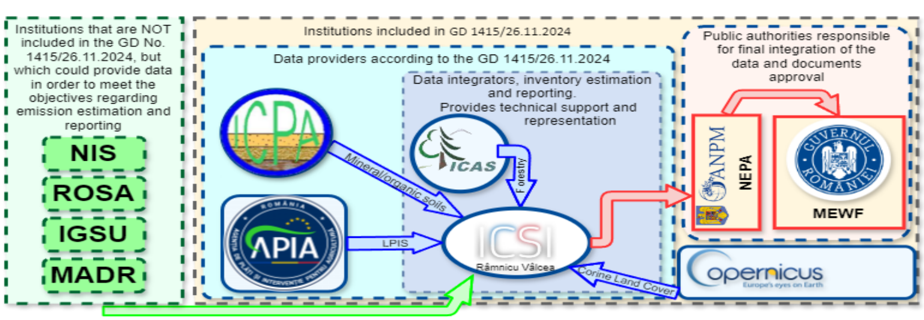
Enhanced EU Climate Ambition: The Commission's proposal aims to strengthen the LULUCF sector's contribution by establishing an EU-wide target of 310 million tons of CO_2 equivalent in net GHG removals by 2030. These targets align with the EU's broader climate objectives and support emissions reduction efforts while fostering biodiversity conservation.

Integration of Sectors for Climate Neutrality: From 2031 onward, the EU intends to merge non-CO_2 emissions from agriculture with the LULUCF sector into a unified pillar known as AFOLU (Agriculture, Forestry, and Other Land Use). This integrated approach is designed to achieve climate neutrality in the AFOLU sector by 2035, streamlining mitigation strategies across land use sectors.

Romania's Commitments and Vision: Through its Recovery and Resilience Program, Romania seeks to address the socioeconomic impacts of climate change while advancing sustainable development. By prioritizing green and digital transitions, Romania aims to foster a resilient, adaptive economy and society that aligns with EU climate and biodiversity goals.

Synergies with Biodiversity Goals: The revised regulatory framework will ensure that land use and forestry not only contribute fully to emissions reduction targets but also enhance biodiversity. This dual focus is vital for achieving long-term sustainability.

Figure 6.1 Romania's LULUCF data flow



In alignment with the objectives of the EU, the European Commission (EC), and UNFCCC, the Government of Romania adopted Government Decision (GD) No. 1415/2024, published in the Official Monitor No. 1176 on November 26, 2024. This decision establishes the legal, institutional, and procedural framework for managing the LULUCF subdomain as an integral component of the NGHGI. Consequently, it is mandatory to monitor, estimate, and report GHG E/R generated by specific activities under this subdomain to the EC, the EEA, and the UNFCCC Secretariat according to pre-established deadlines. The data flow process for activities conducted under GD No. 1415/2024 is illustrated in Figure 6.1. The figure also highlights, on its right side, the roles of the NEPA and the MEWF as the public authorities responsible for final data QA/QC, data aggregation, and document approval. The NID for the LULUCF sector covers all CO_2 E/R associated with gains and losses in the relevant carbon pools across six predefined land-use categories. It also includes non-CO_2 emissions from biomass burning and disturbances related to land-use conversions and changes in management practices. Notably, several factors used in estimating GHGs are based on default values recommended by the IPCC Guidelines. Where feasible, these values have been adjusted based on country-specific analysis to enhance reporting accuracy.

The primary objectives of the NID include improving the precision of reporting, ensuring high-quality data, and maintaining consistency in methodologies for estimating GHG E/R. In preparing the NID, Romania adhered to the TACCC principles as defined in the 2006 IPCC Guidelines. Table 6.1 provides the general definition of these principles and demonstrates how Romania has implemented them effectively.

Table 6.1 TACCC principles and their consideration in Romania´s LULUCF inventory

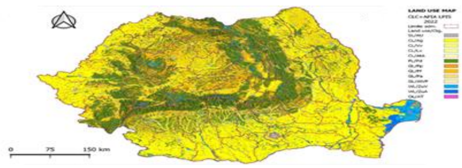
Transparency	
There is sufficient and clear documentation such that individuals or groups, other than the inventory compilers, can understand how the inventory was compiled and can assure themselves it meets the good practice requirements for national greenhouse gas emissions inventories.	*Transparency of data/ information, respectively, traceability of data/information,* *(a) do I know what will I use?;* *(b) what will I use?* *(c) where do I get my data/information from?* *(d) where will I use them?*
Completeness	
Estimates are reported for all relevant categories of sources and sinks, and gases. Geographic areas within the scope of the National Inventory Report are recommended in these Guidelines. Where elements are missing their absence should be clearly documented together with a justification for exclusion.	*Comprehensive GHG E/R estimates were conducted for all land-use categories, covering emissions of CO_2, CH_4, and N_2O.*
Consistency	

Estimates for different inventory years, gases and categories are made in such a way that differences in the results between years and categories reflect real differences in emissions. Inventory annual trends, as far as possible, should be calculated using the same method and data sources in all years and should aim to reflect the real annual fluctuations in emissions or removals and not be subject to changes resulting from methodological differences.	*To ensure consistency, the NID incorporates new data and methods for the 1989–2023 time period using a hybrid approach that combines mathematical modeling with explicit geospatial information.*
Comparability	
The national greenhouse gas inventory is reported in a way that allows it to be compared with national greenhouse gas inventories of other countries. This comparability should be reflected in appropriate choice of key categories, and in the use of the reporting guidance and tables and use of the classification and definition of categories of emissions and removals in 2006 IPCC.	*Reporting focuses on correctly identifying and prioritizing resources, respectively the LULUCF key land use are: FL, CL, GL, while also ensuring that data and information for WL, SL, and OL, are not neglected.*
Accuracy	
The national greenhouse gas inventory contains neither over- nor under-estimates so far as can be judged. This means making all endeavours to remove bias from the inventory estimates.	*accuracy of data using explicit geospatial data/information – technologies and formats: LPIS/IACS; CLC [reference year 1990, 2000, 2006, 2012, 2018]; ArcGIS and QGIS; LiDAR and aero-photogrammetry*
The entire territory of Romania is covered in the NID report, adhering to all specific criteria, including the TACCC principles. This ensures a comprehensive representation and characterization of all land use categories at the national level. The land use categories for Romania's entire territory, dating back to 1989, are based on officially reported statistical data that is updated annually. For Romania, GHG E/R estimates in the LULUCF sector, were accounted using the *IPCC 2006* and *IPCC 2019 Refinement* methodology.	

LULUCF results

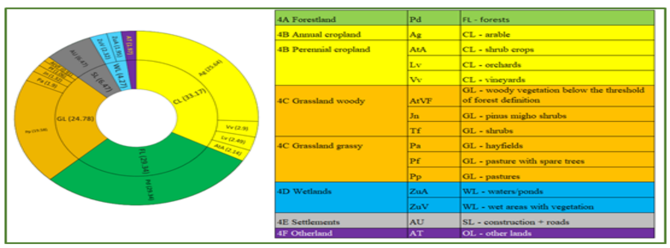
The LULUCF sector, land use categories have the following structure: (i) forest land, (ii) cropland, (iii) grassland, (iv) wetlands, (v) settlements (built areas and roads/railways), (vi) other lands. Figure 6.2 shows the distribution of the land areas in the latest year in the time series. In recent years the LULUCF sector has become more influential, in terms of the level of removals from the total GHG emissions, following the trend of the EU/EC policies to increase/maximize the potential of this sink sector into detriment of other source sectors, in an attempt to mitigate the impact/effect generated by climate changes.

Figure 6.2 LULUCF 2023. EGM – explicit geospatial map



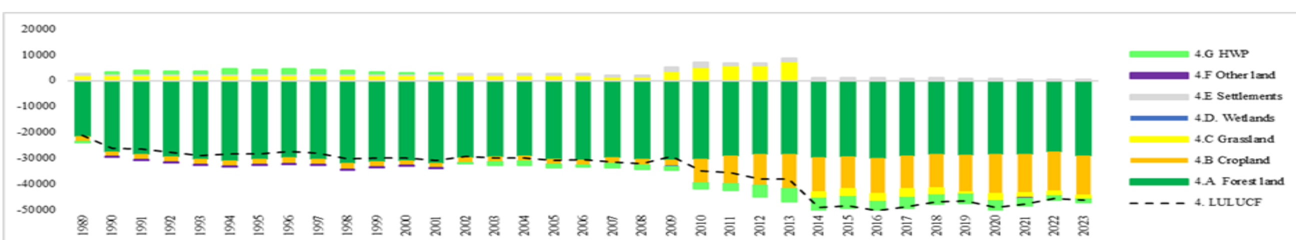
The figure below shows the structure of subcategories in LULUCF, respectively their % distribution, according to their activity data (kha) in the latest year in the time series.

Figure 6.3 LULUCF Sector structure (%)



The GHG E/R estimates distribution in the LULUCF Sector are presented in Figure 6.4.

Figure 6.4 LULUCF Sector. GHG E(+)/R(-) estimates (kt CO_2 eq.)



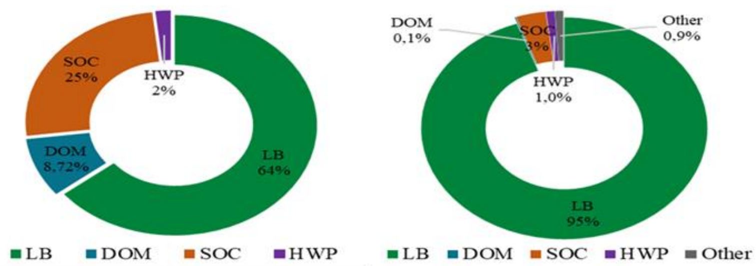
The NGHGI of LULUCF Sector comprises GHG E/R estimates of CO_2, CH_4 and N_2O due to overall carbon gains or losses, in the relevant carbon pools of the predefined six land use categories. The level of GHG E/R estimates in the LULUCF sector shows an increase in annual removals across the time series. The FL category generates most of the E/R of GHG in the LULUCF sector. Table 6.2 shows the change in annual historical E/R across the time series. The changes depend on several factors, such as growing conditions, harvesting levels, management practices and changes in land use. Overall, removals have increased over the time series and slightly decreased between the most recent two years.

Table 6.2 LULUCF Sector. Numerical analysis of land use categories

LU	Evaluation	Time period	
		1989–2023	2022–2023
Forest land	Emission change (kt CO_2 eq.)	-7261,56	-1268,76
	Percentage difference	34%	5%
Cropland	Emission change (kt CO_2 eq.)	-13696,72	-172.34
	Percentage difference	753%	1%
Grassland	Emission change (kt CO_2 eq.)	-3300,15	218.25
	Percentage difference	-168%	-14%
Wetlands	Emission change (kt CO_2 eq.)	-139.22	12.35
	Percentage difference	128%	-5%
Settlements	Emission change (kt CO_2 eq.)	-121.05	-14.51
	Percentage difference	-15%	-2%
Other land	Emission change (kt CO_2 eq.)	-0.71	3.65
	Percentage difference	3%	-12%
HWP	Emission change (kt CO_2 eq.)	-781,53	482,68
	Percentage difference	250%	-31%
Total	Emission change (kt CO_2 eq.)	-25300,95	-738,67
	Percentage difference	119%	2%

In the LULUCF sector, CO_2 has consistently been the largest contributor to the GHG pool, while non-CO_2 gases such as CH_4 and N_2O have had negligible contributions. The 4.A Forest Land category is recognized as the primary source of CO_2 removals, largely due to annual harvest rates being lower than the annual forest biomass growth. This imbalance results in a significant carbon stock increase. The net emissions trend indicates that the sector has consistently acted as a carbon sink throughout the entire time period, with the FL category being the primary driver. Within this category, forest biomass in FL remaining FL and forest soils in land converted to FL are the dominant carbon pools, significantly contributing to the sink function. However, this sink is mainly offset by emissions from areas categorized as GL, where nitrogen mineralization has been a consistent source of emissions over time. The distribution of GHG E/R across the carbon pools is shown in Figure 6.5.

Figure 6.5 LULUCF sector in the latest year R(-) (left) / E(+) (right) distribution in carbon pools



Note: other includes emissions from 4(III) and 4(V)

All land use categories have shown significant improvements in GHG E/R levels over time, serving as a crucial catalyst in mitigating the effects of climate change. These improvements have increased the amount of CO_2 removed from the atmosphere and sequestrated within landscapes. This progress is being achieved alongside efforts to restore ecosystems, enhancing the long-term sustainability of natural resources, ecosystem services, biodiversity, and organic food production. The LULUCF sector plays a vital role in limiting global warming to 1.5 °C without significant overruns, positioning itself as an integral part of the solution during this critical decade.

6.1.1 Key sources

Key category analysis is performed for LULUCF sector according to the provisions of *IPCC 2006, V1, Ch. 4,* following the Approach 1, used for prioritize efforts for improving the quality of the NIR – the relevant implemented and future studies referring mainly to the use of higher Tier methods in key categories, Table 6.3.

Table 6.3 LULUCF sector. GHG E(+)/R(-) key categories

E(+)/R(-) key categories	**Gas**	**Criteria used for key source identification**		**Contribution in total GHG emissions [%]**	**Methodological tier used**
		L	T	(%)	
4.A.1 Forest Land Remaining Forest Land	CO_2	X		58.62	T1, T2
4.A.2 Land Converted to Forest Land	CO_2	X		3.09	T2
4.B.1 Cropland Remaining Cropland	CO_2	X		7.37	T1,T2
4.B.2 Land Converted to Cropland	CO_2	X		25.80	T1, T2

E(+)/R(-) key categories	Gas	Criteria used for key source identification		Contribution in total GHG emissions [%]	Methodological tier used
		L	T	(%)	
4.C.1 Grassland Remaining Grassland	CO_2	X		1.37	T1, T2
4.E.2 Land Converted to Settlements	CO_2	X		1.41	T1, T2
4.G Harvested Wood Products	CO_2	X		2.34	T2

6.1.2 Land uses classification for representing LULUCF areas

For the reporting purposes under the UNFCCC it is recommended to assign national land use categories, as specified in the GD 1415/2024, to the appropriate categories of land use, consistently with the *IPCC 2006 Guidelines, V4, Ch. 3.3.1*. The IPCC Guidelines specify six land use categories for the LULUCF sector: *Forest Land*, *Cropland*, *Grassland*, *Wetlands*, *Settlements*, and *Other Land*. Land use categories definitions are as follows:

(i) Forest vegetation land associate with FL – is defined as an area covered by woody vegetation larger than 0.25 hectares with a minimum tree height of 5 meters at maturity and a canopy cover over 10 percent and wider than 20 m. It also includes lands partially or entirely, but temporarily, without tree cover, areas under regeneration (e.g., clear–cut regions and areas affected by natural disturbances). The Forest land category contains areas covered by woody vegetation that temporarily do not meet the above minimum thresholds but are expected to reach them in the future. Other areas under forest management not covered by trees, yet under forest exploatation, including forest roads, water bodies, and administrative areas, are excluded from the FL category.

(ii) Agricultural land associated with CL – lands that serve to crop needs, nurseries, solaria, plantations and mother plant cultures, grouped into two subcategories, non-woody crops Ag ~ arable; woody crops Lv ~ orchard and Vv ~ vineyards and other wooded land and trees outside forests, AtA~Shrub crops, which do not meet the Forest definition parameters (e.g. Forest belts which are narrower than 20 m).

(iii) Grassland associated with GL – includes land with destination such as grazing or mowing hay for livestock production, Pp ~ pasture; Pf ~ pasture with spare trees; Pa ~ hayfields, as well as other wooded land and trees outside forests which do not meet the Forest definition parameters, AtVf ~ woody vegetation below the threshold of forest definition; Tf ~ Shrubs; Jn ~ Pinus mugo shrubs, as Forest belts which are narrower than 20 m. Current assumption is that all Grasslands are managed.

(iv) Water bodies and wet areas associated with WL – it includes all lands covered by water bodies, rivers, ponds, dams, swimming pools, etc. and land affected by humidity, caused by water stagnation, marshy areas, etc., with the exception of agricultural land; it contains two sections ZuV ~ wet areas with vegetation; ZuA ~ Waters / ponds. Wetlands are assumed to be unmanaged.

(v) Buildings/constructions/infrastructure associated with SL – urban, rural areas and infrastructure across the country, associates with SL - has 3 groups: urban/rural, buildings and infrastructure and includes: fenced and constructed areas, sealed, urban/rural lawns, playgrounds in green areas, beach lawn and other areas with lawn, dwellings, industrial and administration buildings, warehouses, huts, ruins, greenhouses, graveyards, dirt roads, trails, railroads and roads, bridges and dams.

(vi) Other land associated with OL – includes following categories: rocky areas, excavations, stone quarries, active, closed, stony debris, gravel/sand/earth pits, drilling perimeters and locally degraded lands.

GHG E/R estimates, generated by specific activities in the six land use categories, are based on land use matrix. For the most accurate evaluation of the GHG emissions from the specific activities of land use changes, the primary data were used in the compilation file for several subcategories corresponding to the lands of interest in LULUCF sector, respectively, Figure 6.3.

The land use matrix was completed with AD(kha), as follows:

(i) for the land use category FL, the land use matrix is developed through an initial assessment that utilizes point sampling across a range of national and global geospatial datasets from 1976 to 2020. This process is further refined by overlaying time series forest estimations from the National Forest Inventory (NFI) at three specific points in time, 1985, 2012, and 2017, to construct the time series for forest land (FL) areas. Extrapolation methods are employed to estimate forest areas for periods outside these specified intervals, as elaborated in section 6.1.3.

(ii) for the land use categories CL and GL which are key categories in LULUCF sector, AD (kha) estimates were derived for the period starting from 2008 using explicit geospatial data (approach 3), based on LPIS/IACS technology, which tracks farmers enrolled in the APIA payment program, covering approximately 70% of the total areas. The remaining areas were supplemented using maps from the CLC dataset, with reference years of 1990, 2000, 2006, 2012, and 2018. For the period from 1970 to 2006, Romania’s land-use change matrix is based on a series of linear interpolations and extrapolations, using data from the NIS as the primary source.

(iii) for the land use categories WL, SL and OL from 2008 onward, differences between explicit geospatial maps developed for CL and GL (based on LPIS/IACS data and farmers' statements), CLC maps (for the reference years 1990, 2000, 2006, 2012, and 2018), and NIS statistical data were addressed using a combination of Approach 1, Approach 2, and Approach 3. For the period from 1970 to 2006, Romania's land-use change matrix incorporates a series of linear interpolations and extrapolations.

The final area of annual cropland in 2008 was significantly higher (1.5 times) compared to 2006, while other non-forest land categories showed a marked decrease. Due to the large discrepancies in the final areas between 2006 and 2008, it was determined that the non-forest land areas for 2007 could not be interpolated. Instead, two options were considered: back-calculating land remaining areas using the 2008 values or forward-calculating land remaining areas using the 2006 values.

The estimates for the more recent years of the time series are considered more accurate. However, back-calculating the land remaining areas would have resulted in negative areas at the beginning of the time series. Therefore, the land remaining areas for 2006 were used as a baseline, and land conversions for subsequent years were applied to calculate the land remaining areas from 2007 onward. In the absence of additional data, the land-use conversions for 2007 were assumed to be identical to those for 2008.

The adjusted land-use matrices were then used to calculate land use areas, considering the 20-year transition from land converted to land remaining categories. All AD (kha) for the land use categories and land use changes were normalized to the total area of the LULUCF sector, consistent with previous inventory reports for Romania, and based on the total area of 23,839.02 kha as reported by the National Agency for Cadastre and Real Estate Advertising.

6.1.3 Information on approaches used for representing land areas and on land–use databases used for the inventory preparation

For the purpose of the NID, a new reporting system was being put in place starting with 2021 submission. This new approach intends to use any explicit geospatial information existing in the country, either for land classification or for quality check. It strives to assess the land, consistently in time, within the national territory, according to harmonized classifications. Improved reporting of land use categories is based on multiple data sources:

(i) explicit geospatial maps – LPIS/IACS, 2008-2022, APIA used as source of AD (kha) for CL and GL;

(ii) explicit geospatial maps – LiDAR and aero-photogrammetry technology, 2019/2020, to validate some small areas or to complete gaps;

(iii) explicit geospatial maps – CLC [reference year 1990, 2000, 2006, 2012, 2018];

(iv) specific forest cover geospatial maps (Table 6.4);

(v) statistical data from NIS.

Each of the IPCC land-use categories was addressed in accordance with the national framework established by GD 1415/2024. Under this new system, several Research and Development Institutes in Romania, specializing in specific activities, were involved to enhance the level of reporting. Their contributions are designed to provide more detailed, complex, and reliable data, significantly increasing the accuracy and certainty of the reports. These institutes include:

(i) INCDS – covers the Forestland category in the NID.

Regarding the approach for forest land area representation, the forest definition elected by Romania to report the Forest land use IPCC category, matches the national definition of the forests included in the National Forest Fund – NFF, administered by forest districts and subject to national regulations for forest management plans, for which quantitative data is available in the national statistics. However, new data evidence (NFI estimates) showed that the forest area (according to the above-elected definition thresholds) in Romania is more extensive than what is included in the NFF, which led to new area estimation efforts. Additional data sources and database (above described) used for forest area reporting forest land in the National GHGI, are described in Table 6.4.

(1) – the NIS database that receives data about the forest area each year from forest districts in the country and summarizes it at the national level. The database covers the 1990–2022 time period and can be found at http://statistici.insse.ro:8077/tempo-online/. It covers only the forest area included in the National Forest Fund (approx. 93% of the total Forestland category) and is used for AR and Rv area estimates;

(2) – the NFI estimates measured forest area during two inventories in 2012 and 2017. NFI estimates forest area by cross–validating ortho-imagery land evaluation with field assessment to estimate the overall Forest land. Thus, NFI's area can be considered a more accurate estimation of FL, according to the IPCC category definition in Romania;

The NFI defines the forest category as: "land covered with trees: an area larger than 0.5 hectares and wider than 20 meters covered with trees reaching a minimum height at maturity of 5 meters (except Pinus mugo and Alnus viridis) and minimum crown cover over 10%, including afforested lands and land with young natural forest regeneration as well as land under regeneration: lands partially or entirely, but temporary without tree cover after a clear cut or a natural disturbance, under forest management;." The NFI data and methodology are available at: http://roifn.ro/site/en/ and http://www.mmediu.ro/app/webroot/uploads/files/2016-06-08_Metodologie_IFN.pdf;

(3) – Historical topographic maps based on images collected through photogrammetric surveys between the 1974–1978 period. The methodology also included field assessments to correct the photo interpretation uncertainties. The empty areas under regeneration were identified and displayed on maps. 1976 year was chosen as the middle year for the whole land assessment period for this cartographic product. The information in the topographical maps refers to all forests in Romania (regardless of property or administrative arrangements). This is used to determine the FL area in 1976 and also to track forest loss in the time series; data is available at: http://www.geomil.ro/Produse/HartiTopografice25ST#;

(4) – The digital boundary of the NFF includes approximately 80% of the 6.5 million hectares of the Forest

in the management plans, which are strictly regulated by the forest code (Law no. 46/2008) and thus considered roughly constant throughout the time series. The dataset has been used as a forest land-use mask for the 2012–2020 period to identify forest areas under regeneration in the remote sensing analysis. The digital map will be updated as new management plans will be revised (every ten years) and the maps upgraded to a digital format. The dataset is available at http://inspectorulpadurii.ro ;

(5) – The digital boundary of the forest cover from orthophoto imagery for 2005 year. It is a geospatial product developed by the Romanian NFI's. Dataset is used to estimate forest cover in 2005 and forest cover loss in the time series;

(6) – Eastern Europe's forest cover dynamics from 1985 to 2012 quantified from the full Landsat archive, P.V. Potapov et al. 2015. Dataset is used to estimate forest cover loss in the time series;

(7) – High-Resolution Global Maps of 21st-Century Forest Cover Change, M. C. Hansen, et al. 2013. Dataset is used to estimate forest cover loss in the time series;

(8) – The FTY datasets consist of a high-resolution layer of forest cover from the European Environment Agency Copernicus Land Monitoring Service. The product has three thematic layers (all non-forest areas/ broadleaved Forest and coniferous Forest) with a minimum mapping unit of 0.5 ha, following the Food and Agriculture Organization (FAO) forest definition. The dataset is available at https://land.copernicus.eu/pan-european/high-resolution-layers/forests/forest-type-1/status-maps/forest-type-2018?tab=metadata. The dataset is used to estimate forest cover loss in the time series;

(9) – Corine Land Cover products were used to determine the land subcategory percentage of the conversion area from and to Forest.

Table 6.4 Summary of the datasets used in the land identification approach for representing areas

No.	Data name	Data Type	Temporal Coverage	AD were data is used
1	NIS	value	1990–2022	A/D, Rv
2	NFI	value	2012, 2017	FL
3	Digital topographic maps	geospatial product	1976	FL, FL–L
4	Digital forest cover boundary	geospatial product	2005	FL, FL–L
5	Digital NFF forest boundary	geospatial product	2012–2020	FL, FL–L
6	Potapov and Hansen datasets	geospatial product	1985–2020	FL, FL–L
7	Forest Type Copernicus	geospatial product	2012, 2015, 2018	FL, FL–L

No.	Data name	Data Type	Temporal Coverage	AD were data is used
8	Corine Land Cover	geospatial product	1990, 200, 2006, 2012, 2018	% of the land subcategories of the L–FL and FL–L

The approach used for representing forest land areas:

Spatial representation of forestland in time series is developed by interpolation between seven spatial products, for the 1976–2018 time period, with an additional overlap of forest area reported by NFI between the 2012–2017 time period. Outside these intervals, extrapolation was used to report forest areas. Thus, Romania adopted a Tier 2 approach to represent forest land area. The spatial representation of forest areas is established on the time series observation of a sampling grid of 100 x 100 meters (covering the whole country). To estimate forest land areas the following steps were adopted:

(1) – adopting the total FL area from assessments of the topographical maps for 1976 and the total FL area for years 2012 and 2017 for the first and second NFI cycle;

(2) – determine the spatial distribution of FL–L area by year, based on the interpolation of the geospatial product. To correct the annual intervariability an harmonized approach for classification based on whole time series forest cover to each sample point has been performed, being able to identify the forest areas under regeneration;

(3) – determine the annual L–FL area as the difference between two FL area estimates and the sum of FL–L for this period:

$$\boldsymbol{L\text{–}FLyr = (FL2 - FL1 + \sum FL\text{-}Lyr\ ) \,/\, time;}$$

(4) - establish the annual subcategory conversion rates by tracking changes from the CLC dataset. For the sample points classified as L–FL or FL–L the CLC information available between 1990 and 2018 has been interpolated and determined the convention area of the IPCC land classification and national land subcategories;

(ii) National Research and Development Institute for Pedology, Agrochemistry and Environmental Protection (ICPA – Bucharest) – establishes the methodology used to determine the C stock and EF's to estimate E/R from mineral and organic soils, respectively for CL and GL. ICPA provides monitoring mechanism for the purpose of accounting for the activities corresponding to the management of CL and GL;

(iii) ICSI – processes geosatellite data through handling of LPIS/IACS and CLC technologies and estimates GHG E/R generated by specific activities for GL, CL, WL, SL, OL during the 1970–2023 historical time period.

6.1.4 Methodological issues

The majority of estimated CO_2 E/R in the LULUCF sector are derived from the CSC. The CSC for each category is calculated following the IPCC 2006 Guidelines, Version 4, Chapter 2, Equation 2.3, as the sum of the CSCs from all carbon pools: AGB, BGB, DW, LT, SOC, and HWP. For areas transitioning between land uses, the CSC is determined as the difference between the final carbon stocks of the destination use and the initial carbon stocks of the origin use. This difference is then divided over a period of 1 or 20 years, ensuring that the carbon stocks reach equilibrium during this transition period. The following table summarizes the methodology used to estimate the CSC for the various carbon pools in the LULUCF sector.

Table 6.5 LULUCF sector. Methodological summary of the estimation of the CSC of the pools

To / From		FL			CL			GL			WL			SL			OL		
		ME	**AD**	**EF**	**ME**	**AD**	**EF**	**ME**	**AD**	**EF**	**ME**	**AD**	**EF**	**ME**	**AD**	**EF**	**ME**	**AD**	**EF**
FL	**LB**	T2	NIS,NFI	CS	T2	NFI	CS	T2	NFI	CS	T2	NFI	CS	T2	NFI	CS	T2	NFI	CS
	DOM	T1	NFI	D	T2	ICP,NFI	CS	T2	ICP,NFI	CS	T2	ICP,NFI	CS	T2	ICP,NFI	CS	T2	ICP,NFI	CS
	SOC	T1	NFI	D	T2	ICPA	CS	T2	ICPA	CS	T2	ICPA	CS	T2	ICPA	CS	T2	ICPA	CS
CL	**LB**	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	DOM	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	SOC	T2	JI,NIS	CS	T2	ICPA	CS	T2	ICPA	CS	T1,T2	ICPA	D, CS	T1,T2	ICPA	D, CS	T1,T2	ICPA	D, CS
GL	**LB**	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	DOM	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	SOC	T2	ICPA	CS	T2	ICPA	CS	T2	ICPA	CS	T1,T2	ICPA	D, CS	T1,T2	ICPA	D, CS	T1,T2	ICPA	D, CS
WL	**LB**	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	DOM	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	SOC	T2	JI,NIS	CS	T2	JI,NIS	D, CS	T2	JI,NIS	D, CS	T1	JI,NIS	D, CS	T2	JI,NIS	D, CS	T2	JI,NIS	D, CS
SL	**LB**	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	DOM	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	SOC	T2	JI,NIS	CS	T1,T2	JI,NIS	D, CS	T1,T2	JI,NIS	D, CS	T1,T2	JI,NIS	D, CS	T1	JI,NIS	D, CS	T1,T2	JI,NIS	D, CS
OL	**LB**	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	DOM	T2	JI,NIS	CS	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D	T1	IPCC	D
	SOC	T2	JI,NIS	CS	T1,T2	JI,NIS	D, CS	T1,T2	JI,NIS	D, CS	T1,T2	JI,NIS	D, CS	T1,T2	JI,NIS	D, CS	T1	JI,NIS	D, CS

Note: *ME – methods; AD – activity data; EF – emission factor; NFI–national forest inventory; JI – join implementation project; ICP – International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests; NIS – National Institute of Statistics*

6.1.4.1 Change in C stock in biomass carbon pool

Within the framework of the Romanian GHG inventory, the carbon stocks from the AGB and BGB pools are presented in Table 6.6. The changes in biomass stocks are calculated using the gain-loss method outlined in the IPCC 2006 Guidelines. Losses are assumed to occur in the year of land use conversions, while gains from perennial cropland (CL) accumulate over a 20-year period. With the exception of Forest Land (FL), carbon stocks in the biomass carbon pool for the other land-use categories remain constant throughout the time series. Depending on the land-use category, the biomass reporting follows either a Tier 1 or Tier 2 method, with Forest Land (FL) being an example of the Tier 2 method.

Table 6.6 LULUCF . Carbon stocks, in above-ground and below-ground biomass and by type of land–use change (tC/ha)

		To (t)														
	Gain (tC/ha/y)	**Ag**	**Pp**	**Pf**	**Pa**	**Vv**	**Lv**	**AtA**	**Pd***	**AtVF**	**Jn**	**Tf**	**AU**	**ZuV**	**ZuA**	**AT**
FROM (t-1)	**Ag**	E	2.87	2.87	2.87	0.425	0.425	0.425	2.84/0.72	0.425	0.425	0.425	NA	2.87	NA	NA
	Pp	5.00	E	2.87	2.87	0.425	0.425	0.425	2.95/0.83	0.425	0.425	0.425	NA	2.87	NA	NA
	Pf	5.00	2.87	E	2.87	0.425	0.425	0.425	2.95/0.83	0.425	0.425	0.425	NA	2.87	NA	NA
	Pa	5.00	2.87	2.87	E	0.425	0.425	0.425	2.95/0.83	0.425	0.425	0.425	NA	2.87	NA	NA
	Vv	5.00	2.87	2.87	2.87	E	0.425	0.425	2.77/0.65	0.425	0.425	0.425	NA	2.87	NA	NA
	Lv	5.00	2.87	2.87	2.87	0.425	E	0.425	2.77/0.65	0.425	0.425	0.425	NA	2.87	NA	NA
	AtA	5.00	2.87	2.87	2.87	0.425	0.425	E	2.77/0.65	0.425	0.425	0.425	NA	2.87	NA	NA
	Pd	5.00	2.87	2.87	2.87	6.40	6.40	6.40	1.75	6.40	6.40	6.40	NA	2.87	NA	NA
	AtVF	5.00	2.87	2.87	2.87	0.425	0.425	0.425	2.77/0.65	E	0.425	0.425	NA	2.87	NA	NA
	Jn	5.00	2.87	2.87	2.87	0.425	0.425	0.425	2.77/0.65	0.425	E	0.425	NA	2.87	NA	NA
	Tf	5.00	2.87	2.87	2.87	0.425	0.425	0.425	2.77/0.65	0.425	0.425	E	NA	2.87	NA	NA
	AU	5.00	2.87	2.87	2.87	0.425	0.425	0.425	3.09/0.97	0.425	0.425	0.425	E	2.87	NA	NA
	ZuV	5.00	2.87	2.87	2.87	0.425	0.425	0.425	2.98/0.83	0.425	0.425	0.425	NA	E	NA	NA
	ZuA	5.00	2.87	2.87	2.87	0.425	0.425	0.425	3.09/0.97	0.425	0.425	0.425	NA	2.87	E	NA
	AT	5.00	2.87	2.87	2.87	0.425	0.425	0.425	3.09/0.97	0.425	0.425	0.425	NA	2.87	NA	E

		To (t)														
	Loss (tC/ha/y)	**Ag**	**Pp**	**Pf**	**Pa**	**Vv**	**Lv**	**AtA**	**Pd**	**AtVF**	**Jn**	**Tf**	**AU**	**ZuV**	**ZuA**	**AT**
FROM (t-1)	**Ag**	E	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	Pp	2.87	E	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87
	Pf	2.87	2.87	E	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87
	Pa	2.87	2.87	2.87	E	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87
	Vv	6.40	6.40	6.40	6.40	E	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40
	Lv	6.40	6.40	6.40	6.40	6.40	E	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40
	AtA	6.40	6.40	6.40	6.40	6.40	6.40	E	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40
	Pd	96.30	96.30	96.30	96.30	96.30	96.30	96.30	E	96.30	96.30	96.30	96.30	96.30	96.30	96.30
	AtVF	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	E	6.40	6.40	6.40	6.40	6.40	6.40
	Jn	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	E	6.40	6.40	6.40	6.40	6.40
	Tf	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	E	6.40	6.40	6.40	6.40
	AU	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	E	NA	NA	NA
	ZuV	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	E	2.87	NA
	ZuA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
	AT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	E

** For L–FL (under Pd column), carbon stock change per year is estimated in AR sites and on natural established forest stands, E = in equilibrium no carbon stock changes are calculated*

6.1.4.2 Change of C stock in dead organic matter carbon pool

The changes in Dead Organic Matter (DOM) are calculated in accordance with the IPCC 2006 Guidelines. Reporting on DOM follows a Tier 2 method for FL (Pd). For all other categories, a Tier 1 method is assumed, where it is either considered that DOM is in equilibrium or no DOM is applied.

Table 6.7 LULUCF sector. Carbon stocks in the year of the change, in DOM, by type of land-use change (tC/ha)

		To (t)														
	Gain (tC/ha/y)	**Ag**	**Pp**	**Pf**	**Pa**	**Vv**	**Lv**	**AtA**	**Pd**	**AtVF**	**Jn**	**Tf**	**AU**	**ZuV**	**ZuA**	**AT**
FROM (t-1)	**Ag**	E	NA	NA	NA	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA	NA
	Pp	NA	E	NA	NA	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA	NA
	Pf	NA	NA	E	NA	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA	NA
	Pa	NA	NA	NA	E	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA	NA
	Vv	NA	NA	NA	NA	E	NA	NA	0.08	NA	NA	NA	NA	NA	NA	NA
	Lv	NA	NA	NA	NA	NA	E	NA	0.08	NA	NA	NA	NA	NA	NA	NA
	AtA	NA	NA	NA	NA	NA	NA	E	0.08	NA	NA	NA	NA	NA	NA	NA
	Pd	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18	E	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18
	AtVF	NA	NA	NA	NA	NA	NA	NA	0.08	E	NA	NA	NA	NA	NA	NA
	Jn	NA	NA	NA	NA	NA	NA	NA	0.08	NA	E	NA	NA	NA	NA	NA
	Tf	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA	E	NA	NA	NA	NA
	AU	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA	NA	E	NA	NA	NA
	ZuV	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA	NA	NA	E	NA	NA
	ZuA	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA	NA	NA	NA	E	NA
	AT	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA	E

6.1.4.3 Change of C stock in soil carbon pool

The area of mineral soils is calculated as the difference between the total national area and the areas covered by organic soils. Changes in carbon and nitrogen stocks in mineral soils are calculated according to the IPCC 2006 Guidelines, Equation 2.25, as the difference between the stocks before and after relevant land use or management practice changes. Emission Factors (EFs) have been derived on a CS basis, which refers to the carbon stock in mineral soils across various land use categories. The methodology accounts for the 20-year period needed to reach equilibrium in soil organic carbon (SOC) values. For each period of the time series with varying SOC values, the annual rate of C change is estimated to reach equilibrium over 20 years, even if the time between data collections is shorter than 20 years. It is assumed that SOC was in equilibrium in 1990, as no data is available prior to this year to estimate C stock changes. When SOC changes, the carbon stock shows a linear gain or loss over 20 years until equilibrium is reached. For instance, when estimating SOC for 2010 in Ag, the value would be 40.5 tC/ha, reflecting an increase from 34.9 tC/ha in 1990. In 2010, an annual CSC value of 0.28 tC/ha ((40.5 – 34.9)/20) is applied to the total area of Ag remaining Ag.

In land conversion categories, the SOC_{REF} value is maintained (as the conversion occurs in that soil type), and the SOC factors (e.g., F_{LU}, F_{MG}, F_{I}) from the new land-use category are used to calculate the new total SOC, which is reached after 20 years. In the case of conversions to WL, SL, or OL, the country-specific SOC values for these categories are used, as separate SOC factors are not available.

When land transitions from a land converted to a land remaining category, the SOC value reached after 20 years is considered as the starting SOC in equilibrium. Because SOC values in GL grassy and CL annual vary throughout the time series, the year of conversion impacts the CSC. The approach considers the SOC value in the original land use up until the year of conversion and the SOC value to be reached in equilibrium in the new land use, with calculations reflecting cumulative increases or decreases over the 20-year period.

Information on the SOC values applied for each land-use category is provided in the respective chapters below. The derived CSC from these stocks, used as EFs, are shown for the most recent year in the time series in Table 6.8.

Table 6.8 LULUCF sector. Carbon stocks in mineral soils, by type of land-use change in 2023 (tC/ha)

		To (t)														
	Gain (tC/ha/y)	**Ag**	**Pp**	**Pf**	**Pa**	**Vv**	**Lv**	**AtA**	**Pd**	**AtVF**	**Jn**	**Tf**	**AU**	**ZuV**	**ZuA**	**AT**
FROM (t-1)	**Ag**	0.32	0.21	0.21	0.21	0.53	0.53	0.53	2.14	0.51	0.51	0.51	-0.14	0.26	0.26	0.31
	Pp	0.68	0.55	0.55	0.55	0.93	0.93	0.93	1.85	0.90	0.90	0.90	-0.20	0.20	0.20	0.25
	Pf	0.68	0.55	0.55	0.55	0.93	0.93	0.93	1.85	0.90	0.90	0.90	-0.20	0.20	0.20	0.25
	Pa	0.68	0.55	0.55	0.55	0.93	0.93	0.93	1.85	0.90	0.90	0.90	-0.20	0.20	0.20	0.25
	Vv	-0.18	-0.27	-0.27	-0.27	E	E	E	2.23	-0.02	-0.02	-0.02	-0.37	0.03	0.03	0.08
	Lv	-0.18	-0.27	-0.27	-0.27	E	E	E	2.23	-0.02	-0.02	-0.02	-0.37	0.03	0.03	0.08
	AtA	-0.18	-0.27	-0.27	-0.27	E	E	E	2.23	-0.02	-0.02	-0.02	-0.37	0.03	0.03	0.08
	Pd	-2.14	-1.85	-1.85	-1.85	-2.23	-2.23	-2.23	E	-1.50	-1.50	-1.50	-2.60	-2.20	-2.20	-2.15
	AtVF	-0.22	-0.35	-0.35	-0.35	0.03	0.03	0.03	1.50	E	E	E	-1.10	-0.70	-0.70	-0.65
	Jn	-0.22	-0.35	-0.35	-0.35	0.03	0.03	0.03	1.50	E	E	E	-1.10	-0.70	-0.70	-0.65
	Tf	-0.22	-0.35	-0.35	-0.35	0.03	0.03	0.03	1.50	E	E	E	-1.10	-0.70	-0.70	-0.65
	AU	-0.13	-0.21	-0.21	-0.21	0.02	0.02	0.02	2.60	E	E	E	E	0.40	0.40	0.45
	ZuV	-0.17	-0.26	-0.26	-0.26	0.02	0.02	0.02	2.20	E	E	E	-0.40	E	E	0.05
	ZuA	-0.17	-0.26	-0.26	-0.26	0.02	0.02	0.02	2.20	E	E	E	-0.40	E	E	0.05
	AT	-0.17	-0.27	-0.27	-0.27	0.02	0.02	0.02	2.15	E	E	E	-0.45	-0.05	-0.05	E

6.1.5 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

6.1.6 Uncertainty assessment and time-series consistency

Romania is part of Annex I to the UNFCCC and presents annual reports on its GHG E/R estimates, i.e. the assessment of uncertainty and the analysis of key categories are intrinsic elements of the NID.

Activity data uncertainty

The uncertainty of the activity data (AD) is determined by the uncertainty in land use and land-use change mapping based on explicit geospatial data. In this case, the uncertainty arises from the following sources: ***(i)*** Information based on periodically updated 1:5000 maps - These maps link the AD (kha) to data beyond the purely statistical calculations that were previously used. The LPIS/IACS maps, which cover most of the country, bring accuracy and consistency to the reported areas, with a 0.5 ha minimum mapping unit. This system reduces errors and interpretations because the land use categories are determined directly from farmers' declarations through the LPIS/IACS system; ***(ii)*** The influence of using CLC maps from the reference years 1990, 2000, 2006, 2012, and 2018 still contributes to the uncertainty; ***(iii)*** The LiDAR and aero-photogrammetry technology used for lower-accuracy mapping also plays a role in introducing some uncertainty. Based on these mapping sources and approaches, it has been estimated that the uncertainty for AD (kha) related to the CL and GL key categories has an uncertainty of ±10% at a 95% confidence level. For the WL, SL, and OL categories, the uncertainty has been assumed to be 30%, also at a 95% confidence level.

Emission factor uncertainty

The uncertainty associated with the GHG E/R factors is generally greater than that of the AD. For the land use categories CL and GL, the uncertainty of the EF has been revised from ±300% to ±100% at a 95% confidence level, thanks to updates using CS parameters, such as SOC_{REF}, F_{LU}, F_{MG}, and F_I. For other land use categories, namely WL, SL, and OL, an uncertainty of ±300% at a 95% confidence level is assumed. This represents the highest uncertainty factor estimated through approach 1, the propagation of errors uncertainty analysis, assuming symmetrical uncertainty.

Regarding CH_4 emissions, these are released due to wildfires in GL. The uncertainty for AD is considered high due to assumptions made while extracting data from the original source. Therefore, a 30% uncertainty is assumed for the CH_4 estimates. The EF used for these emissions is based on savanna and grassland, with the associated uncertainty taken from Table 2.5, IPCC 2006 Volume 4.

For N_2O emissions, they stem from wildfires and mineralization linked to SOC loss in GL remaining GL. The uncertainty for these two sources is reported together. The AD uncertainty is assumed to be the same as the maximum uncertainty of the EF for wildfires and mineralization, which is 100.5%—the same as for CO_2 emissions from GL carbon pools. The EF uncertainty is assumed to be the maximum for wildfires and mineralization, i.e., 98.57% (from Table 11.1, IPCC 2006 Volume 4). For the rest of the land use categories, N_2O emissions occur solely due to mineralization associated with the loss or gain of soil organic matter. The AD uncertainty is assumed to follow the same uncertainty as for CO_2 emissions from carbon pools (i.e., 100.5% for CL, and 301.5% for WL, SL, OL). The EF uncertainty for these categories is the same as the EF for mineralization, i.e., 98.57% (from Table 11.1, IPCC 2006 Volume 4).

Global Warming Potentials (GWPs) from the IPCC Fifth Assessment Report (AR5) were applied for GHG conversions. The values of the GHG estimates generated by specific activities in the LULUCF sector were consolidated. By using the calculation equations from the 2006 IPCC Guidelines, the uncertainties associated with the GHG E/R estimates for each land use category were determined. To calculate uncertainty, Romania followed Approach 1, Error Propagation, as outlined in IPCC 2006 Guidelines for National Greenhouse Gas Inventories, Volume 1, Chapter 3 (Uncertainty).

6.1.7 Category–specific QA/QC and verification, if applicable

The IPCC 2006 Guidelines outline the steps for the reporting of the NID. The activity plan encompasses all QA/QC activities and other necessary actions aimed at achieving and maintaining the appropriate quality of the tables and reports submitted. Key elements of QA/QC implemented in the LULUCF sector include:

(i) *are the values correct, checked for transcription errors?* ***(ii)*** *checked plausibility of input data, time-series, order of magnitude;* ***(iii)*** *is the data set complete for the whole time series?* ***(iv)*** *are the calculation units correct?;* ***(v)*** *are the results, time-series, order of magnitude plausibile?* ***(vi)*** *are the data correctly transcripted into the CRTs?* ***(vii)*** *could data be cross-checked with data from other sources?* ***(viii)*** *is the order of magnitude consistent?* ***(ix)*** *are all references clearly made?****(x)*** *are all of them well documented?* ***(xi)*** *is there a QA/QC developed and implemented plan to ensure that sufficient time is given in the inventory cycle to identify and correct errors?*

The QA/QC Plan for the checks outlined in Table 6.9, along with a timeline, ensures that any identified errors are addressed and corrected before submission. The primary goal of QA/QC is to ensure that the inventory is comparable, consistent, complete, transparent, and accurate, to the extent possible, given the available resources and expertise. The QA/QC process is closely linked to the completion of key steps, which represent the activities and procedures carried out throughout the process. Specifically, issues arose when calculating land use areas during the 20-year transition period, which led to some negative areas. Planned improvements have been identified to prevent these errors in future inventory cycles (see section 6.1.9).

Table 6.9 QA/QC Activities and procedures

Activity	Procedures
Verifying the accuracy of input data from the original source	Confirm that the correct references have been used. Data poll verification for transcription errors
Verifying Database Integrity	Confirm that the data path is correctly represented and that the necessary calculation steps are performed. Confirm that the computing relationships used are correct.
AD (kha) are plausible compared to other references	Confirm AD (kha) by checking maps LPIS/IACS, CLC, LiDAR and aero-photogrammetry technology/NIS/MADR, ANCPI
Checks whether data or methodology changes are documented	Analysis of the clarity and transparency of documentation in the case of identified changes
Checks whether all calculations are included	Confirm whether all categories are fully represented and calculated
Checks whether units are properly labelled and transported correctly from the beginning to the end of the calculation	Spot–checks verifying the correctness of the units used from the beginning to the end of the calculation
Checks a representative sample of calculations, manually or electronically	Selectively choose a category and verify the correctness of the calculations
Checks the aggregation of data in a category	Randomly choose a category and follow the way the data is processed, their completeness.
Check estimates for the current year over previous years (if available) and investigate unexplained deviations from estimated trends	Compare the current year's values with previous years, along with the expected trends. In the case of identification of differences, it is verified that there are documented justifications.
Check any unexplained or unusual deviation from the expected trends, both for input data and other calculation parameters in the time series	Identification of unusual data is required to be documented or the initiation of calculations or calculation methods
Internal approval of drawn up documents	Application of the internal procedure for analyzing and endorsing documents

For continuous methodological improvement, the compilation file used in the E/R estimation is updated with new QA/QC elements. The compilation file has improved the transparency of the methodology and will enable updates in future cycles to be implemented more efficiently. This improved system will also strengthen the institutional memory of the LULUCF inventory. SWOT analysis presents the current image of the inventory, Table 6.10:

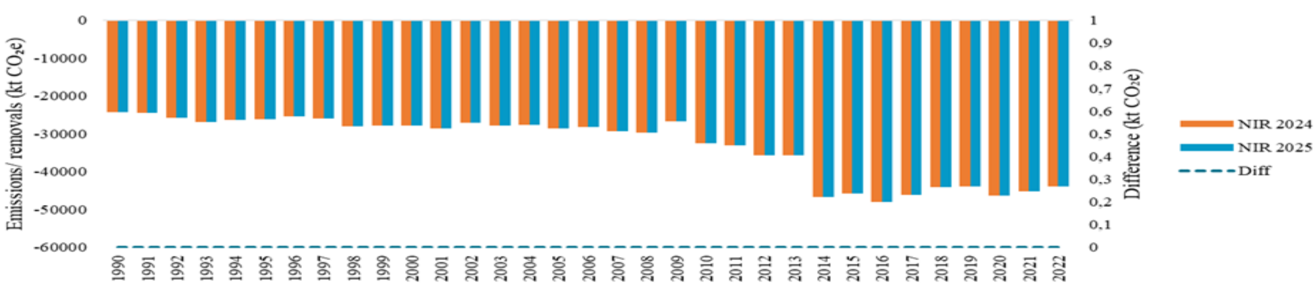
Table 6.10 LULUCF sector. SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
EGM (AD kha) update - LPIS/IACS [2007-2022] - CLC [reference year 1990, 2000, 2006, 2012, 2018] and Forest Type (FTY) Copernicus Land Monitoring Products] - LiDAR and aero photogrammetry	*Insufficient explicit geospatial data*	*EGM (AD kha) update* 2nd generation CORINE Land Cover/CLC +	*Amendments to EU/EC and UNFCCC Regulations* Fit for 55 package
Stock C and EF's parameters (CS, D) of carbon pools (LB, DOM, Soil) updated	*The need to improve the stock C and EF's parameters as CS type, for different carbon pools*	*Ensuring traceability and TACCC of information*	*Increasing reporting costs*
Historical recalculation (1970-2021)		*R&D studies for the development of CS parameters*	

6.1.8 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

LULUCF sector recalculations, are summarized in the following figure:

Figure 6.6 Quantification of recalculations performed across the time period (kt CO_2 eq.)



For all land use categories,excepted 4G, no recalculations were made to the historical data.

6.1.9 Completeness

Table 6.11 gives an overview of the completeness of the LULUCF sector. Highlighted categories marked with *R – reported, NO – not occurred, NA – not applied, NE – not estimated, E – equilibrium,* have been estimated.

Table 6.11 LULUCF sector. Overview of the completeness

From \ To			FL	CL	GL	WL	SL	OL
FL	**LB**	**CO_2**	R	E	E	E	E	E
	DOM	CO_2	R	E	E	E	E	E
	SOC min	CO_2	R	E	E	E	E	E
	SOC min 4(III)	N_2O	NO	E	E	E	E	E
	SOC org	CO_2	E	NO	NO	NO	NO	NO
	4(V)	CO_2	E					
		N_2O	E					
		CH_4	E					
CL	LB	CO_2	R	R	E	E	E	E
	DOM	CO_2	R	NA	NA	NA	NA	NA
	SOC min	CO_2	R	R	E	R	E	R
	SOC min 4(III)	N_2O	E	E	E	NO	E	NO
	SOC org	CO_2	NO	E	NO	NO	NO	NO
GL	LB	CO_2	R	R	R	R	E	E
	DOM	CO_2	R	NA	NA	NA	NA	NA
	SOC min	CO_2	R	R	R	R	E	R
	SOC min 4(III)	N_2O	E	E	E	E	E	E
	SOC org	CO_2	NO	NO	E	NO	NO	NO
	4(V)	CO_2			NA			
		N_2O			E			
		CH_4			E			
WL	LB	CO_2	R	R	R	R	E	E
	DOM	CO_2	R	NA	NA	NA	NA	NA
	SOC min	CO_2	R	E	E	NA	E	R
	SOC min 4(III)	N_2O	E	E	E	NO	E	NO
	SOC org	CO_2	NO	NO	NO	NO	NO	NO
SL	LB	CO_2	R	R	R	R	NA	NA
	DOM	CO_2	R	NA	NA	NA	NA	NA
	SOC min	CO_2	R	E	E	R	NA	R

From \ To			FL	CL	GL	WL	SL	OL
	SOC min 4(III)	N_2O	E	NO	E	NO	NO	NO
	SOC org	CO_2	NO	NO	NO	NO	NA	NO
OL	LB	CO_2	NO	R	R	R	NA	NO
	DOM	CO_2	NO	NA	NA	NA	NA	NO
	SOC min	CO_2	NO	E	E	E	E	NA
	SOC min 4(III)	N_2O	NO	E	E	E	E	NO
	SOC org	CO_2	NO	NO	NO	NO	NO	NO
HWP		CO_2						

6.1.10 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

In the interest of improving the GHG E/R from LULUCF sector, estimates that used input parameters and applied methods are continuously re-evaluated. A number of potential future improvements have been identified, and will be considered for inclusion in future inventory submissions. These include:

(i) regarding the FL category, additional data checks and improvements of AD and EF are considered for the next inventory submissions. The category and subcategory description of the data checks and improvements related to the land areas are covered in 6.2.6 section;

(ii) use of database provided by LiDAR and aero–photogrammetry technology for verifying the consistency of CLC data, comparing spatial and statistical limits, coverage areas of land use categories, considering the possibility of different interpretation of land use, leading to changes in the category of plots;

(iii) review of country specific SOC stocks based on ongoing research project (see details in Cropland section).

6.2 Land-use definitions and the land representation approach(es) used and their correspondence to the land use, land-use change and forestry categories (e.g. land use and land-use change matrix)

The specific information regarding the land-use definitions and the land representation approach(es) used and their correspondence to the land use, land-use change and forestry categories are presented in section 6.1.2 of the current document.

6.3 Country-specific approaches

6.3.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The information on approaches used for representing land areas and on land-use databases used for the inventory preparation are presented in section 6.1.3 of the current document.

6.3.2 Information on approaches used for natural disturbances, if applicable

Since no such big events happened and since no appropriate data were available to estimate GHG emissions from natural disturbances (i.e., windstorms and wildfire) that have occurred (only those provided by NIS), these emissions were accounted for in the total annual harvest, and therefore reported as NO.

6.3.3 Information on approaches used for reporting harvested wood products

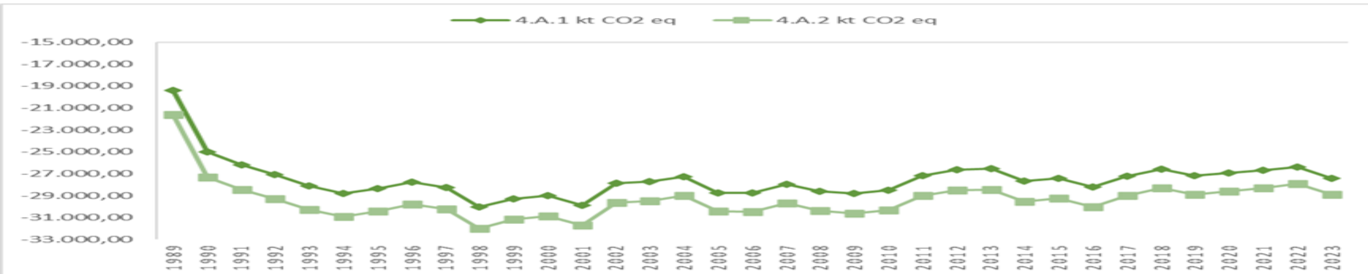
Any wood loss that occurs is assumed to be subject to instant oxidation.

6.4 Forest Land (CRT 4.A)

6.4.1 Category description

The GHG inventory for the Forest land (CRT 4.A) category includes emissions and removals of CO_2 associated with forest land remaining forestland (4.A.1) and the land converted to forestland (4.A.2) and non–CO_2 estimates from wildfires (reported in section 6.10.5 below). The total removals from the FL category for reporting year 2023 are – 28861.91 kt, of which the land converted to forestland accounts for 6%. Figure 6.7 estimates the CO_2 removals by subcategory, showing an abrupt increase in the CO_2 removals for the 1989–2000 period. This is a direct consequence of the marked decrease in harvest rates after the communist period (a reduction of 34% comparing average values for decades before and after 1989).

Figure 6.7 Summary of removals from the FL category in the 1989–2023 period (in kt CO_2 eq)



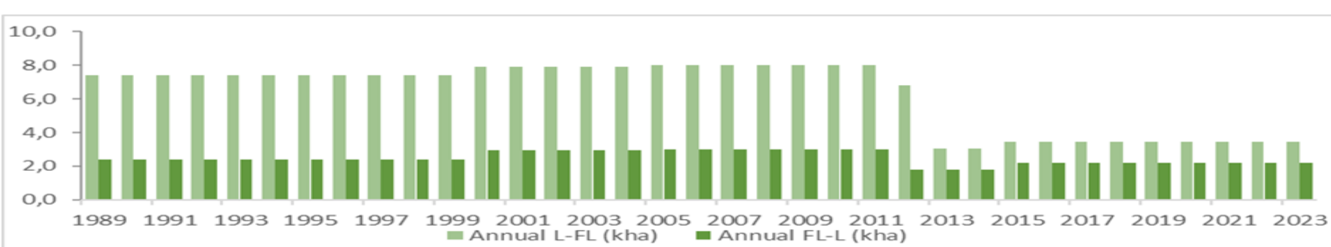
The CO_2 removals for each subcategory are presented in Figure 6.8.

Figure 6.8 The comparison of CO_2 removals for 4.A sub-categories for the years 1989 and 2023

FL sub–category	1989 (kt CO_2 e)	2023 (kt CO_2 e)
4.A.1 FL–FL	-19,398.95	-27,431.54
4.A.2 CL–FL	-901.80	-504.16
4.A.2 GL–FL	-997.46	-835.18
4.A.2 WL–FL	-93.03	-24.32
4.A.2 SL–FL	-211.33	-80.52
4.A.2 OL–FL	0	0

Although the annual area of land converted to forest land decreased over the years, it was still higher than deforestation activity, which resulted in an increase in total forest area by 1.84% between 1989 (6,864.23 kha) and 2023 (6,993.22 kha), Figure 6.9.

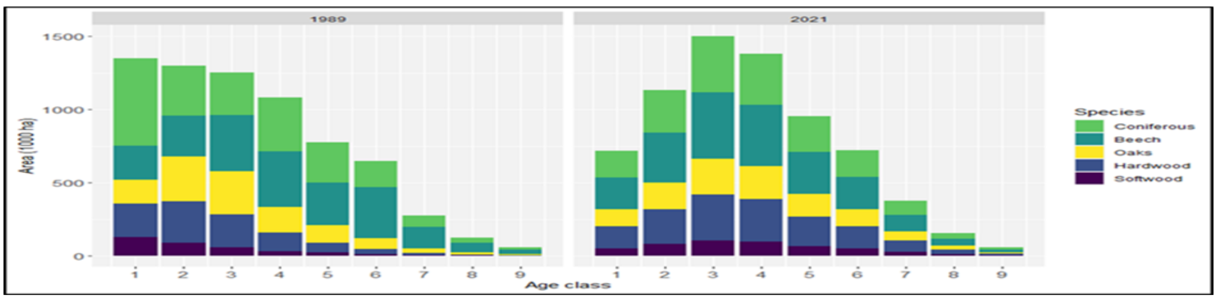
Figure 6.9 The area of forest–related land conversions



The Forest land category covers 6,993.22 kha (4.A. 2022), equivalent to 29% of the country's area.

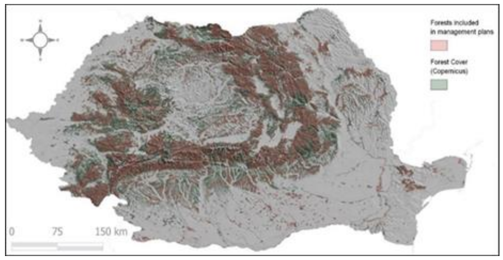
Between the first two NFI cycles (which ended in 2012 and 2017, respectively), the land covered by woody vegetation increased by 28 kha (5.6 kha/yr), while areas under regeneration decreased by 22 kha (4.4 kha/yr), resulting in a net increase of 6.28 kha of the Forest land category between the two inventories. During this time, the area with young forest stands showed a decreasing trend (the proportion of the size of the age classes being: 1st NFI Cycle: 1-20 yr – 13.1%, 21-40 yr – 21.0%, 41-60 yr – 18.5%, 61-80 yr – 18.7%; 2nd NFI Cycle: 1-20 yr – 11.2%, 21-40 yr – 17.8%, 41-60 yr – 20.5%, 61-80 yr – 19.4%), while forests over 100 years, covering 17.3 % in 2018, altogether gained more than 197 kha, Figure 6.10. All forests older than 100 years were included in just one age class (i.e., age class 6) in the National Forest Fund Inventory (NFFI) but were separately reported in the NFI where forests older than 160 years were included in the last age class (i.e., age class 9).

Figure 6.10 resents a comparison of forest area distribution between the year 1989 and projections made for the year 2023. This comparison is based on the latest inventory data available since 2017, focusing on age classes and the main categories of species



Forests have a complex structure and high (bio)diversity; the forest stands with two or more tree species covering more than 72% of the total area, while natural forest types with predominant native species occupy over 90% of the total forest area. On the other hand, about 85% of the total forest area is even–aged. Concerning species composition, the Romanian forest is a predominantly mixed forest of broadleaves species (67%), followed by forests of mainly coniferous (26%), the rest being mixed forests. The most widespread species is European beech (*Fagus sylvatica* L.), covering over 30% of the FL area, followed by Norway spruce (*Picea abies* (L.) H. Karst. – 19.8 %), Sessile oak (*Quercus petraea* (Matt.) Liebl. – 8.4%) and European hornbeam (*Carpinus betulus* L. – 7.0%). Forest cover differs significantly despite the relatively equal proportions of the major landforms within the national territory. According to NFI Cycle II, most of them are located in the mountains (58.9%) and hills (34.4%), while only a small share (6.5%) can be found in the lowlands. The majority of forest areas (over 90%) are included in the management plans where the application of forest regime according to forest code and norms is required, see Figure 6.11.

Figure 6.11 Area of forest land category stratified between included or not into forest management plans

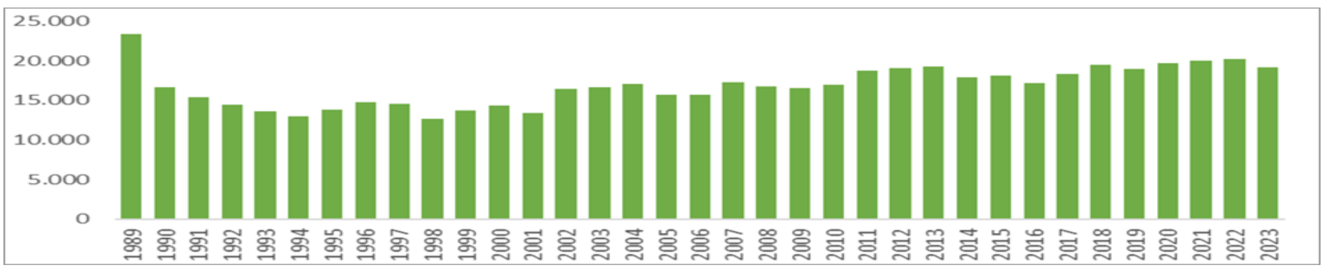


The forest area in Romania is managed under the provisions of the Forest Code (Law no. 46/2008) and is defined as follows:

- Forest land use with forestry/silvicultural purposes, equivalent to the National Forest Fund (NFF), is managed by forest districts. The NFF is subjected to new management plans every ten years. The areas under forest management, afforestation (new area included in NFF through plantation), and deforestation (areas excluded from NFF by removing the forest vegetation) are reported by each forest district to the national authorities and aggregated at the national level by the National Institute of Statistics (NIS). This category covers approximately 93% of the total forested lands in Romania.
- Forested lands outside the NFF are only subject to harvested material traceability regulations.

Romanian forestry has a long tradition: the first management plans were developed in the last half of the XVIIIth century. Notable improvements in forestry occurred under the communist regime, driven by centralized planning at the national level. Governmental technical norms, long-term planning of wood harvesting, and consequent industrial processing guided the strict implementation of management practices. Since 1990, due to land property change, Romanian forestry was registered under an inconsistent regulatory framework and pressure from international wood markets. It initially proved to fall short in applying sustainable management principles. In the past years, Romania has managed to set and follow objectives addressing forest protection and preservation by choosing and promoting treatments based on natural regeneration that consider environmental conditions and socio–economic requirements (State of Romanian Forests Report 2017). Since 2000, the restitution process of the forest lands (which started in 1991) has intensified (Law no. 18/1991, Law no. 1/2000, and Law no. 247/2005). The state-owned forests cover less than 50% of the entire forest area, and the management system is divided between the National Forest Administration and private forest districts. Beginning around 1990, the annual harvest level decreased from 24 million cubic meters per year to around 15 million cubic meters per year, according to the NIS, followed by a constant increase reaching about 20 million m^3 per year in 2021 (NIS 2021). The wood harvest's initial reduction resulted from the political turmoil due to the East-European markets' fall for Romanian furniture products. The following increase in harvest later was most likely caused by land property change and owners' desire to accelerate and increase financial benefits. The maximum allowable cut is fixed annually by national authorities (MEWF) and distributed among all forest districts based on their annual harvest possibility (estimated by each forest district according to management plans and later aggregated and agreed upon nationally) without exceeding the national threshold. This rule has preserved the sustainability management of forests in Romania. Indeed, the annual national harvest level was lower than the allowable cut all over the reporting period; for instance, the total amount of potential yearly harvest, thinning, and final cut is estimated at 22.05 million m^3 (State of Romanian Forests Report 2017). Figure 6.12 reports the annual harvest rate for the period 1989–2023.

Figure 6.12 Annual harvest (mil. m^3 $year^{-1}$) for the period 1990–2023



Romania's virgin forests area is about 8.6 kha, while the quasi-virgin forests cover 61.5 kha, as registered in Romania's Virgin and Quasi–Virgin Forests Catalog[5]. In contrast, a much larger area of about 582 kha of the forest fund is included in Natural and National Parks and Nature 2000 sites. The forestry sector is one of the most important contributors to the Romanian economy. In the last three years, this sector's gross income exceeded 3.5 billion € (with furniture exports representing more than 2 billion €, NIS 2018). Non–timber forest products are an essential source of income for the local rural communities (Abrudan 2019).

The information on the forest structure at the necessary disaggregation level is available from the 1984 National Forest Fund Inventory (below referred to as NFFI) and from the 1st and 2nd NFI cycles (2012 and 2018, respectively) for all forests. Both data sources provide aggregated values on the area and above-ground woody volume for five species groups (conifers, beech, oaks, hardwoods, softwoods), nine 20–year–wide age classes, and five yield classes, totaling 225 forest structure classes.

The 1984 NFFI used the aggregated data of all management plans for that year, whereas the NFI methodology is based on a permanent sampling plot grid during the NFI cycle length.

[5] http://www.mmediu.ro/articol/catalogul-padurilor-virgine-si-cvasivirgine-din-romania/4790

6.4.2 Methodological issues

The methodology of estimating emissions and removals from Forest land is predominantly based on Tier 2 of the 2006 IPCC GL with country–specific EFs wherever possible, Table 6.12.

Table 6.12 Summary of the methodological approach for the 4.A. sub–categories

	4.A.1	**4.A.2**
method	Tier 2	Tier 2
approach	2,3	2,3
carbon pool estimated	LB; DOM; SOC	LB; DOM; SOC
Area 1989–2023 (kha)	Avg / Stdev	Avg / Stdev
	6784.64 / 65.84	6.32 / 2.02
GHG pools and gases	CO_2, CH_4, N_2O	CO_2, CH_4, N_2O

6.4.2.1 Forest Land remaining Forest Land (CRT 4.A.1)

The estimation of CO_2 removals for the FL–FL category employs country-specific parameters and the Tier 2 method from the 2006 IPCC Guidelines for the time series 1989–2023. These estimates are refined by incorporating the stock difference calculation between two National Forest Inventories (NFIs) conducted in 2012 and 2017. Following this overlap exercise, the annual harvested volume is adjusted—specifically increased in this instance—to ensure that the gain and loss estimations match the stock difference calculation. For this category, changes in carbon stocks and E/R were estimated across categories: living biomass (both above and below ground), deadwood, litter, and both mineral and organic soils. The annual estimated emissions for category 4.A.1, broken down by gas, are detailed in Table 6.13.

Table 6.13 Emissions in 4.A.1 FL–FL category in inventory years by gas

Year	**CO_2 (kt)**	**CH_4 (kt)**	**N_2O (kt)**	**Year**	**CO_2 (kt)**	**CH_4 (kt)**	**N_2O (kt)**
1989	-19,396.98	0.01	0.00	**2007**	-27,891.44	0.16	0.01
1990	-25,004.98	0.03	0.00	**2008**	-28,582.41	0.02	0.00
1991	-26,174.77	0.02	0.00	**2009**	-28,788.72	0.06	0.00

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)
1992	-27,062.29	0.05	0.00	**2010**	-28,499.12	0.01	0.00
1993	-28,099.49	0.03	0.00	**2011**	-27,111.29	0.14	0.01
1994	-28,774.18	0.02	0.00	**2012**	-26,488.81	0.42	0.02
1995	-28,328.09	0.01	0.00	**2013**	-26,521.16	0.03	0.00
1996	-27,746.65	0.01	0.00	**2014**	-27,663.34	0.01	0.00
1997	-28,231.35	0.00	0.00	**2015**	-27,387.81	0.10	0.01
1998	-30,033.19	0.01	0.00	**2016**	-28,184.66	0.04	0.00
1999	-29,259.68	0.02	0.00	**2017**	-27,184.22	0.15	0.01
2000	-28,926.35	0.23	0.01	**2018**	-26,552.39	0.08	0.00
2001	-29,863.74	0.06	0.00	**2019**	-27,129.51	0.15	0.01
2002	-27,786.03	0.22	0.01	**2020**	-26,832.92	0.32	0.02
2003	-27,695.02	0.05	0.00	**2021**	-26,655.80	0.13	0.01
2004	-27,271.84	0.01	0.00	**2022**	-26,108.19	0.81	0.04
2005	-28,722.37	0.01	0.00	**2023**	-27,431.54	0.50	0.05
2006	-28,748.23	0.06	0.00				

6.4.2.1.1 Change of C stocks in living biomass

The estimation of the annual FL–FL C stock change in biomass was done applying Equation 2.7 of IPCC (2006):

Equation 6.1 Estimation of the annual FL-FL C stock change in biomass

$$\Delta CLB = C_G - C_L$$

where:

ΔCLB = annual change in C stocks in biomass (includes above- and below–ground biomass) in FL–FL, tonnes C yr^{-1};

C_G = annual increase in carbon stocks due to biomass growth, tonnes C yr^{-1}calculated as multiplication of the activity data, i.e., area and country-specific growth rates;

C_L = annual decrease in carbon stocks due to biomass loss, tonnes C yr^{-1}. These estimates are derived from the statistics reported (NIS) on wood removals from the forest (i.e., wood harvest) and other losses (i.e., those due to forest fires and other disturbances).

Activity data. To achieve good accuracy, the activity data, i.e., forest area, is stratified in five species groups (conifers, beech, oaks, other hardwood species, and other softwood species), nine age classes (of 20 yr), and five yield classes. Forest area is stratified yearly for 225 forest structure classes (i.e., species group class x productivity class x age class) through the following steps:

(1) for the inventory years 1984 (NFFI), 2012, and 2018 (NFI), the forest area for each class (described above) was estimated as a proportion of the total forest (i.e., FL) in the inventory year;

(2) assuming constant changes between the inventory years and applying a linear interpolation, the share of each forest structure class was estimated for each year between the respective inventory years;

(3) for the period after 2018 year and before 1984 year linear extrapolation was used;

(4) assuming that the FL–FL forest structure is the same as that of FL, the data for each of the 225 classes was estimated by applying the calculated proportions to the total FL–FL area for the given year.

Equation 6.2 Activity data: FL-FL annual area by species, age class, and yield class

$$A_i = A_{FLFL} \times \ Percentage_i$$

where

A_i = forest area of species group, age-class, and yield class, kha i (i = 1…..225);

A_{FLFL} = the total area of forest land remaining forest land in a year, kha;

$Percentage_i$ = the class rate i (%) from the total FL–FL area in that year.

The annual C stock gains in biomass. The annual above–ground and below-ground C stock gains due to tree growth (CG) was estimated by applying the biomass growth factor estimated to each of the above class areas and different carbon fractions for broadleaves and conifers, using Equation 2.9 of IPCC 2006 guidelines:

Equation 6.3 Annual increase in above-ground and below-ground biomass carbon stock due to biomass growth in FL-FL

$$\Delta C_G = \sum_{i=1}^{225} A_i \times G_{TOTAL_i} \times CF_i$$

where:

ΔC_G = annual increase in above-ground and below–ground biomass carbon stock due to biomass growth in FL–FL, tonnes C yr^{-1};

A_i = forest area of class *i* in the *FL–FL* category, kha;

G_{TOTALi} = area–specific above-ground and below-ground biomass growth rate of class *i*, d.m. ha^{-1} yr^{-1};

CF_i = carbon fraction of dry matter of class *i*, tonne C $(tonnes\ d.m.)^{-1}$;

i = species group, age, and yield class as above.

The biomass growth factor G_{TOTALi} was estimated using equation 2.10 from the 2006 IPCC GL as follows:

Equation 6.4 Area-specific above-ground and below-ground biomass growth rate

$$G_{TOTAL_i} = Iv_i \times D_i \times BEF_1 \times (1 + R_i)$$

where:

G_{TOTALi} = area-specific above-ground and below-ground biomass growth rate, tonnes C $ha^{-1}yr^{-1}$;

I_{Vi} = net woody above-ground volume increment, volume estimated over bark including all branches with at least 5 cm diameter $m^3ha^{-1}yr^{-1}$ (Table 6.16);

D_i = basic wood density, tonnes d.m. m^{-3}, derived from national studies (Table 6.15);

R_i = ratio of below-ground biomass to above–ground biomass, dimensionless (Table 6.16);

BEF_i = biomass expansion factor;

i = species group, age class, and yield class as above.

Iv, average annual net woody increment. The annual increment (Iv) for each above class is estimated for the above-ground biomass from the 1984 NFFI stand data by applying country-specific yield tables (Giurgiu et al. 2004; Giurgiu and Draghiciu 2004). The net increment is estimated for the whole tree (including branches) in the case of broadleaves; for conifers, the values only include the merchantable volume. For indicative purposes, the average weighted annual net volume increment was estimated by species group using the share of the area of a class from the FL–FL category:

Equation 6.5 Average weighted annual net volume increment

$$\boldsymbol{Iv_{mean}} = \frac{(\sum_i \boldsymbol{A_i} \times \boldsymbol{Iv_i})}{\sum_i \boldsymbol{A_i}}$$

where *i* represents yield and age classes, **Table 6.14**.

Table 6.14 Time series of mean species group-specific weighted annual increment values in selected years ($m^3ha^{-1}yr^{-1}$). Co – coniferous, Be – beech, Oak – oaks, Hw – hardwood, Sw – softwoods

Year	Co	Be	Oak	Hw	Sw
	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$
1990	6.82	5.07	4.43	4.48	6.31
1995	6.89	5.18	4.40	4.47	6.47
2000	6.95	5.28	4.36	4.46	6.61
2005	7.03	5.38	4.33	4.45	6.74
2010	7.11	5.48	4.29	4.44	6.86

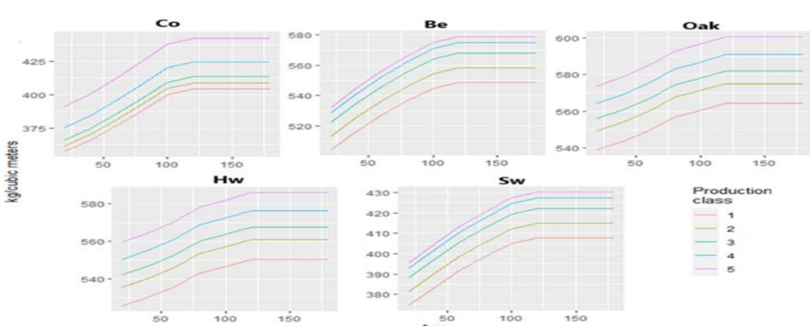
Year	Co	Be	Oak	Hw	Sw
	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$
2015	7.09	5.53	4.24	4.40	6.95
2020	7.03	5.54	4.19	4.37	7.00
2022	7.03	5.53	4.19	4.37	7.00
2023	7.03	5.53	4.19	4.37	7.00

The NFI second cycle (2018) provides both estimates of the increment for each species group and actual loss due to harvest. These data differ considerably from the national statistics from the forest district's mandatory reporting concerning growth rates estimated based on the above yield tables and actual harvested wood volumes. The discussions among scientists, stakeholders, and authorities within the country on these differences are still open. Further assessment is needed to fully understand the discrepancies between NFI results and the other sources. To be consistent, for the whole time series of this GHG inventory, Romania has used the more conservative dataset for both increment and the amount of harvest (see below).

The biomass expansion factor (BEF1) estimates the above-ground volume from the available merchantable volume for conifers (as the yields tables only estimate the merchantable volume growth for these species). The BEF1 for conifers is estimated using Table 3A.1.0 from the Good Practice Guidance for LULUCF 2003 (1.15, dimensionless). For broadleaves, the BEF1 value is equal to one.

Country–specific wood density (D) values are available from Giurgiu et al. (2004). Using density values for 19 tree species and additional data for yield classes and age classes for Beech, Sessile Oak, and Spruce, mean wood density values for each of the five species groups were computed for age and yield class, Figure 6.13.

Figure 6.13 D as a function by yield class and age for the five species groups Co – conifers, Be – beech, Ok – oaks, Hw – hardwoods, Sw – softwoods



For indicative purposes, average wood density (D_{mean}) was estimated for each species group as a weighted average computed from the area of the corresponding age and yield class in a year and is reported in Table 6.15:

Equation 6.6 Average wood density

$$D_{mean} = \frac{\sum_i (A_i \times D_i)}{\sum_i A_i}$$

where *i* represents yield and age classes (note that the calculated mean values change over time due to the change of the forest structure only).

Table 6.15 Time series of mean species group-specific weighted annual mean wood density values in selected years (m^3 ha^{-1} yr^{-1}). Co – coniferous, Be – beech, Oak – oaks, Hw – hardwood, Sw – softwoods

Year	Co	Be	Oak	Hw	Sw
	t d.m. m-3	t d.m. m-3	t d.m. m-3	t d.m. m-3	t d.m. m-3
1990	0.387	0.551	0.567	0.554	0.399
1995	0.388	0.549	0.567	0.554	0.400
2000	0.388	0.548	0.567	0.554	0.402
2005	0.389	0.547	0.567	0.554	0.403
2010	0.390	0.546	0.567	0.554	0.405
2015	0.391	0.546	0.568	0.554	0.405
2020	0.391	0.547	0.568	0.554	0.406
2022	0.391	0.546	0.568	0.554	0.406
2023	0.391	0.546	0.568	0.554	0.406

The C fraction (CF) of dry matter is assumed to be the IPCC 2006 GL (Table 4.3) default value of 0.48 for conifers and 0.51 for broadleaves, tonnes C $(t.d.m)^{-1}$.

Using country-specific factors, the Root-to-shoot factor (R) was applied differently for specific species groups (Giurgiu et al. 2004, Table 6.16).

Table 6.16 Root–to–shoot factor value by species group (dimensionless)

Species groups	Root to shoot factor value
Conifers	0.19
Beech	0.19
Oaks	0.22
Hardwoods	0.20
Softwoods	0.20

The estimated total carbon stock gains from biomass growth, activity data, and mean emission factors (reported for demonstrative purposes only) for the FL-FL category are presented in Table 6.17.

Table 6.17 The activity data and mean emission factor used in the estimation of C gain in LB for the FL–FL category for selected years

Year	FL–FL area	Mean annual increment Iv	Calculated mean annual wood density D	Calculated mean root–to–shoot ratio R	Calculated mean carbon fraction of dry matter CF	Annual C gain in LB ΔCG
	kha	$m^3\ ha^{-1}\ yr^{-1}$	t d.m. m^3	dimensionless	t C t dm^{-1}	Kt C yr^{-1}
1990	6,666.27	5.812	0.495	0.197	0.501	11,008.96
1995	6,709.51	5.830	0.496	0.197	0.501	11,160.90
2000	6,752.23	5.848	0.498	0.197	0.501	11,312.90
2005	6,792.79	5.867	0.499	0.197	0.502	11,462.15
2010	6,814.83	5.885	0.501	0.198	0.502	11,580.79
2015	6,841.34	5.860	0.502	0.198	0.502	11,610.26
2020	6,868.05	5.807	0.502	0.198	0.502	11,608.00
2022	6,879.57	5.829	0.502	0.198	0.502	11,626.56
2023	6,885.32	5.829	0.502	0.198	0.502	11,338.85

The annual C stock losses from biomass. The annual biomass C stock losses (C_L) are estimated from the annual harvest statistics ($H_{FL\text{-}harvest}$). The $H_{FL\text{-}harvest}$ account for all the biomass losses in the FL category. The values include, although not separately:

i. wood harvested in normal forestry operations, e.g., from thinning and final harvest, and

ii. wood extracted from trees damaged or killed by disturbances such as windstorms and forest fires.

To avoid double-counting, the amount of harvest that is accounted for FL-FL is calculated by subtracting the losses due to harvest resulting from the deforestation from $H_{FL\text{-}harvest}$:

Equation 6.7 Annual carbon loss due to the harvest and disturbances

$$H_{FLFL-harvest} = H_{FL-harvest} - H_{D-harvest}$$

where:

$H_{FL\text{-}harvest}$ = annual carbon loss due to the harvest and disturbances from the entire forest land [tC yr^{-1}];

$H_{D\text{-}harvest}$ = annual carbon loss due to deforestation [tC yr^{-1}].

NIS's total harvest ($HFL_{\text{-harvest}}$) data results from each district's aggregated reported values on wood removals in each specific year. The harvest values are provided for the same species groups used for C stock gain estimation. The wood volume resulting from the harvest activity (Table 6.18) includes for all species the total tree above-ground volume estimated over bark, including all branches with at least 5 cm diameter (for both broadleaves and conifers, Technical Norms for commercial wood volume assessment, O.M no. 1651/2000, MAPPM). Therefore, conifers are not required to apply a BEF (as in the C gain calculation) to estimate losses from harvest (Giurgiu et al. 2004).

Table 6.18 $H_{FL\text{-}harvest}$ data provided by the NIS for selected years (1000 m^3 yr^{-1}) for Co – conifers, Be – beech, Oak – oaks, Hw – hardwoods, and Sw - softwoods

Year	$H_{FL-harvest}$ (1000 m^3 yr^{-1})					
	Co	Be	Oak	Hw	Sw	Total harvest
1990	5,813.40	4,957.80	2,045.40	2,070.70	1,761.70	16,649.00
1995	4,973.10	4,214.70	1,550.50	1,774.40	1,300.00	13,812.70
2000	5,346.10	4,508.40	1,333.00	1,731.00	1,366.20	14,284.70
2005	6,060.50	4,794.20	1,586.10	1,852.10	1,378.40	15,671.30
2010	6,832.20	5,654.20	1,565.90	1,784.30	1,155.00	16,991.60
2011	7,521.20	6,174.90	1,747.20	1,946.30	1,315.40	18,705.00
2012	7,615.10	6,332.10	1,687.10	2,014.40	1,432.50	19,081.20
2013	7,921.80	6,226.50	1,741.60	1,968.90	1,423.30	19,282.10
2014	7,225.00	5,836.60	1,664.10	1,876.00	1,287.60	17,889.30
2015	6,782.20	6,215.50	1,768.60	1,950.60	1,416.20	18,133.10

Year	$H_{FL-harvest}$ (1000 m^3 yr^{-1})					
	Co	Be	Oak	Hw	Sw	Total harvest
2016	6,268.20	5,798.30	1,687.90	2,008.30	1,434.80	17,197.50
2017	6,530.70	6,211.50	1,788.50	2,227.60	1,557.50	18,315.80
2018	7,127.40	6,583.00	2,041.00	2,190.00	1,518.00	19,459.42
2019	6,961.90	6,430.40	1,927.10	2,163.00	1,421.30	18,903.70
2020	8,261.10	6,109.80	1,894.20	2,096.00	1,290.90	19,652.00
2022	7,334.30	6,469.00	2,215.00	2,531.70	1,688.10	20,238.10
2023	7,179.30	6,194.70	2,035.50	2,280.20	1,480.60	19,170.30

The loss of biomass carbon due to the annual harvest values was computed according to equation 2.12 of IPCC (2006) as follows:

Equation 6.8 Loss of biomass carbon due to the annual harvest values

$$C_{Li} = H_{FLFL-harvest\ i} \times D_i \times (1 + R_i) \times CF_i$$

where:

$H_{FLFL\text{-}harvest}$ = total annual volume of wood extracted [m^3 yr^{-1}] (Table 6.18);

D_i and R_i = derived from national data and used consistent with respective values for the annual biomass growth and below-ground estimation above, respectively (Table 6.19 and 6.20);

CF_i = carbon fraction, tC tdm^{-1}, applied consistent with values for estimation of C gain (i.e., 0.51 for broadleaves and 0.48 for conifers);

ki = species group (Co, Be, Oak, Hw, Sw).

The carbon stock losses in the biomass pool, calculated on the harvest reported values and the emission factors (estimated for indicative purposes), are presented in Table 6.19.

Table 6.19 The activity data and mean emission factors used in the estimation of C losses in the LB for FL-FL category

Year	Annual wood harvest volume in FL–FL $H_{FL-harvest}$	Annual wood harvest in D $H_{D-harvest}$	Calculated mean annual wood density D	Calculated mean root–to–shoot ratio R	Calculated mean carbon fraction of dry matter CF	Initial Annual C loss in FL–FL	Corrected* Annual C loss in FL–FL
	1000 m^3/yr	1000 m^3/yr	t d.m. m^{-3}	dimensionless	tC $d.m^{-1}$.	ktC yr^{-1}	ktC yr^{-1}
1990	16,027.06	621.94	0.480	0.196	0.500	-4,618.18	-7,294.42
1995	13,155.79	656.91	0.480	0.196	0.499	-3,786.08	-5,141.26
2000	13,443.52	841.18	0.477	0.195	0.499	-3,840.04	-5,213.23
2005	14,763.47	907.83	0.476	0.195	0.498	-4,208.38	-5,541.32
2010	16,040.08	951.52	0.476	0.194	0.498	-4,567.35	-5,856.13
2015	17,431.30	701.80	0.480	0.195	0.499	-5,008.13	-6,221.32
2021	18,911.14	740.86	0.475	0.195	0.497	-5,362.66	-6,510.12
2022	19,497.24	740.86	0.482	0.195	0.499	-5,483.50	-6,610.55
2023	18,429.44	740.86	0.481	0.195	0.491	-5178.63	-6172.30

** The annual carbon loss in the FL–FL category was corrected by applying an overlap method between the initial Gain and Loss method and stock difference estimates from the NFI.*

Including estimates from the National Forest Inventory (NFI). The NFI provides national-level estimates of growth and harvested volumes between two inventory cycles. The estimates from the NFI significantly differ from those provided by the National Forest Administration by a margin that yields similar values regarding the estimated carbon (C) stock change factor (see Table 6.20). Additionally, the NFI estimates are available between 2008 and 2017, covering two five-year cycles, which poses challenges for reporting across the entire time series. Moreover, due to differences in the initial sampling points for area and forest standpoint sampling between the inventories, the decision was made not to use these estimates for the gain and loss method (i.e., growth and harvest). However, based on data collected by the NFI, **a stock difference method was applied for the inventoried period**. This estimation adhered to the assumptions outlined in IPCC Chapter 4 requirements, i.e., to be used in the same area. The stock change approaches estimated adhere to the following criteria:

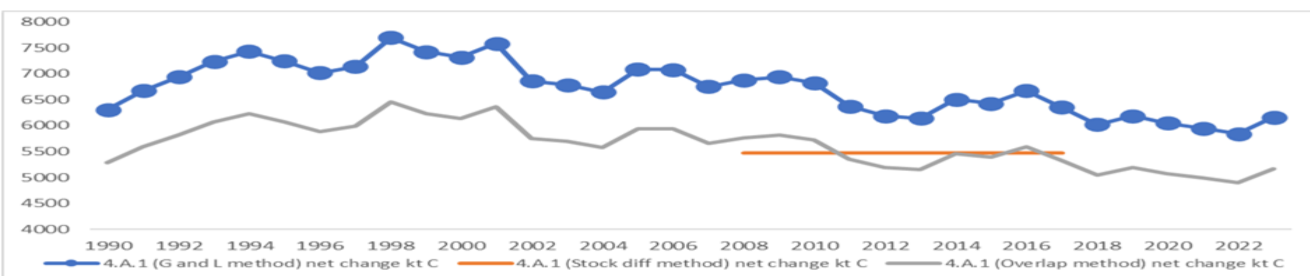
- taking into consideration common areas between the two inventories.
- including in the estimation only plots existing in both inventories.
- assuming the same subplot areas between the two inventories.
- applying a net difference approach for each plot and aggregate to country estimates.

Table 6.20 The implied emissions factors for both NFI and NIS and the calculated impacts on the trend of C stock change from LB in the FL–FL category for 2012–2017 by applying NFI data instead of those by the NIS

Year	**Implied net C stock change factor**	
	t C ha yr^{-1}	
	NFI	**NIS**
2012–2017	0.9	1.0

Between the two sets of estimates–namely, the time series for gain and loss and the stock change during the National Forest Inventory (NFI) implementation period–an overlapping method was employed to adjust the estimate for the entire time series. This application of the overlap method reduced the overall stock in the living biomass (LB) by approximately 10% (refer to the Figure). For comparison purposes, the annual C loss in FL–FL values is included in Table 6.19.

Figure 6.14 **Comparison of Initial and Corrected Carbon Stock Change Estimates Using the Overlap Method.**



6.4.2.1.2 Change of C stocks in dead organic matter

Tier 2 stock–difference estimation method was used, as described in section 2.3.2 of Chapter 2 of the IPCC 2006 guidelines, to estimate the change in carbon stock in the DOM carbon pool. To estimate the carbon stock in the deadwood pool, we used data from national forest inventory data on deadwood (DW) at two different points in time. Data for standing and laying DW on the ground is available for the inventory years 2012 and 2017. Between these two NFI cycles, there was a significant increase in standing DW and a significant decrease in laying DW, with an overall net increase in deadwood biomass. This increase may be due to various factors, such as lower harvest rates, growth in biomass due to age-related structure, sustainable forest management practices, and natural disturbances. In addition, Romania's forest management practices aim to conserve biodiversity by preserving deadwood within ecological limits set by regulations (Low no. 46/2008, art 26.4). To estimate the annual change in carbon stock (CSC) in DW, we used a stock change approach based on the inventory years 2012 and 2017, Table 6.21.

Table 6.21 DW quantities measured during a five years interval NFI and emission factors used carbon estimates

Year	Species group	DW on ground	DW standing	Corresponding area where DW was measured (NFI)	D for DW on the ground	D for DW standing	R for DW standing	CF
Unit		m^3	m^3	ha	t d.m. m^{-3}	t d.m. m^{-3}	dimensionless	tC $d.m^{-1}$
1	2	3	4	5	6	7	8	9
2012	Conifers	32,105,84	0	1,796,09	0.21	0.29	0.19	0.51
2012	Broadleaves	36,199,71	0	5,104,87	0.19	0.31	0.20	0.48
2017	Conifers	28,177,74	14,488,004	1,777,21	0.21	0.29	0.19	0.51
2017	Broadleaves	35,795,37	26,873,888	5,151,83	0.19	0.31	0.20	0.48

According to the initial data, the average CSC per unit area was estimated for the period 2012–2017, Table 6.22.

Table 6.22 Example of estimation method used to calculate the CSC in DW

C stock of DW on ground	C stock of DW standing (including below-ground DW)	Total DW stock	Area-specific C stock	Area of new FL–L type forest	Area of new L–FL type forest	Assumed C stock on L–FL	Assumed C stock on FL–L	Assumed C stock on L–FL	Assumed C stock on FL–L	Area of FL–FL	Stock change on FLFL for 5 years	Area-specific stock change on FL–FL for 5 years	DW C stock change
tC	tC	tC	tC ha-1	ha	ha	tC ha^{-1}	tC ha^{-1}	tC	tC	ha	tC	tC ha^{-1}	tC ha-1 yr^{-1}
10	11	12	13	14	15	16	17	18	19	20	21	22	23
3,166,920.06	0.00	3,166,920.06	1.76			0.00	1.76	0.00	0.00	1,796,095.00			
3,553,906.53	0.00	3,553,906.53	0.70			0.00	0.70	0.00	0.00	5,104,867.00			
2,779,451.98	2,424,735.53	5,204,187.51	2.93	18,881.00	0.00	0.00	2.93	0.00	55,288.93		2,092,556.38	1.17	
3,514,210.84	5,164,301.31	8,678,512.15	1.68	0.00	46,966.00	0.00	1.68	0.00	0.00		5,124,605.62	1.00	
TOTAL											**7,217,162.00**	**1.05**	**0.21**

where:

10 – C stock, according to DW on the ground, estimated as the product of wood volume on the ground (3), wood density (6), and CF(9);

11 – C stock, according to DW standing, estimated as the product of standing wood volume (4), wood density (7), root–to–shoot factor (8), and CF (9);

12 – total DW C stock, estimated as the sum between C stock in DW on the ground (10) and C stock in DW standing(11);

13 – area–specific carbon stock, estimated as the division between total DW C stock (12) and forest area (5);

15 – the area of L–FL type, estimated as the difference between inventory years of forest area (5) and adding FL-L area (14);

17 – similar to area–specific carbon stock (13);

18 – assumed C stock in L–FL estimated as the product between the area of L–FL (15) and carbon stock on L–FL area type (16);

19 – assumed C stock in FL–L estimated as the product between area fo FL–L (14) and carbon stock on FL–L area type (17);

21 – C stock change on FL–FL on five years, estimated as the difference between total DW stock between two inventories (12), adding C stock on FL–L (19), subtracting C stock on L–FL (19);

22 – area-specific on FL–FL for five years estimated as C stock change (21) divided by area of FL–FL (20);

23 – annual carbon stock change in DW estimated as the sum of the area-specific stock change in FL–FL for five years divided by area (5).

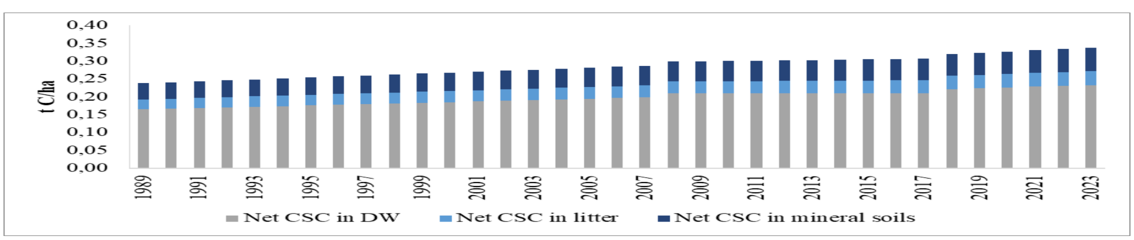
To estimate the carbon stock change in the deadwood pool outside of the 2012–2017 inventory period, we used the standing stock in living biomass as a reference and estimated the area-specific carbon stock in deadwood.

In the case of litter, no measurements were provided by the NFI. We used inventory data on forest area, group species, age classes (see section 6.2.2.1), and growth to estimate the annual carbon stock change in the litter pool using the EFISCEN model.

The European Forest Information Scenario Model (EFISCEN) is a dynamic simulation model used to project the development of European forests under different scenarios. It covers forest resources, forest management practices, and economic aspects of forestry, using a set of indicators to describe the state and development of forest resources, including the age structure of forests, tree species composition, forest area, and growing stock. EFISCEN includes a module (Yasso) that simulates the carbon dynamics of forest ecosystems, including the carbon stored in the soil and litter layers. The carbon stocks in the soil and litter layers were estimated based on various factors such as the type of vegetation, the climate, and forest management practices.

Due to a lack of data, we chose a straightforward model to estimate carbon in DOM and SOC pools, with minimal data entry required using Yasso under EFISCEN. Using the age classes area matrix from the first inventory, multiple simulations were run to identify the best fit for estimating more accurate values, such as growing stock, net annual increment, deadwood, and harvest intensity, compared to actual measurements taken in the second forest inventory. Once the initial parameterization was established (i.e., share of biomass compartments, harvest intensity, initial carbon stock in litter and soil) that successfully reflected the second inventory data, the simulation was run from the second inventory year, 2017, onwards.

Figure 6.15 Annual carbon stock change in DOM and SOC pools.



6.4.2.1.3 Change of C stocks in forest soils

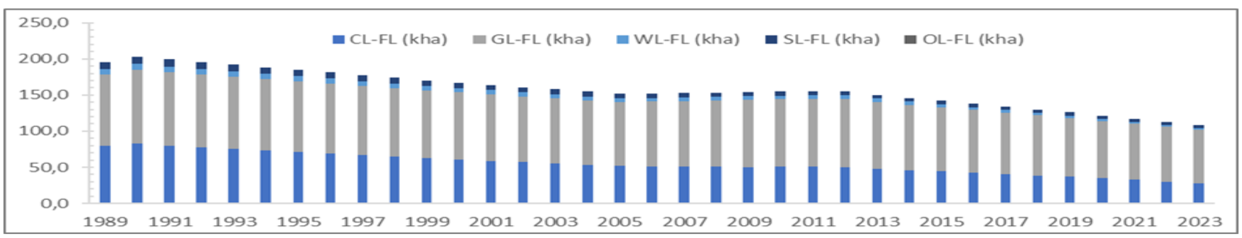
To estimate the change in mineral soil carbon stock, we used the same modeling approach as described in the DOM pool.

The forest area on organic soils in the country is 2.546 kha. We estimated CO_2 emissions from organic soils using the IPCC methodology, applying the default Emission Factor (EF) for Drained Forest land in the temperate zone, as given in Table 2.1 of the IPCC Wetlands Supplement.

6.4.2.2 Land converted to Forest Land (CRT 4.A.2)

Activity data. The land area converted to the FL category (L–FL) is obtained by applying the land identification methodology presented in Chapter 6.3. In Romania, the conversion to forest land occurs through artificial afforestation activity at a much higher rate than natural forest expansion, i.e., the natural establishment of stands. The land in conversion to forest land from each IPCC subcategory is estimated from the CLC analysis, Figure 6.16.

Figure 6.16 Annual area under conversion reported in the 4.A.2 category



The AD for the afforestation areas is collected annually from NIS, where forest districts report it. Regarding the natural establishment of forest stands, the area is estimated by the difference between the total land in conversion to forest land and the AR.

Annual C stock changes in biomass

The carbon stocks change estimates, and total emissions equivalent are presented in Table 6.23.

Table 6.23 The carbon stock change estimates and total CO_2 emissions in the 4.A.2 category

Year	Net carbon stock change LB	Net carbon stock change DOM	Net carbon stock change SOC	Emissions 4.A.2
	kt C	kt C	kt C	kt CO_2
1989	188.27	17.41	395.31	-2,203.63
1990	197.91	16.87	409.98	-2,290.78
1995	180.72	13.52	371.58	-2,074.68
2000	160.13	12.67	334.34	-1,859.49

Year	Net carbon stock change LB	Net carbon stock change DOM	Net carbon stock change SOC	Emissions 4.A.2
	kt C	kt C	kt C	kt CO_2
2005	148.76	12.82	301.90	-1,699.44
2010	176.97	13.29	306.19	-1,820.33
2015	208.87	12.50	280.08	-1,838.62
2020	200.33	8.07	238.59	-1,638.99
2022	187.41	6.88	220.14	-1,519.58
2023	176.42	6.53	210.92	-1,444.19

To estimate the carbon stock in LB, a differentiation is made between the two L–FL sub–categories. The afforestation areas are estimated by assuming that each year, the share of species composition of the afforested area is the same: i.e., 20% for poplar (Populus sp.), 40% for Black locust (Robinia pseudoacacia L.), and 40% for Oaks and other broadleaved species.

These values correspond to these species' share in afforestation projects over the last ten years and are based on estimates developed in two research projects, which allow biomass estimation in the L–FL conversion lands:

1) Reports on the implementation of the monitoring plan of the project "Afforestation of Degraded Agricultural Land Project in Romania" that was conducted as part of a "Joint Implementation (JI)" project under the Kyoto Protocol. The monitoring is carried out by the Forest Research Management and Planning Institute (Romania) according to the "Monitoring Plan for Changes in Carbon Stocks in Forest Plantations," as agreed by partners in the project. Project-related documents are available at INCDS. This plan covers all issues related to sampling, measuring, processing, reporting, and archiving data and information. Data from the second verification of carbon stock accumulated in the project was collected in 2012. The second independent verification of the project was achieved in 2014, and the verification report is available on request.

2) The research project "Modelling Carbon Storage in the Transitional Ecosystem Structures Associated with Forest Land Use Change in Romania (FORLUC)" was financed by the Ministry of Education and Research (Romania) during the 2006–2009 time period. The final report is available at ICAS Bucharest, and some results were published in peer-review journals.

The outcomes of these two projects have facilitated the derivation of biomass equations for the eight forest species that are the most used in plantations on degraded lands in Romania. Both projects estimate C stock changes in the biomass pools based on sampling in about 240 plots (all geo-referenced, with 176 plots re–measured in 2017 by the JI project). Relevant biometric data of trees in sampling plots were registered with administrative information (parcel coding, location, and age). Available stand data were aggregated based on shares of the main tree species (i.e., Black locust, Oak, and softwoods, i.e., poplar and willows), allowing for the derivation of the time series of the biomass C stocks for the three main types of young stands in plantations, Table 6.24.

Table 6.24 The annual amount of C (tC ha-1 yr-1) sequestered in biomass in forestry plantations over age (for the first 20 years of their growth) as measured in the two research projects

Plantation age	Poplar & Willow	Black locust	Oak
yr	**tC ha^{-1} yr^{-1}**	**tC ha^{-1} yr^{-1}**	**tC ha^{-1} yr^{-1}**
1	0.1	1.2	0.3
2	1.7	1.6	0.7
3	2.2	1.9	1.1
4	2.4	2.3	1.4
5	2.4	2.6	2.0
6	2.4	3.0	2.4
7	2.4	3.3	2.9
8	2.3	3.7	3.4
9	2.3	4.0	4.0
10	2.2	4.3	4.4
11	2.1	4.4	4.9
12	2.0	4.6	4.3
13	1.9	4.6	4.7
14	1.8	4.6	4.9
15	1.7	4.4	6.0
16	1.6	4.3	6.1
17	1.4	4.0	6.0
18	1.4	3.8	4.9
19	1.3	3.4	4.8
20	1.3	3.1	4.6

To estimate the LB in the areas where the natural establishment of stands occurred (i.e., new forest stands not identified in a previous cycle of NFI), the average Iv from NFI for the age category of of 0 – 20 is used. By multiplying the Iv by the average wood density, root–to–shoot ratio, and carbon fraction, Table 6.17

shows the EF of 0.96 tC ha-1 yr-1.

Annual C stock changes in the dead organic matter pools

For all L–FL area types, the JI project data is used to report C stock changes in the DOM pool, Table 6.25.

Table 6.25 Annual area–specific C stock change in the DOM pool for the L–FL category

Age	Annual C stock change in the DOM pool
yr	t C $ha^{-1}yr^{-1}$
1	0.04
2	0.04
3	0.08
4	0.13
5	0.18
6	0.21
7	0.22
8	0.20
9	0.16
10	0.13
11	0.09
12	0.06
13	0.04
14	0.03
15	0.02
16	0.01
17	0.01
18	0.01
19	0.01
20	0.01
25	0.01

Annual soil C stock changes

Conversion to forests occurs only on mineral soils. Currently, the estimation of C stock change in mineral soils is based on national level reference C stocks, Table 6.26, which are computed from the results of the project "Monitoring soil quality in Romania" (ICPA, 2006) and, in the case of forest land, from the Forest management plans database. The C stock changes are assumed to occur during the IPCC default 20–year transition period.

Table 6.26 C stocks and C stocks change in mineral soils by conversion types

<table>
<tr><th colspan="2" rowspan="2">Land use categories</th><th colspan="5">C stock (tC ha^{-1}) values in the diagonals, C stock changes (tCha^{-1}yr^{-1}) elsewhere in from the "to" land-use categories</th></tr>
<tr><th>CL</th><th>GL</th><th>WL</th><th>SL</th><th>OL</th></tr>
<tr><td>from</td><td>FL</td><td>2.14 (Ag)
2.23 (Vv)
2.23 (Lv)
2.23 (Ata)</td><td>1.85 (Pp)
1.85 (Pf)
1.85 (Pa)
1.50 (AtVF)
1.50 (Jn)
1.50 (Tf)</td><td>2.20</td><td>2.60</td><td>2.15</td></tr>
</table>

When developing Table 6.26 using country-level averaged data, several assumptions were made, including:
i) because the majority of Wetlands with vegetation occur on mineral soils in Romania, similar soil C stock was assumed as for Grassland;
ii) soil C stock in Settlements was estimated to be 32 t C ha^{-1} assuming that the top 10 cm of the mineral soil of cropland has been removed;
iii) soil C stock of 41 t C ha^{-1} in soils under other lands category was computed as the weighted average of rocky areas (5 t C ha^{-1}) as well as deposits of interior rivers (10 t C ha^{-1}) and the Danube floodplain (60 t C ha^{-1}), each assumed to cover 33 % of the total area of other lands. The definition of organic soils adopted for reporting emissions from these soils is in line with the nationwide available soil data: organic soils under any land use are classified as histosols and are characterized by more than 40 cm peat layer with at least 20% organic content. Such organic soils occur in Romania in small areas (under natural reserves) at high altitudes with no artificial plantations. Therefore, no emissions from organic soils under the L–FL category are reported.

6.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

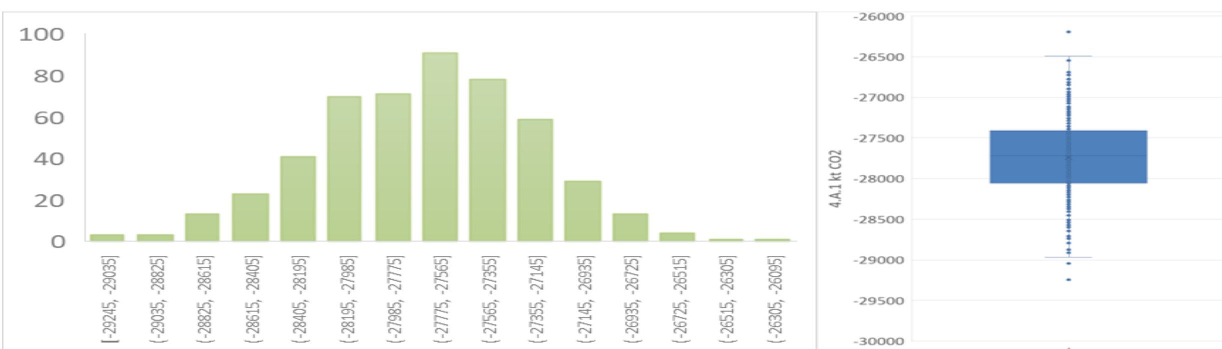
6.4.4 Uncertainty assessment and time-series consistency

To estimate the C stock change in category 4.A, we used consistent emissions factors throughout the time series, ensuring no bias. Our land assessment methodology combines two overlapping trends for total Forest Land (FL) area. This was harmonized using the latest NFI data for accuracy (see section 6.8).

The NFI-based forest area uncertainty (used for reporting total FL area in 2012 and 2018) is 1.024%. For forest area estimates prior to 2011, we applied a 5% uncertainty (based on expert judgment and cross–validation with additional geospatial data). AD trends for category 4.A.1 reflect conversion rates derived from a point sampling method, adjusted to match the overlapping trend.

We used a Monte Carlo analysis with error propagation to estimate category 4.A.1 uncertainty. This involved analyzing standard deviations for each AD and EF in the category through 500 repetitions. The overall uncertainty for 2023 is 5.30%, with Monte Carlo results presented in Figure 6.17.

Figure 6.17 **Monte Carlo Analysis of Carbon Stock Change in the 4.A.1 Category**



We determined the Activity Data (AD) uncertainty for category 4.A.2 using the point sampling area identification method (section 6.1.4). A 50% uncertainty was quantified for conversion areas through cross–checking with additional geospatial data.

The Emission Factor (EF) uncertainty aligns with values used in the Monte Carlo analysis of category 4.A.1. This analysis, with an average EF uncertainty of 15%, resulted in an overall uncertainty of 52.2% for the year 2023 (Table 6.27).

Table 6.27 The results of the uncertainty analysis of the 4.A. category

IPCC category/Group	Gas	Base year emissions (+) or removals (-)	2022 emissions (+) or removals (-)	Activity data uncertainty	Emission factor/estimation parameter uncertainty	Combined uncertainty
4A2 Land converted to Forest Land	CO_2	-19,396.98	-27,419.2861	10.00%	15.00%	18.03%
4A1 Forest Land remaining Forest Land	CH_4	-2203.63	-1444.19	50.00%	15.00%	52.20%
4A2 Land converted to Forest Land	CH_4	0.16	28.15	51.00%	99.00%	111.36%
4A1 Forest Land remaining Forest Land	N_2O	0.00	0.00	51.00%	99.00%	111.36%
4A2 Land converted to Forest Land	N_2O	0.08	14.73	51.00%	99.00%	111.36%

6.4.5 Category–specific QA/QC verification, if applicable

The national inventory reporting within the LULUCF sector incorporates three levels of QA and QC measures:

1. First Level: Data providers conduct initial QC procedures to ensure the quality and accuracy of the data submitted to GHG inventory compilers. This involves applying official procedures to maintain data integrity.
2. Second Level: GHG inventory compilers conduct extensive QC/QA checks, which include:

- Establishing and adhering to step-by-step methods to prevent data management errors, particularly when using complex Excel spreadsheets.
- Verifying land use classifications through repeated assessments of sensitive cases, such as forest conversions and forest/non-forest areas, cross-referencing with other data sources, and consulting experts for clarification on specific issues.
- Cross-checking Intergovernmental Emission Factor (IEF) values against those reported by other

European Union (EU) countries.

- Conducting graphical checks to ensure the smoothness of time series for each land use category and emissions from each carbon (C) pool, addressing any outliers and providing explanations for extreme values in the inventory text.
- Archiving hard or digital copies of original data on all land use categories, including statistical reports, databases with digital maps, and aerial photography.
- Completing and verifying the "List for Quality Control of the National Inventory Report " by different employees of the "Marin Drăcea" National Institute of Research and Development in Forestry, Bucharest.

1. Third Level: Final QA is carried out by the Ministry of Environment department responsible for the National Inventory Report. This involves comprehensive checks related to both the Common Reporting Format (CRT) and all National Inventory Documnet (NID) chapters, ensuring overall accuracy and compliance with national and international standards.

6.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

In the 2025 inventory, no recalculation were made in the 4.A.1. and 4.A.2 categories.

6.4.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

The concerted effort and collaboration among all stakeholders involved in LULUCF sector have steadily progressed over the pasts years, beginning in late 2019 with the initiation of new national inter–institutional agreements. A consistent focus has been placed on enhancing the CO_2 estimation procedure, coupled with an ongoing Quality Assurance/Quality Control (QA/QC) process. Planned improvements encompass:

- Developing coherent and harmonized land identification across all land use and land–use change categories, incorporating spatial information throughout the entire time series.
- Conducting uncertainty evaluations and checks pertaining to the land identification system.
- Enhancing the uncertainty analysis of emission factors.
- Conducting a detailed key category analysis using the latest estimates.
- Harmonizing national statistical data reported annually with National Forest Inventory (NFI) estimates

throughout the entire time series.

- Strengthening collaboration with Land Parcel Identification System (LPIS) data providers and the Cadastral Office.

6.5 Cropland (CRT 4.B)

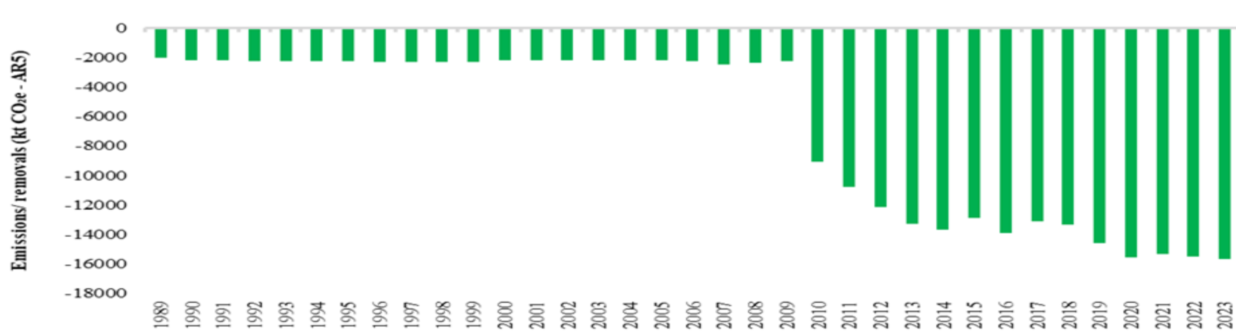
6.5.1 Category description

The CRT 4.B land use category includes arable land, orchards, vineyards, shrub crops, Figure 6.18.

Figure 6.18 4.B land use category. EGM – explicit geospatial map

The following figure include a 4.B summary of GHG E/R estimates:

Figure 6.19 4.B GHG E/R evolution across the time period (kt CO_2 eq.)



In CRT 4.B land use category estimates were based on *IPCC 2006 Guidelines, V.4, Ch. 5*. Anthropogenic GHG E/R estimates on 4.B land use category occur as a result of changes in management practices on cropping lands, crop type and from land use, and include: ***(i)*** total crop area; ***(ii)*** crop type and rotation; ***(iii)*** combustion practices; ***(iv)*** processing techniques; ***(v)*** application of fertilizers; ***(vi)*** irrigation; ***(vii)*** manure application; ***(viii)*** soil improvers. Permanent changes in management practices generate changes in the levels of soil carbon or woody biomass stocks over the longer term. Changes in carbon stock levels during the transition period to a new stock equilibrium are recorded under 4.B land use category.

Combining, processing and querying information

LULUCF surface management involved in this process for current inventory reporting have undergone particularly important changes. The type 3 approach was initiated in 2020, continuing with the same model to build an explicit geospatial database of areas in key categories CL and GL, as well as in WL, SL, OL. The classification is now more detailed, according to the subcategories of land use, Chapter 6.1, Figure 6.3. The main data sources used are:

(i) The Romanian LPIS, a component of the IACS, operates at the reference parcel level. It utilizes aerial and satellite orthophoto imagery that meets uniform standards, ensuring accuracy comparable to mapping at a 1:5000 scale. The imagery features a pixel size of 0.5 meters, delivering submetric precision and covering approximately 70% of the nation's agricultural and pasture areas. Source files are provided in ESRI shapefile format and utilize the Stereo 70 projection system (EPSG: 31700). These files include associated databases containing land use information. The data is updated annually by the designated institution, with initial coverage starting in 2007.

(ii) Corine Land Cover (CLC), a product of the Copernicus European Union Earth Observation Programme, provides an inventory of land use categories classified into 44 distinct land use classes. These classifications are derived through visual interpretation of high-resolution satellite imagery, with geospatial data characterized by minimum unit area of 25 hectares. The greenhouse gas (GHG) inventory began in 1985, with the 1990 reference year, and has been updated in 2000, 2006, 2012, and 2018. The source files are provided in Geopackage SQLite Database format, utilizing the Lambert Azimuthal Equal-Area projection system (ETRS–89 – LAEA, EPSG: 3035), which is standard across the EU.

One key objective achieved in this submission was extending the Type 3 approach, used since the 2012 reporting period, to include data from 2007 onwards. This extension coincides with the initiation of the geospatial management information system for plots at APIA. Given the six-year update frequency for CLC graphical and alphanumeric databases was exceeded for the previous submission, Romania established a criterion for validating the CLC data. This approach ensured the best possible approximation of land use during the period under review and facilitated more accurate assessments of land-use changes. The higher update frequency of the APIA-LPIS system (annual) provides greater temporal precision compared to CLC data. To address the discrepancy in update frequencies, Romania developed a rule for combining CLC and APIA datasets to represent the most accurate field conditions. For instance, combining CLC 2006 data with

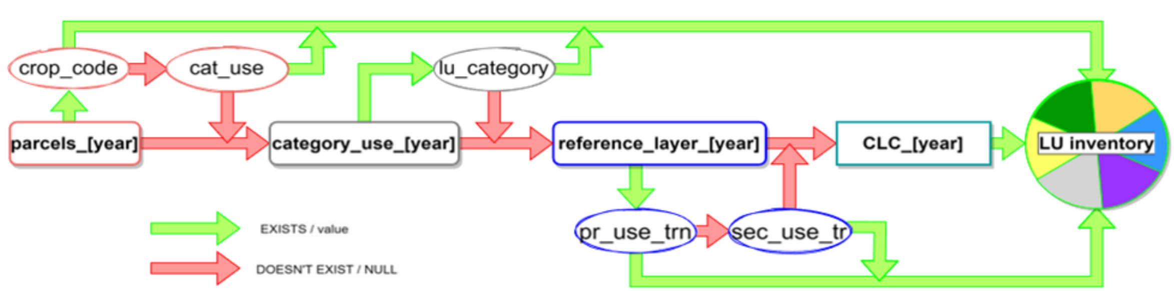
APIA datasets from 2007 to 2012 introduces inaccuracies as field changes accumulate.

Consequently, Romania determined that after three years, accumulated land-use changes necessitate transitioning to the next CLC instance. This approach acknowledges that while the 2012 CLC data best represents that year, by 2010, it is already more accurate than the 2006 instance. Applying this rule ensures a more precise representation of changes and informs subsequent updates. For example, when CLC 2024 is released, datasets for 2022 and 2023 will be recalculated using the updated data rather than CLC 2018.

For the NGHGI 2024 submission, revised versions of CLC maps were utilized. The updates included versions of CLC 2006, CLC 2012, and CLC 2018 based on v2020 revisions, which were made available on the Copernicus website. Romanian coverage was separated from the EU-wide maps, with a margin retained at boundaries to account for potential projection transformation approximations. Following the projection transformation from ETRS–89 – LAEA to Stereo 70, each map was clipped to align with Romania's administrative boundaries and APIA plot inventories.

The APIA–LPIS source data, characterized by a complex schema, underwent extensive processing, including reclassification of database categories and centralization of structural elements. This structure encompasses key features essential for processing, such as edition year, filename, classification data fields, and unique values within these fields. A workflow diagram (Figure 6.20) illustrates the procedures for processing graphical and alphanumeric data from the two primary sources (CLC and APIA) to derive plot classifications and align datasets across years.

Figure 6.20 Graphical and alphanumeric data filtering algorithm that are used from the two combined sources



The next operation, applied to all the maps after they were brought and reduced to the coordinates of the area of interest, was a check on the integrity of the polygons and the elimination of any potential processing problems to be applied, removal of any nodes and/or duplicate lines, or self–intersecting errors of surfaces. Following the time criterion presented above and the data filtering algorithm, after the attributes of interest for the subsequent classification, operations of selection, intersection and division of the maps were applied, keeping for each year the information with the best accuracy. In order to classify polygons from different sources according to land use considering a common criterion in line with our country's reports, two fields have been created for each database representing the corresponding IPCC land use code – called "LU", as well as the one used by Romania – "LUR". Summarizing the annual maps into a common, vector database was the next step that was started, but due to several objective circumstances, the method still applied for surface management was the raster analysis of vector maps. One of the circumstances that led to the adoption of this method is the approach of a much longer period, in this year, in the history of land management maps, an objective that has already greatly increased the number of maps processed, especially since the use of new versions for CLC "reset", virtually, everything obtained in the previous inventory on the approached years (2012 - 2020). A second reason and the one that actually led to the abandonment of using the vector analysis on land management maps in this submission was the imminent appearance of the source Copernicus CLC+, which is expected to be published in the near future and which will significantly increase the reliability and quality of the surface estimates for the recent and future period. The centralization and analysis method uses the conversion of the vector to raster in order to measure the areas. This method is widely used and effective, especially when large map areas with millions of polygons are involved. The principle is to transform vector polygons into raster surfaces (made up of pixels), which can be measured quantitatively as long as the pixel size is known (the area it occupies). To estimate the error of the method, resulting from this approximation, a surface measurement test/a validation method was performed using raster area compared to the area of vector polygons from CLC data source. Validation methods used during all data processing: *batch processing – where applicable; predefined query; checks at every annual instance of land use maps by raster analysis with two different pixel sizes.*

6.5.2 Methodological issues

6.5.2.1 Cropland remaining Cropland (CRT sector 4.B.1)

6.5.2.1.1 Changes of carbon stock in biomass carbon pool

Annual cropland remaining annual cropland (Ag)

It is assumed there is no change in LB when annual cropland remains annual cropland.

Perennial cropland remaining perennial cropland (Ata, Vv, Lv)

It is assumed that when there is a conversion between perennial croplands subcategories (Ata, Lv, Vv), the mean LB in the previous crop is lost in the year of conversion, i.e. 6.4 tC/ha *(IPCC 2019 Refinement, V4,* *Ch. 5, Table 5.3)*. During the year of conversion and the subsequent 19 years, there is an incremental increase in living biomass (LB) within the newly established perennial crop. This growth is quantified as 0.425 tC/ha/year (calculated as 8.5 tC/ha divided by 20 years), in accordance with the guidelines provided in the IPCC 2019 Refinement, Volume 4, Chapter 5, Table 5.3. This value represents the annual carbon stock accumulation in living biomass over the 20-year period. The total and accumulation of carbon is assumed to be the same on all perennial woody land use types (Ata, Lv and Vv). These assumptions will be reviewed in future submissions.

Annual cropland converted to perennial cropland (Ag to Ata, Vv, Lv)

It is assumed that there is a loss of the LB in the annual cropland in the year of conversion, i.e. 5 tC/ha *(IPCC 2006, V4, Ch. 5, Table 5.9)*. It is assumed that there is a gain of LB in the perennial cropland along 20 years, quantified as 0.425 tC/ha/year (calculated as 8.5 tC/ha divided by 20 years).

Perennial cropland converted to annual cropland (Ata, Vv, Lv to Ag)

It is assumed that there is a loss of the LB in the perennial cropland in the year of conversion, and the mean biomass crop is lost, i.e. 6.4 tC/ha. It is assumed that there is a gain of LB in the annual cropland in the year of conversion, i.e. 5 tC/ha. IPCC 2006 indicates that the total accumulation of carbon in perennial woody biomass will exceed, over time, that of the default carbon stock for annual cropland, and in *Table 5.1* the AGB carbon stock at harvest is 63 tC/ha. The loss and gain of carbon in perennial woody biomass use the values for orchards in *IPCC 2019 Refinement, Table 5.2*. The total and accumulation of carbon is assumed to be the same on all perennial woody land use types (Ata, Lv and Vv). These assumptions will be reviewed in future submissions.

6.5.2.1.2 Changes of carbon stock in dead organic matter carbon pool

CSC change in DOM is assumed 0, in line with tier 1 assumption of IPCC 2006.

6.5.2.1.3 Changes of carbon stock in soil carbon pool

Changes in SOC can occur when there is a change in the crop type or the management practices. The estimates follow the method described in *IPCC 2006, V4, Ch. 5, 4.2.3 Soil carbon*. Romania has updated the SOC values used for cropland and grassland for the previous submission. The SOC values applied for cropland are shown in the table below.

Table 6.28 4.B.1 parameters developed for the soil carbon pool

Year	SOC_{REF} (t C/ha)	SOC_{REF} source	F_{LU}	F_{LU} source	F_{MG}	F_{MG} source	F_{I}	F_{I} Source	SOC (t C/ha)
Annual cropland: arable (Ag)									
1990	45	ICPA owned soil databases, such as: SIGSTAR–200 (the GIS of Soil Resources of Romania, has been developed based on the information contained in the 50 tiles constituting The Soil Map of Romania at the scale 1:200.000, published from 1963 to 1993); PROFISOL (soil database containing data on soil properties, collected from 1986 to 2000).	0.8	*IPCC 2006 default V4, Ch.5 Table 5.5, annual CL temperate dry*	1.02	*IPCC 2006 Reduced tillage – temperate dry*	0.95	*IPCC 2006 default temperate dry – low*	34.9
2010	45		0.76	CS factor based on weighted average of the areas under cropland –NSI data on areas under CL).	1.02	*IPCC 2006 Reduced tillage – temperate dry*	1.16	CS factor starting in 2010 (ICPA methodology for estimating the crop production potential)	40.5
2019	45		0.76		1.04	CS factor based on APIA introduced a payment measure for farmers: Beneficial practices for environment and climate (crop diversification; greening; cover crops; over 30% of the straw remains on the field etc.)	1.16		41.3
Perennial cropland: vineyards, orchards, shrub crops (Vv, Lv, Ata)									
All	39	Applies to all perennial cropland areas. Technical–scientific Report prepared for NEPA (*ICPA Technical Report, November 2022*)	1	*IPCC 2006 default V4 Ch.5, Table 5.5*	1.02	*IPCC 2006 default V4 Ch.5, Table 5.5; temperate dry, reduced tillage*	0.99	CS factor based on weighted average, ICPA methodology for estimating the crop production potential (*ICPA Technical Report, November 2022*)	39.4

Information regarding the parameters for soil carbon pool - CL

The methodology has been improved to better consider the period needed for the SOC values in equilibrium to be achieved (20 years). For each period of the time series with different SOC values, the annual rate of C change is estimated to reach equilibrium over 20 years even when the time period between data collection is shorter than 20 years. It is assumed that in 1990 SOC is in equilibrium, since no data is available prior 1990 to estimate C stock changes. When there is a change in SOC, there is a linear gain or loss of C. SOC changes have been calculated for annual croplands remaining and conversions between perennial and annual cropland. Changes in SOC for conversions between perennial cropland subcategories are reported as 'NA' as the same SOC value is assumed over the timeseries. When calculating SOC in annual cropland remaining, the area of organic soil has been subtracted from the accumulated area of remaining annual cropland to avoid double counting. The APIA payment measure for farmers promotes beneficial practices for environment and climate (crop diversification; greening; cover crops; over 30% of the straw remains on the field, etc.) from 2010, therefore SOC on annual cropland increases from 2010 onwards. In order to determine the AD (kha) corresponding to organic soils, the vector analysis methodology was used. EGM (*Explicit Geospatial Map*) developed was used with the explicit geospatial intersection of the polygons that delimit the types of soils in Romania. The resulting polygons are thus geometrically divided using two criteria: land use category and soil type.

The attributes associated with each of these geometries have been preserved, thus making it possible to classify the information according to any of the desired criteria, previously included in the two maps.

The balance of the areas was finally made by summing the areas by category of use, the partial amounts being grouped according to certain parameters that characterizes the type of soil corresponding to each category of use in each plot. The database handles information about: soil map units, types and subtypes, texture in top horizon, the skeleton, and the intensity of main soil threats, like the erosion by water and wind, salinization, alkalization, water excess – gleization and stagnogleization. As a result of the OSM (Organic Soil Map) development, AD (kha) for organic soils is 4.66 kha. Recalculations of AD (kha) took place over the entire time series, thus generating recalculations for the entire time period. GHG E/R from organic soils under 4.B.1 land use subcategory are reported under Cultivation of Histosols. For organic soils area, GHG E/R are estimated for the entire time series using the classification under Warm temperate climate zone, -10 tC/ha/year, default value, in accordance with *IPCC 2006 Guidelines, V4, Cropland, Ch. 5, Table 5.6*.

6.5.2.1.4 Biomass burning

The burning of vineyard or orchard crop residues occurs to some minor extent in Romania. The GHG E/R estimates from burning of these agricultural residues are included in the CO_2 emissions from biomass harvesting of perennial Cropland and NE notation key is therefore applied since the carbon released during the combustion process is assumed to be reabsorbed by the vegetation during the next growing season, CRT table 4(V). CH_4 and N_2O emissions from biomass burning of vineyard and orchard residues, identified with IE notation key, are reported in 3.F Agriculture sector.

6.5.2.2 Land converted to Cropland (CRT sector 4.B.2)

6.5.2.2.1 Changes of carbon stock in biomass carbon pool

Forest land converted to cropland

See the Forest land section

Grassland converted to cropland

Grassy GL (Pa, Pf, Pp) to CLannual (Ag)

It is assumed a loss of the LB in the GLgrassy (Pa, Pf, Pp) in the year of conversion, i.e. 2.87 tC/ha *(6.1*0.47/ IPCC 2006, V4, Ch. 6, Table 6.4, 6.3.1.4, total non-woody biomass, above-ground and below-ground, Warm Temperate – Dry)*; and a gain of LB in CLannual (Ag) in the year of conversion equal to 5 tC/ha. Afterwards, C stock in LB is assumed in equilibrium, in line with IPCC 2006.

Woody GL to CLannual (AtVf, Tf, Jn to Ag)

It is assumed a CSC in the year of conversion, marked by a loss of the mean LB in GLwoody (6.4 tC/ha) and a gain of the LB in CLannual (Ag) (5.0 tC/ha). Afterwards, the C in LB is assumed in equilibrium.

Grassy GL to CLperennial (Pa, Pf, Pp to Lv, Vv, Ata)

It is assumed a loss of LB in GLgrassy in the year of conversion, i.e. 2.87 tC/ha; and a gain of LB in CLperennial (Lv, Vv, Ata) along 20 years equal to 0.425 tC/ha/year, until maturity is reached. Afterwards, C stock in LB is assumed in equilibrium.

Woody GL to CLperennial (Jn, Tf, AtVf to Lv, Vv, Ata)

It is assumed a loss of the mean LB in GLgrassy in the year of conversion, i.e. 6.4 tC/ha; and a gain of LB in CLperennial along 20 years equal to 0.425 tC/ha/year, until maturity is reached. Afterwards, C stock in LB is assumed in equilibrium.

Wetlands converted to cropland

WL to annual cropland (ZuV, ZuA to Ag)

It is assumed a loss of 2.87 tC/ha in the conversions from WL - wet areas with vegetation, ZuV, to annual cropland, Ag. For WL – waters/ponds, ZuA, no loss in LB is assumed. It is also assumed that there is a gain of C in the new annual cropland in the year of transition, i.e. 5 tC/ha.

WL to perennial cropland (ZuV, ZuA to Lv, Vv, Ata)

It is assumed a loss of 2.87 tC/ha in the conversions from WL - wet areas with vegetation, ZuV, to perennial cropland. For WL – waters/ponds, no loss in LB is assumed. It is also assumed that there is a gain of C in the new perennial cropland equal to 0.425 tC/ha along next 20 years, when the crop will reach maturity.

Settlements converted to cropland

SL to CLannual (AU to Ag)

It is assumed a gain of the LB in the new annual cropland in the year of transition will be equal to 5 tC/ha. It is assumed that LB in settlements is 0, so there is no loss of LB.

SL to CLperennial (AU to Lv, Vv, Ata)

It is assumed a gain of LB in CLperennial along 20 years, equal to 0.425 tC/ha/year, until maturity is reached. It is assumed that LB in settlements is 0, so there is not loss of LB.

Other land converted to cropland

OL to annual cropland (AT to Ag)

It is assumed a gain of the LB in the new annual cropland, in the year of transition, i.e. 5 tC/ha.

It is assumed that LB in Other land is 0, so there is not loss of LB.

OL to perennial cropland (AT to Lv, Vv, Ata)

It is assumed a gain of LB in CLperennial along 20 years, equal to 0.425 tC/ha/year, until maturity is reached. It is assumed that LB in Other land is 0, so there is not loss of LB.

6.5.2.2.2 Changes of carbon stock in dead organic matter carbon pool

CSC in DOM is assumed 0, in line with tier 1 assumption of IPCC 2006.

Information on DOM CSCs in FL is included in the Forest land section.

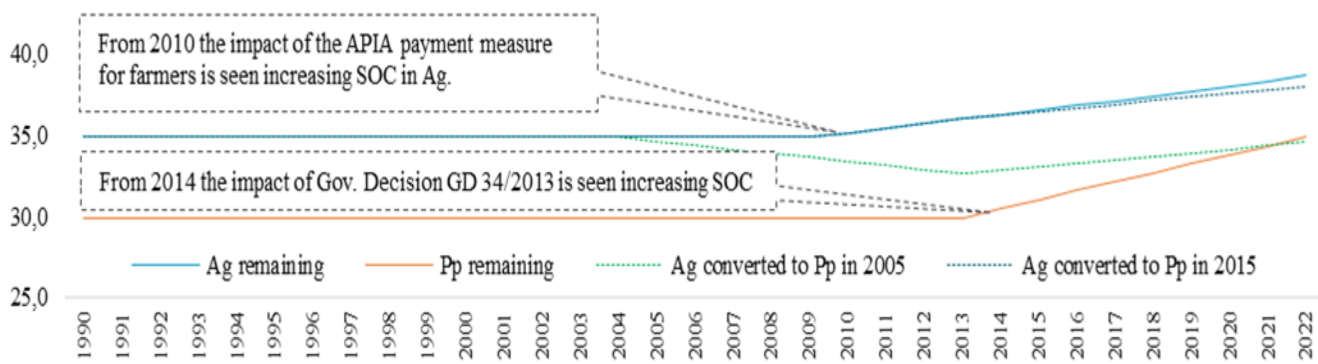
6.5.2.2.3 Changes of carbon stock in soil carbon pool

The cropland stock values are presented in Table 6.28. The C stock changes are assumed to occur during the IPCC default 20 – year period. Chapter 6.1.4.3, Table 6.8 presents the CSCFs applied for the year 2021.

The SOC values for forest land and grassland are presented in their respective chapters. The values of C stock of 41 tC/ha in soils under Other lands and 32 tC/ha in soils under Settlements are based on field and laboratory surveys which were carried out within the *Monitoring system of agricultural and forestry soils*, a system that was financed, firstly, by the Ministry of Waters, Forests and Environmental Protection, period 1992–2000. The researches were carried out in the national monitoring network of level I (16 x 16 km grid), thus covering the entire territory of the country, respectively 670 agricultural sites and 274 forest sites. Then during the period 2000–2002, the second determination of the monitoring parameters was started, in 197 level I agricultural sites, within the Relansin Program. Starting with 2003, the second set of measurements within the level I agricultural network (16 x 16 km grid) was continued, based on the Ministry of Agriculture Order no. 223/2002 – National Soil – Land Monitoring System for Agriculture. Thus, the total of 670 agricultural sites was covered, in total, including the second determination, through field and laboratory surveys. Currently, the *National Soil-Land Monitoring System for Agriculture*, is on the second stage of soil monitoring in the 8 x 8 km grid, starting with the western part of Romania (Ministry of Agriculture and Rural Development Order no. 278/2011).

The figure below presents a worked example for the calculated total SOC in annual cropland (Ag) and pasture grassland (Pp).

Figure 6.21 Worked example, total SOC in 1 ha of land converted from Ag to Pp



6.5.2.2.4 Biomass burning

Romania reports the NO notation key, because this activity does not occur in Cropland remaining or and land converted to Cropland.

6.5.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

6.5.4 Uncertainties and time–series consistency

Uncertainties for 4.B.1 and 4.B.2 land use categories have been separated into three carbon pools, LB, DOM and SOC. Uncertainty estimates have only been calculated for categories from which E(+)/R(-) arise. DOM in the land remaining categories have therefore been excluded as these categories are assumed to be in equilibrium and GHGs E(+)/R(-) estimates are not applicable.

Activity data uncertainty

The uncertainty of activity data associated with the 4.B.1 and 4.B.2 land use categories is tied to the uncertainty in the corresponding land use data. An uncertainty level of ±10% has been assumed for the land use data, based on expert judgment. This represents an improvement from the previous uncertainty value of ±30%, achieved through the adoption of spatial information derived from periodically updated 1:5000-scale maps. These maps provide a more comprehensive basis for activity data compared to the earlier reliance on purely statistical methods. LPIS/IACS maps, which cover the majority of the relevant territory, enhance the accuracy and consistency of reported areas with a minimum mapping unit of 0.5 hectares. Furthermore, the high-precision mapping provided by the Corine Land Cover (CLC) service complements the LPIS/IACS data, contributing to a more reliable estimate of uncertainty. The overall accuracy of the information is further improved by the validation process, as LPIS/IACS-generated activity data are corroborated by farmers' declarations regarding land use categories. This validation ensures that the reported areas align with actual field conditions, enhancing both precision and reliability.

Emission factor uncertainty

The uncertainty of emission factors associated with the 4.B land use category is linked to the uncertainty in the carbon stock and stock change factors applied. For biomass in the 4.B land use category, an uncertainty level of ±75% has been assumed, based on the default value provided in the IPCC 2006 Guidelines (Volume 4, Chapter 2, Section 5.2.1.5). However, additional analysis is required to evaluate the uncertainty of the country-specific factors currently in use. As an interim measure, an uncertainty factor of ±100% has been applied. This represents the maximum uncertainty factor allowable under the propagation of errors analysis in approach 1, assuming symmetrical uncertainty.

Table 6.29 4.B Uncertainty estimation

4B	**Gas**	**U_c (%)**	**Contribution to variance by category in year x (%)**	**Type B sensitivity (%)**	**U in trend by U_{AD} (%)**	**U in total national emissions (%)**
4B1	**CO_2**	100.499	0.003	1.200	0.170	0.000

4B	Gas	U_c (%)	Contribution to variance by category in year x (%)	Type B sensitivity (%)	U in trend by U_{AD} (%)	U in total national emissions (%)
4B2	**CO_2**	100.499	0.043	4.180	0.590	0.000
4B1	**CH_4**	0.000	0.000	0.000	0.000	0.000
4B2	**CH_4**	0.000	0.000	0.000	0.000	0.000
4B1	**N_2O**	140.770	0.000	0.000	0.000	0.000
4B2	**N_2O**	140.770	0.000	0.000	0.000	0.000

6.5.5 Category–specific QA/QC and verification, if applicable

(i) the first level of QA/QC is conducted by the data providers; ***(ii)*** perform basic checks consisting of various procedures applied to avoid errors associated with different stages of data processing or calculation like and ***(iii)*** third level of QA/QC is implemented by the NEPA and MEWF, which consists of checks related to both CRT and NID chapters.

6.5.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The specific recalculations in the CL land use categories are summarized in the following figures:

Figure 6.22 Quantification of cropland remaining recalculations performed across the time period (kt CO_2 eq.)

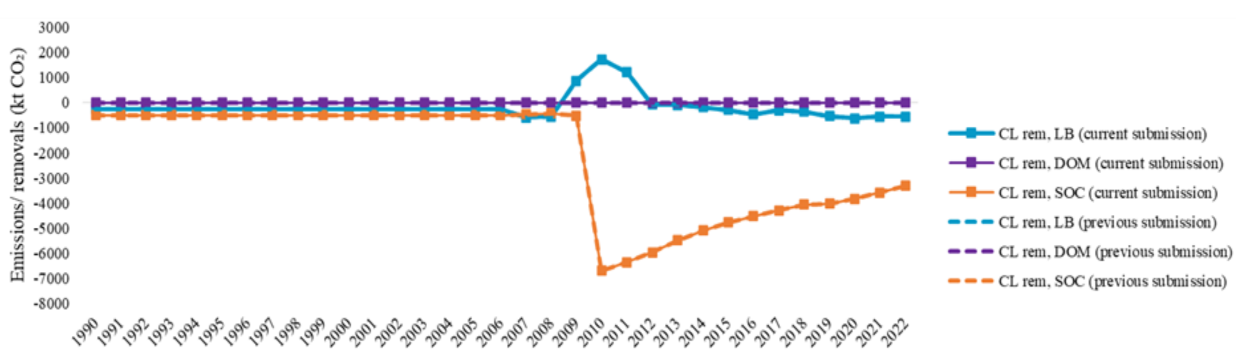
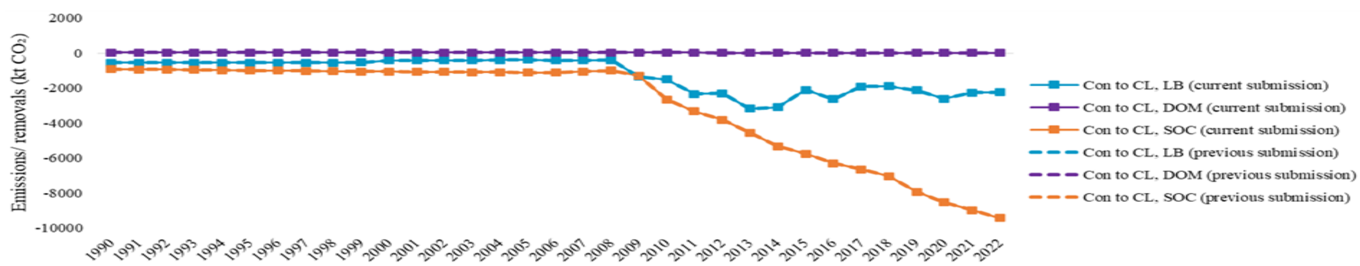


Figure 6.23 Quantification of land converted to cropland recalculations performed across the time period (kt CO_2 eq.)



For the NID 2025 submission, no recalculations were made to the historical data.

6.5.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

As part of the improvement plan of NID, Romania will continue its efforts to improve GHG E/R estimation associated with CL to complete adaptation to the latest methodologies:

(i) estimation of the country specific emission factors for the soil carbon pool in organic soils;

(ii) estimation of the CS values for carbon stock in living biomass for CL perennial (Vv and Lv) through designated studies, planned to be carried out over the next 2 years;

(iii) further investigation is being carried out for SOC in Cropland and Grassland thanks to the following project:

The development of agricultural technologies at the main cultivated plants for the intensification of soil carbon sequestration in accordance with the 4‰ initiative

Funding programme: “ADER 2026” of the Ministry of Agriculture and Rural Development

Time period: 2023–2026

Expected outcomes:

(I) evaluation of the organic carbon sequestration potential in Romanian agricultural soils (arable and pastures) in farms of different economic sizes;

(II) evaluation of the current organic carbon stocks in soils under different agricultural systems (conventional, conservative) and land uses (arable, pastures);

(III) portfolio of measures for carbon sequestration in agricultural soils and evaluation of the carbon sequestration potential associated with each measure;

(IV) estimating the critical limit values of organic carbon at which the soil health is not affected;

(V) codes of good practices with measures and technologies that lead to carbon sequestration in soils under arable and pastures land uses

The methodology for the first outcome (which was reported this year) is based on the results published by Hassink (1997).

For grasslands (pastures and hayfields) and long-term uncultivated soils, Hassink (1997) found that the SOC content was in an equilibrium status, reaching a maximum under certain local conditions, defined as the maximum potential storage content (SOCpot, g/kg), which can be calculated through a linear relationship depending on the content of fine soil particles:

$$SOCpot = 4.09 + 0.37 \times (\% \text{ fine clay and silt})$$

Hassink then defined the SOC sequestration deficit (SOCdef, g/kg) as the difference between the potential storage content (SOC_{pot}) and the actual soil organic C content (SOC, g/kg). The organic carbon sequestration potential (SOC sequestration potential) was defined as equal to SOCdef, but considered as a stock (t/ha), resulting from multiplying the size of SOC_{def} (g/kg) with the soil bulk density (DA, kg/dm^3) and with the thickness of the soil horizon (cm), then subtracting the skeleton value (% of particles > 2 mm).

$$\text{SOC sequestration potential} = SOC_{pot} - SOC_{stock} - \text{soil skeleton}$$

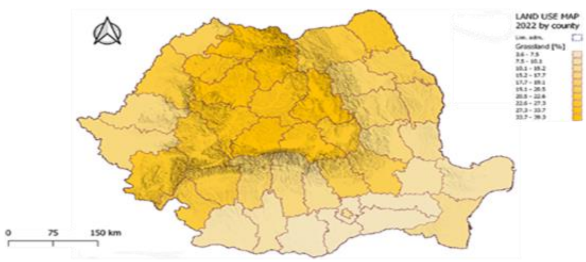
Positive values of SOC sequestration potential show that the respective soil horizons have a relatively high SOC sequestration capacity, while its negative values show that SOC has been sequestered in excess and can be easily lost through decomposition, emissions of greenhouse gases, erosion, etc. The analyzed soil profiles, are classified into soil classes and types, according to the classification of Florea and Munteanu (2012) and IUSS Working Group WRB (2022). All soil classes and mineral soil types are represented in this study, except Andisols and Histisols (organic soils). Hassink's (1997) equations described above were applied to the soil data set collected from profiles sampled in the last period of time to calculate the magnitude of actual SOC, SOC_{pot}, SOC_{def} and SOC sequestration potential. Then, the data were grouped according to different soil and environmental parameters (land use, soil classes, soil type, etc.) and were processed through the ANOVA Program, using SPSS14 Software. Average values were calculated for the mentioned groups, and they were then compared; significant differences were determined using Duncan's test. The data were then analyzed, synthesized and interpreted.

6.6 Grassland (CRT 4.C)

6.6.1 Category description

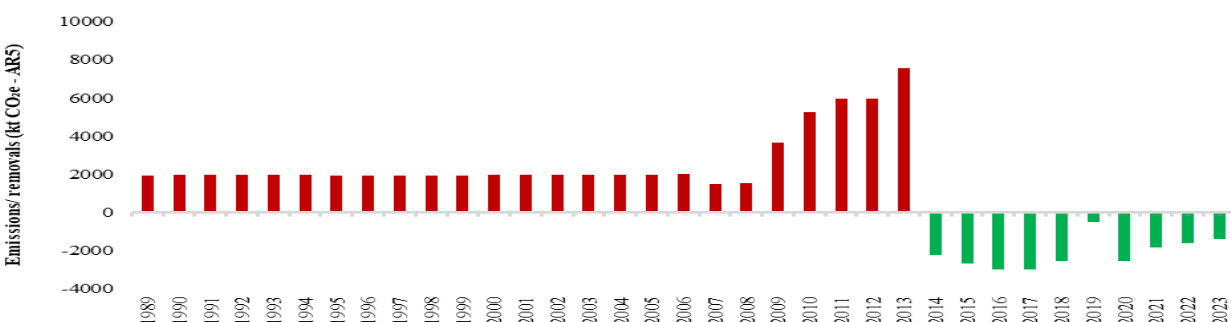
The 4.C land use category includes pastures, pasture with spares trees, hayfields, woody vegetation below the threshold of forest definition; pinus mugo shrubs; shrubs, Figure 6.24.

Figure 6.24 4.C land use category. EGM - explicit geospatial map



The following figure include a 4.C summary of the GHG E/R estimates:

Figure 6.25 4.C GHG E(+)/R(-) evolution across the time period



Under this category, CO_2 emissions from LB, soils and DOM have been reported. CH_4 and N_2O emissions from biomass burning are included in Grassland remaining Grassland. Grassland remaining grassland and land converted to grassland are key categories. As in the case of another key category, namely 4.B land use category, the type 3 approach was considered, implemented in the GHG E/R estimates, methodology detailed in Chapter 6.3.1 paragraph *Combining, processing and querying information*.

6.6.2 Methodological issues

6.6.2.1 Grassland remaining Grassland (CRT sector 4.C.1)

6.6.2.1.1 Changes of carbon stock in biomass carbon pool

Grassy grassland remaining grassy grassland (Pp, Pf, Pa)

It is assumed no CSC in the conversions among different types of grassy grasslands.

Woody grassland remaining woody grassland (Jn, Tf, AtVf)

It is assumed no CSC in the conversions among different types of woody grasslands.

Grassy grassland converted to woody grassland (Pp, Pf, Pa to Jn, Tf, AtVf)

It is assumed that there is a loss of the LB in the grassy grassland in the year of conversion, i.e. 2.87 tC/ha. It is assumed that there is a gain of LB in the woody grassland along 20 years, quantified as 0.425 tC/ha/year (calculated as 8.5 tC/ha divided by 20 years).

Woody grassland converted to grassy grassland (Jn, Tf, AtVf to Pp, Pf, Pa)

It is assumed that there is a loss of the LB in the woody grassland in the year of conversion, and the mean biomass is lost (i.e. 6.4 tC/ha). It is assumed that there is a gain of LB in the grassy grassland in the year of conversion (i.e. 2.87 tC/ha) and that C stocks are then in equilibrium.

6.6.2.1.2 Change of carbon stock in dead organic matter carbon pool

CSC in DOM is assumed 0, in line with tier 1 assumption of *IPCC 2006*.

6.6.2.1.3 Change of carbon stock in soil carbon pool

Changes in SOC can occur when there is a change in the management practices. The estimates follow the method detailed in *IPCC 2006, V4, Ch. 5, 4.2.3 Soil carbon*. Romania has collected information for 10 years that allows for the estimates of CSC in SOC, in Grassland categories. SOC_{REF} is estimated for the type of soils, mineral or organic, regardless of the category of use. Consequently, the same value of 54 tC/ha is used for both GLgrassy and GLwoody. EFs are also applicable for the entire GL category.

In the case of GL woody, SOC is consistent over the timeseries and therefore there are not emissions/removals associated. In the case of GL grassy, policy affecting management lead to changes in input (F_I) and management (F_{MG}) factors, beginning in 2014, a year after the implementation of the

Governmental Decision (GD 34/2013). Further information on the SOC method approach is included in Section 6.1.4.

Table 6.30 4.C.1 parameters developed for the soil carbon pool

Year	SOC_{REF} (tC/ha)	SOC_{REF} source	F_{LU}	F_{LU} source	F_{MG}	F_{MG} source	F_I	F_I Source	SOC (tC/ha)
Grassland grassy: pastures, pasture with spare trees, hayfields (Pp, Pf, Pa)									
1990	54	Applies to all types of grassland (*SOC_{REF} based on GIS mineral soils layer with areas under GL*) Technical-scientific Report prepared for NEPA (*ICPA Technical Report, November 2022*)	0.7	Country-specific factor based on weighted average of the areas under grassland (*NSI data on areas under GL*)	0.95	*IPCC 2006 default, V.4 Ch. 6, Table 6.2, moderately degraded*	1	*IPCC 2006 default, V.4 Ch. 6, Table 6.2, medium.* Applies to grassy grassland where there is no additional management	35.9
2014	54		0.7		1.14	*IPCC 2006 default, V.4 Ch. 6 Table 6.2, improved grassland*	1.09	CS used from 2014, a year later after implementation of Goverment decision (GD 34/2013)	47.0
Grassland woody: other lands with forest vegetation (below forest land definition), Pinus mugo shrubs, Shrubs (AtVF, Jn, Tf)									
All	54	See above	1	*IPCC 2006 default V4 Ch. 6 Table 6.2, All.* It is assumed that there is no management.	1	*IPCC 2006 default, V. 4 Ch. 6 Table 6.2, All.* It is assumed that there is no management	1	*IPCC 2006 default, V.4 Ch.6, Table 6.2, All.* It is assumed there is no management	54.0

The overlapping explicit geospatial maps with the polygons that delimit the types of soils in Romania, led to the evaluation of AD(kha) for organic soils in the GL category as being in quantum of 3.62 kha. In order to determine the AD(kha) corresponding to organic soils, the same methodology was applied as in the case of the CL category, detailed in Chapter 6.5.1. For organic soils area, GHG E/R have been estimated for the entire time series using the classification under *Warm temperate climate zone*, -2.5 tC/ha/year, default value, in accordance with *IPCC 2006 Guidelines, V4, Ch. 6, Grassland, Table 6.3*.

6.6.2.1.4 Biomass burning

The burning of Grassland residues occurs to some minor extent in Romania; however, efforst have been made to find data and use it for the estimates. The notation key NE was used for CO_2 emissions. In Grassland Remaining Grassland CO_2 emissions are not reported since they are largely balanced by the CO_2 that is reincorporated back into biomass via photosynthetic activity, within weeks to few years after burning. For the latest years of the time series (2019–2023), CH_4 and N_2O emissions are reported, using information delivered by Romanian General Inspectorate for Emergency Situations. Tier 1 is applied, using the value of fuel biomass consumption for Grasslans (4.1 tonnes dry matter/ha) from table 2.4 and EF for Savanna and grassland from table 2.5 Vol. 4, Chapter 2 IPCC 2006.

6.6.2.2 Land converted to Grassland (CRT sector 4.C.2)

6.6.2.2.1 Changes of carbon stock in biomass carbon pool

Forest land converted to grassland

See the Forest land section

Cropland converted to grassland

Annual cropland to grassy grassland (Ag to Pp, Pf, Pa)

It is assumed a loss of the LB in the annual cropland, 5 tC/ha, and a gain of the LB in grassland in the year of conversion, 2.87 tC/ha. After the first year, the C in LB is assumed in equilibrium.

Annual cropland to woody grassland (Ag to Jn, Tf, AtVf)

It is assumed a loss of the LB in the annual cropland in the year of transition, 5 tC/ha, and a gain of LB in woody grassland along 20 years equal to 0.425 tC/ha/year, until maturity is reached. Afterwards, C stock in LB is assumed in equilibrium.

Perennial cropland to grassy grassland (Vv, Lv, Ata to Pp, Pf, Pa)

It is assumed a CSC in the year of conversion, marked by a loss of the mean LB in the perennial cropland (6.4 tC/ha) and a gain of the LB in the new grassland (2.87 tC/ha). Afterwards, the C in LB is assumed in equilibrium.

Perennial cropland to woody grassland (Vv, Lv, Ata to Jn, Tf, AtVf)

It is assumed a loss of the mean LB in perennial cropland is lost in the year of conversion, 6.4 tC/ha, and there is a gain in LB in the new woody grassland along 20 years equal to 0.425 tC/ha/year, until maturity is reached.

Wetlands converted to grassland

Wetlands to grassy grassland (ZuA, ZuV to Pp, Pf, Pa)

For conversions of ZuA to grassy grassland there is assumed to be a gain in LB of 2.87 tC/ha, in the year of conversion. No loss in C in LB is assumed to occur. For conversions from ZuV to grassy grassland, the gain in C and loss in C are assumed to be equal and to only occur in the year of conversion. Therefore, the net change in C is assumed to be zero for ZuV to grassy grassland.

Wetlands to woody grassland (ZuA, ZuV to Jn, Tf, AtVf)

For ZuV, it is assumed that the LB in WL is loss in the year of transition, 2.87 tC/ha, but for conversions from ZuA, no loss in LB is assumed to occur. A gain of LB in woody grassland is assumed, along 20 years, equal to 0.425 tC/ha/year, until maturity is reached. Afterwards, C stock in LB is assumed in equilibrium.

Settlements converted to grassland

Settlements to grassy grassland (AU to Pp, Pf, Pa)

It is assumed a gain of the LB in the new grassy grassland in the year of transition will be equal to 2.87 tC/ha. It is assumed that LB in settlements is 0, so there is no loss of LB.

Settlements to woody grassland (AU to Jn, Tf, AtVf)

It is assumed a gain of LB in woody grassland along 20 years, equal to 0.425 tC/ha/year, until maturity is reached. It is assumed that LB in settlements is 0, so there is not loss of LB.

Other lands converted to grassland

Other lands to grassy grassland (AT to Pp, Pf, Pa)

It is assumed a gain of the LB in the new grassy grassland, in the year of transition, i.e. 2.87 tC/ha.

It is assumed that LB in Other land is 0, so there is not loss of LB.

Other lands to woody grassland (AT to Jn, Tf, AtVf)

It is assumed a gain of LB in woody grassland along 20 years, equal to 0.425 tC/ha/year, until maturity is reached. It is assumed that LB in Other land is 0, so there is not loss of LB.

6.6.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in DOM is assumed 0, in line with tier 1 assumption of IPCC 2006 on all lands except for FL.

6.6.2.2.3 Change of carbon stock in soil carbon pool

Information on the SOC values used are presented in the land remaining sections. See Section 6.5.2.2.3 for information on the methodology applied for SOC in land converted categories.

6.6.2.2.4 Biomass burning

Romania reports the NO notation key, because this kind of activities doesn't happen in Grassland remaining or in land converted to Grassland.

6.6.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

6.6.4 Uncertainty assessment and time-series consistency

Romania used the same methodology in developing the uncertainty associated with the GHG emission/removal levels specific to GL category as described and detailed in Chapters 6.1.6 and 6.5.4.

Table 6.31 4.C Uncertainty estimation

4C	Gas	U_c (%)	Contribution to variance by category in year x (%)	Type B sensitivity (%)	U in trend by U_{AD} (%)	U in total national emissions (%)
4C1	**CO_2**	100.499	0.000	0.250	0.030	0.000
4C2	**CO_2**	100.499	0.000	0.260	0.040	0.000
4C1	**CH_4**	49.307	0.000	0.000	0.000	0.000
4C2	**CH_4**	0.000	0.000	0.000	0.000	0.000
4C1	**N_2O**	140.770	0.000	0.019	0.026	0.000
4C2	**N_2O**	140.770	0.000	0.020	0.028	0.000

6.6.5 Category–specific QA/QC and verification, if applicable

(i) the first level of QA/QC is conducted by the data providers; ***(ii)*** perform basic checks consisting of various procedures applied to avoid errors associated with different stages of data processing or calculation and ***(iii)*** third level of QA/QC is implemented by the NEPA and MEWF, which consists of checks related to both CRT and NID chapters.

6.6.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The specific recalculations in the GL land use categories are summarized in the following figures:

Figure 6.26 Quantification of grassland remaining recalculations performed across the time period (kt CO_2 eq.)

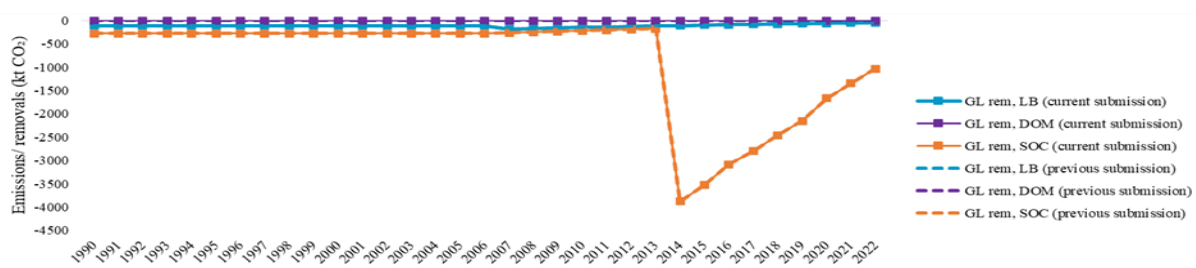
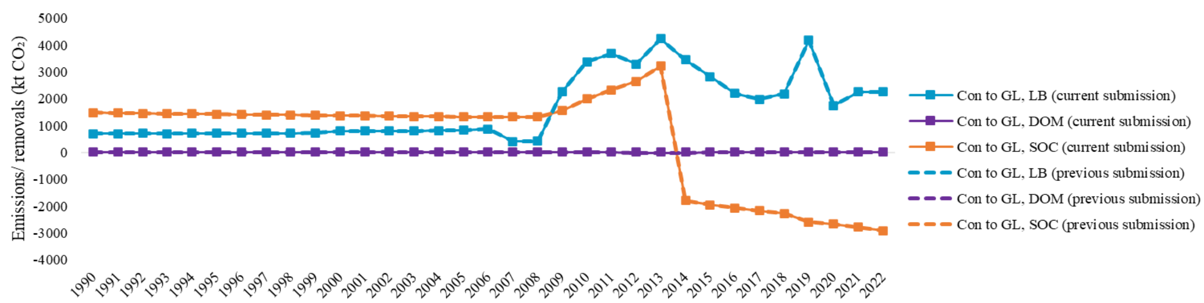


Figure 6.27 Quantification of land converted to grassland recalculations performed across the time period (kt CO_2 eq.)



For the NID 2025 submission, no recalculations were made to the historical data.

6.6.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

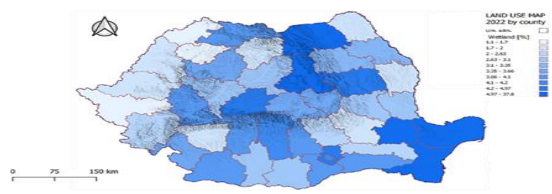
As part of the improvement plan of inventory, Romania will continue its efforts to improve GHG E/R estimation associated with GL to complete adaptation to the latest methodologies. In particular, regarding SOC, see Cropland section. Estimation of the CS values for carbon stock in living biomass for GLgrassy will be realized through designated studies, planned to be carried out over the next 2 years.

6.7 Wetlands (CRT 4.D)

6.7.1 Category description

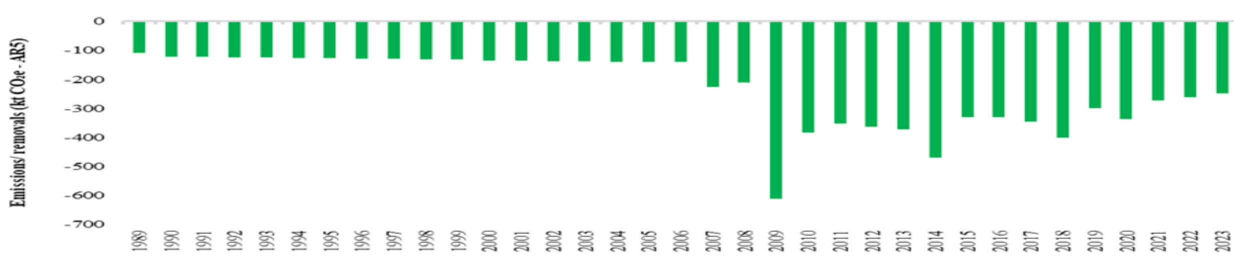
The 4.D category includes wet areas with vegetation, waters/ponds, Figure 6.28, and GHG E/R estimates are reported.

Figure 6.28 4.D land use category. EGM - explicit geospatial map



The following figure include a 4.D summary of the time series GHG E(+)/R(-) estimates:

Figure 6.29 4. D GHG E/R evolution in across the time period (kt CO_2 eq.)



6.7.2 Methodological issues

6.7.2.1 Wetland remaining Wetland (CRT sector 4.D.1)

Regarding living biomass, for wetlands remaining in the same subcategory of wetlands (e.g., ZuA remaining ZuA), no change in LB is assumed to occur.

For ZuA converting to ZuV, a gain in LB is assumed to occur in the first year of conversion only, equal to 2.87 tC/ha. No loss in LB is assumed to occur.

For ZuV converting to ZuA, the change in LB, a loss equal to 2.87 tC/ha in the year of conversion is assumed.

The C stock in DOM and SOC of Wetland remaining in the same subcategory for more than a 20 years period is assumed to be 0.

6.7.2.2 Land converted to Wetland (CRT sector 4.D.2)

6.7.2.2.1 Changes of carbon stock in biomass carbon pool

Forest land to wetlands

See the Forest land section

Cropland to wetlands

Annual cropland to wetlands (Ag to ZuA, ZuV)

It is assumed that the LB in annual cropland is lost in the year of conversion, equal to 5 tC/ha.

For ZuA, it is assumed that there will be no gain in LB.

For conversions to ZuV, a gain in LB equal to 2.87 tC/ha is assumed in the year of conversion.

Perennial cropland to wetlands (Vv, Lv, Ata to ZuA, ZuV)

It is assumed that the mean LB in perennial cropland is lost, 6.4 tC/ha, and that the LB in ZuV is gained, 2.87 tC/ha, in the year of conversion. There is no gain in C associated with ZuA.

Grassland converted to wetlands

Grassy grasslands to wetlands (Pp, Pf, Pa to ZuA, ZuV)

It is assumed that the loss in LB in the year of conversion is equal to 2.87tC/ha. For conversions to ZuV, a gain in LB is assumed in the year of conversion of 2.87 tC/ha. Therefore, for conversions to ZuV the overall change in LB is 0. However, for ZuA no gain in LB is assumed and therefore conversion from grassy grassland to ZuA is considered to result in a loss in LB of 2.87tC/ha.

Woody grasslands to wetlands (Jn, Tf, AtVf to ZuA, ZuV)

For woody grasslands, it is assumed a loss of the mean LB in the year of the conversion, 6.4 tC/ha, and a gain of LB in ZuV, 2.87 tC/ha, in the year of conversion. No gain in LB is assumed to occur for conversions to ZuA.

Settlements converted to wetlands (AU to ZuA, ZuV)

It is assumed a gain of the LB in ZuV in the year of conversion, 2.87 tC/ha.

No CSC is associated with the conversion of settlements to ZuA.

No loss in LB is associated with conversions from settlements.

Other land converted to wetlands (AT to ZuA, ZuV)

It is assumed a gain of the LB in ZuV in the year of conversion, 2.87 tC/ha.

No CSC is associated with the conversion of other land to ZuA.

No loss in LB is associated with conversions from other land .

6.7.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in DOM is assumed 0, in line with tier 1 assumption of IPCC 2006, except for on FL.

6.7.2.2.3 Change of carbon stock in soil carbon pool

The value assumed for Wetlands mineral soils is 40 tC/ha. The area of the mineral soils was calculated as the difference between the national total areas and the areas covered by organic soils. The level of the organic soil surface, AD (kha), 98.42 kha, was evaluated according to the methodology described in the Chapter 6.5.2.2.3 and represents the most important area of organic soil among all the land use categories in the LULUCF sector. See Section 6.5.2.2.3 for information on the methodology applied for SOC in land converted categories.

6.7.2.2.4 Biomass burning

Romania reports the NO notation key, because this kind of activities doesn't happen in Wetlands remaining or land converted to Wetlands.

6.7.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

6.7.4 Uncertainty assessment and time-series consistency

The party used the same uncertainty values associated with the GHG emission/removal levels specific to the WL categories, both for AD and EF, described as in NGHGI 2020 and detailed in this inventory report, Chapter 6.1.6.

Table 6.32 4.D Uncertainty estimation

4D	Gas	U_c (%)	Contribution to variance by category in year x (%)	Type B sensitivity (%)	U in trend by U_{AD} (%)	U in total national emissions (%)
4D1	**CO_2**	301.496	0.000	0.000	0.000	0.000
4D2	**CO_2**	301.496	0.000	0.001	0.000	0.000
4D1	**CH_4**	0.000	0.000	0.000	0.000	0.000
4D2	**CH_4**	0.000	0.000	0.000	0.000	0.000
4D1	**N_2O**	315.779	0.000	0.000	0.000	0.000
4D2	**N_2O**	315.779	0.000	0.000	0.000	0.000

6.7.5 Category–specific QA/QC and verification, if applicable

(i) the first level of QA/QC is conducted by the data providers; ***(ii)*** perform basic checks consisting of various procedures applied to avoid errors associated with different stages of data processing or calculation and ***(iii)*** third level of QA/QC is implemented by the NEPA and MEWF, which consists of checks related to both CRT and NID chapters.

6.7.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The specific recalculations in the WL categories are summarized in the following figures:

Figure 6.30 Quantification of wetland remaining recalculations performed across the time period (kt CO_2 eq.)

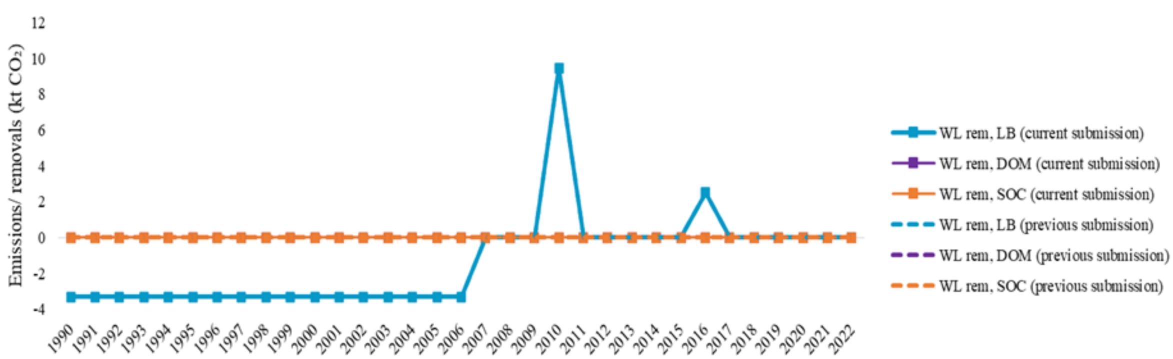
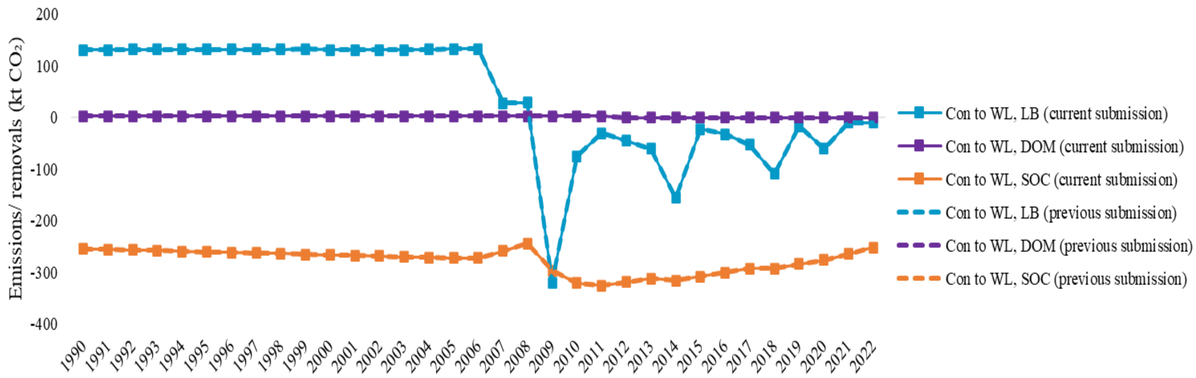


Figure 6.31 Quantification of land converted to wetland recalculations performed across the time period (kt CO_2 eq.)



For the NID 2025 submission, no recalculations were made to the historical data.

6.7.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

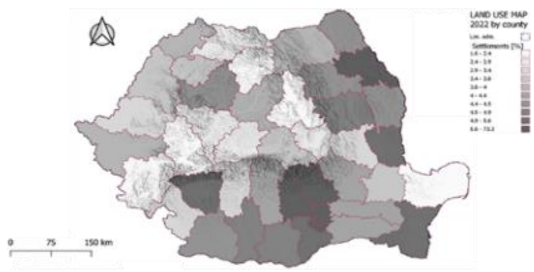
As part of the improvement plan of inventory, Romania will continue its efforts to improve GHG E/R estimation associated with WL to complete adaptation to the latest methodologies. In particular, regarding SOC, see Cropland section.

6.8 Settlements (CRT 4.E)

6.8.1 Category description

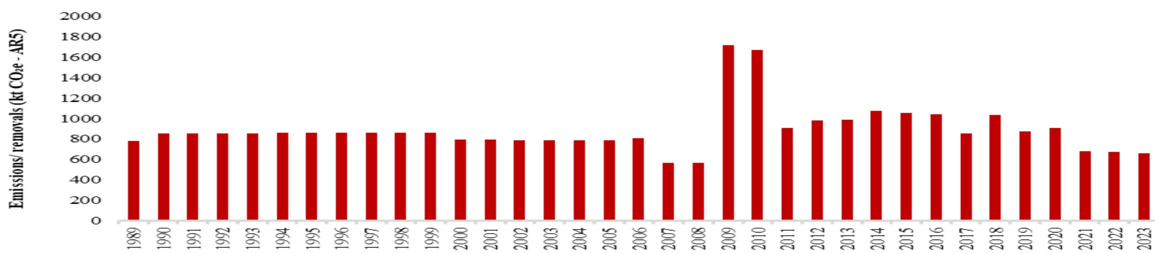
The calculations of the GHG E/R estimates were made for all individual years across the time series for the subcategories and related sources/sinks. Under this category, GHG E/R estimates from LB, Soil and DOM have been reported. The type 3 approach was considered for GHG E/R estimates, according to the methodology detailed in Chapter 6.3.1, paragraph *Combining, Processing and Querying Information*. The Settlements category estimates are presented in Figure 6.32.

Figure 6.32 4.E land use category. EGM - explicit geospatial map



The following figure include a 4.E summary of the GHG E(+)/R(-) estimates:

Figure 6.33 4. E GHG E/R evolution across the time period (kt CO_2 eq.)



6.8.2 Methodological issues

6.8.2.1 Settlements remaining Settlements (CRT sector 4.E.1)

It is assumed no CSC in LB, DOM or SOC in Settlements remaining Settlements.

6.8.2.2 Land converted to Settlement (CRT sector 4.E.2)

6.8.2.2.1 Changes of carbon stock in biomass carbon pool

For all land conversion, no gain in LB is associated with conversions to settlements.

Forest land to settlements

See the Forest land section for information on the loss of biomass associated with forest land converted to settlements.

Annual cropland to settlements (Ag to AU)

It is assumed a loss of LB in cropland annual in the year of conversion, 5 tC/ha.

Perennial cropland to settlements (Vv, Lv, Ata to AU)

For Ata, Vv and Lv, it is assumed that the loss of LB in the year of conversion is equal to the mean LB for perennial cropland, 6.4 tC/ha.

Grassland converted to settlements

Grassy grasslands to settlements (Pp, Pf, Pa to AU)

It is assumed a loss of LB in grassland grassy in the year of conversion, 2.87 tC/ha.

Woody grasslands to settlements (Jn, Tf, AtVf to AU)

For Jn, Tf and AtVf it is assumed that the loss of LB, in the year of conversion, is equal to the mean LB for perennial cropland, 6.4 tC/ha.

Wetlands converted to settlements *(ZuA, ZuV to AU)*

It is assumed there will be a loss of LB in wetlands with vegetation, ZuV, in the year of conversion, equal to 2.87 tC/ha. No loss in LB is associated with wetlands – waters/ponds, ZuA.

Other lands converted to settlements *(AT to AU)*

Therefore there is no CSC in LB in conversion from OL to SL.

6.8.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in dead organic matter it is only estimated for forest land conversions to the SL.

6.8.2.2.3 Change of carbon stock in soil carbon pool

In 2006, Romania established national reference carbon (C) stocks in mineral soils through a research and development project titled Monitoring Soil Quality in Romania, based on a 20-year transition period. The carbon stock in settlements was estimated at 32 tC/ha, assuming the removal of the top 10 cm of mineral soil from croplands and a uniform distribution of soil organic carbon (SOC) within the top 10 cm of mineral soil. Details regarding the methodology applied for SOC in land conversion categories can be found in Section 6.5.2.2.3.

6.8.2.2.4 Biomass burning

Romania reports the NO notation key, because this kind of activities doesn’t happen in Settlements remaining or land converted to Settlements.

6.8.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

6.8.4 Uncertainty assessment and time-series consistency

Romania used the same uncertainty values associated with the GHG emission/removal levels specific to the SL categories, both for AD and EF, described in NGHGI 2020 and detailed in this inventory report, Chapter 6.1.6.

Table 6.33 4.E Uncertainty estimation

4E	Gas	U_c (%)	Contribution to variance by category in year x (%)	Type B sensitivity (%)	U in trend by U_{AD} (%)	U in total national emissions (%)
4E1	**CO_2**	301.496	0.000	0.000	0.000	0.000
4E2	**CO_2**	301.496	0.001	0.002	0.001	0.000
4E1	**CH_4**	0.000	0.000	0.000	0.000	0.000
4E2	**CH_4**	0.000	0.000	0.000	0.000	0.000
4E1	**N_2O**	315.779	0.000	0.000	0.000	0.000
4E2	**N_2O**	315.779	0.000	0.000	0.001	0.000

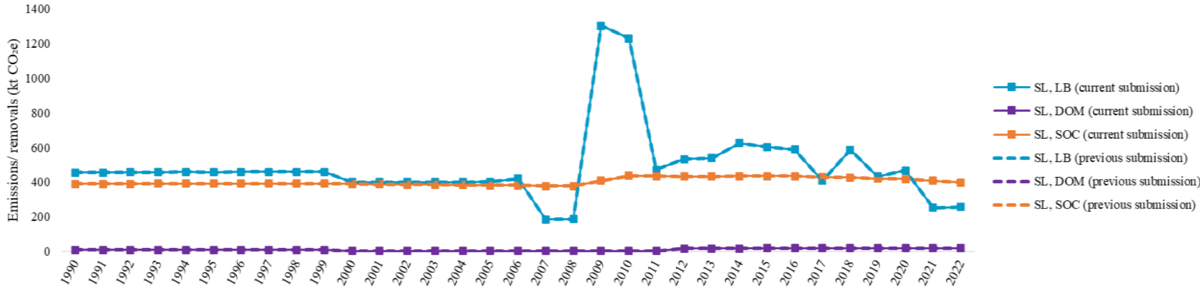
6.8.5 Category–specific QA/QC and verification, if applicable

(i) the first level of QA/QC is conducted by the data providers; ***(ii)*** perform basic checks consisting of various procedures applied to avoid errors associated with different stages of data processing or calculation like and ***(iii)*** third level of QA/QC is implemented by the NEPA and MEWF, which consists of checks related to both CRT and NID chapters.

6.8.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The specific recalculations in the SL categories are summarized in the following figure:

Figure 6.34 Quantification of land converted to settlement recalculations performed across the time period (kt CO_2 eq.)



For the NID 2025 submission, no recalculations were made to the historical data.

6.8.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

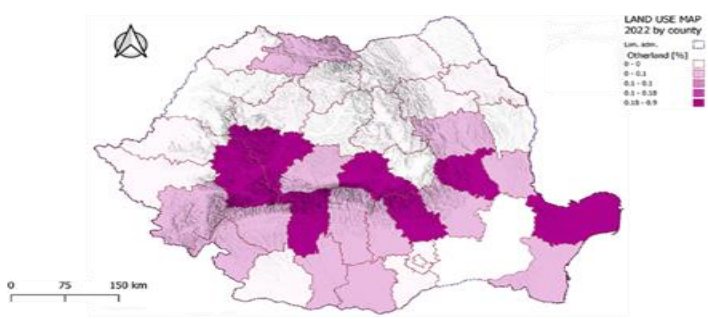
As part of the improvement plan of inventory, Romania will continue its efforts to improve GHG E/R estimation associated with SL to complete adaptation to the latest methodologies. In particular, regarding SOC, see Cropland section.

6.9 Other lands (CRT 4.F)

6.9.1 Catgory description

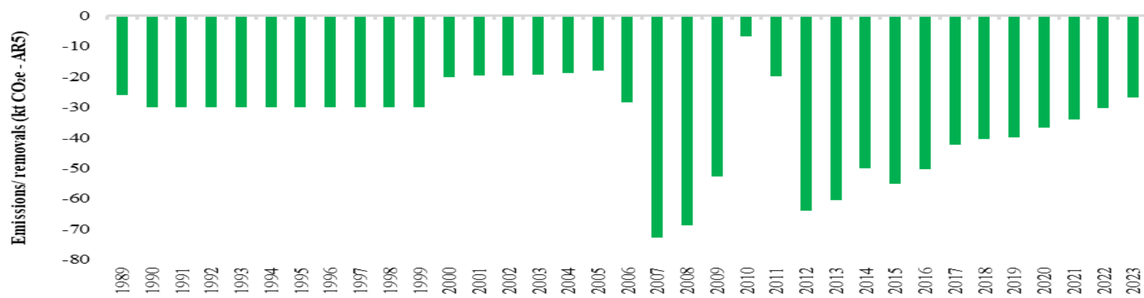
In the 4.F category, GHG E/R estimates are reported. The Other land use category estimates are presented in the figure below.

Figure 6.35 4.F land use category. EGM - explicit geospatial map



The following figure include a 4.F summary of the GHG E(+)/R(-) estimates:

Figure 6.36 4.F GHG E/R evolution across the time period (kt CO_2 eq.)



6.9.2 Methodological issues

6.9.2.1 Other land remaining Other land (CRT sector 4.F.1)

It is assumed no CSC in LB, DOM or SOC in Other land remaining other land.

6.9.2.2 Land converted to Other land (CRT sector 4.F.2)

6.9.2.2.1 Changes of carbon stock in biomass carbon pool

For all land conversion, no gain in LB is associated with conversions to other land.

Forest land to Other land

See the Forest land section for information on the loss of biomass associated with forest land converted to other lands.

Cropland converted to Other land

Annual cropland to Other land (Ag to AT)

It is assumed a loss of LB in cropland annual in the year of conversion, 5 tC/ha.

Perennial cropland to Other land (Vv, Lv, Ata to AT)

For Ata, Vv and Lv, it is assumed that the loss of LB in the year of conversion is equal to the mean LB for perennial cropland, 6.4 tC/ha.

Grassland converted to Other land

Grassy grasslands to Other land (Pp, Pf, Pa to AT)

It is assumed a loss of LB in grassland grassy in the year of conversion, 2.87 tC/ha.

Woody grasslands to Other land (Jn, Tf, AtVf to AT)

For Jn, Tf and AtVf it is assumed that the loss of LB, in the year of conversion, is equal to the mean LB for perennial cropland, 6.4 tC/ha.

Wetlands converted to Other land *(ZuA, ZuV to AT)*

It is assumed there will be a loss of LB in wetlands with vegetation, ZuV, in the year of conversion, equal to 2.87 tC/ha. No loss in LB is associated with wetlands – waters/ponds, ZuA.

Settlements converted to Other land *(AU to AT)*

It is assumed no LB in SL or OL, and therefore is no CSC.

6.9.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in dead organic matter it is only estimated in forest land conversions to the OL. It is considered DOM as loss in the year of conversion, and no C is gain afterwards, detailed in Chapter 6.1.4.2, Table 6.7.

6.9.2.2.3 Change of carbon stock in soil carbon pool

Romania has developed through a research-development project, *Monitoring soil quality in Romania*, 2006, national reference C stocks in mineral soils, assuming a 20 years transition period. The value assumed by Romania for Other land mineral soils is 41 tC/ha.

The assumption that OL use category consists of deposits of interior rivers and Danube floodplains is based on the fact that excavations of stony debris, gravel/sand/earth pits are located mostly on the interior river beds and Danube floodplains. The value of 41tC/ha represents the result of the national research study estimates carried out over a period of 10 years, Monitoring soil quality in Romania (2006), NGHGI 2022, ref. 37, p. 827. The estimated value of 41 tC/ha assigned to C stock for OL category takes into account the organic matter addition brought by river alluvium which were deposited on the riverbanks and beds, and it is considered more appropriate. The C stock of 41 tC/ha in soils under OL was computed as the weighted average of rocky areas, 5 tC/ha, as well as deposits of interior rivers, 10 tC/ha and the Danube, 60 tC/ha, each assumed to cover 33% of the total area of OL. The level of the organic soil surface, AD (kha), 0.40 kha, was evaluated according to the methodology described in the Chapter 6.5.2.2.3. See Section 6.5.2.2.3 for information on the methodology applied for SOC in land converted categories.

There are currently discussions regarding the financing of a new national study to re-estimate C stocks and C stocks change in mineral soils for all land use categories.

6.9.2.2.4 Biomass burning

Romania reports the notation key NO, because this kind of activities does not happen.

6.9.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

6.9.4 Uncertainty assessment and time-series consistency

Romania used the same uncertainty values associated with the GHG emission/removal levels specific to the OL categories, both for AD and EF, described in NGHGI 2020 and detailed in this inventory report, Chapter 6.1.6.

Table 6.34 4.F Uncertainty estimation

4F	Gas	U_c (%)	Contribution to variance by category in year x (%)	Type B sensitivity (%)	U in trend by U_{AD} (%)	U in total national emissions (%)
4F1	**CO_2**	301.496	0.000	0.000	0.000	0.000
4F2	**CO_2**	301.496	0.000	0.000	0.004	0.000
4F1	**CH_4**	0.000	0.000	0.000	0.000	0.000
4F2	**CH_4**	0.000	0.000	0.000	0.000	0.000
4F1	**N_2O**	315.779	0.000	0.000	0.000	0.000
4F2	**N_2O**	315.779	0.000	0.000	0.000	0.000

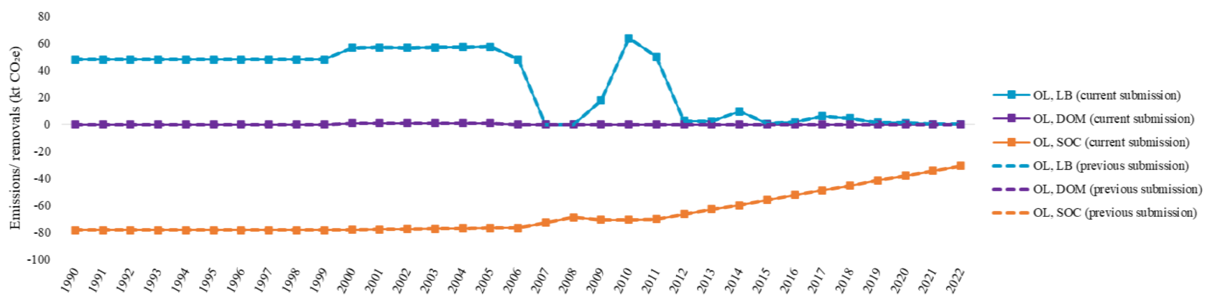
6.9.5 Category–specific QA/QC and verification, if applicable

(i) the first level of QA/QC is conducted by the data providers; ***(ii)*** perform basic checks consisting of various procedures applied to avoid errors associated with different stages of data processing or calculation and ***(iii)*** third level of QA/QC is implemented by the NEPA and MEWF, which consists of checks related to both CRT and NID chapters.

6.9.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The specific recalculations in the OL categories are summarized in the following figure:

Figure 6.37 Quantification of land converted to other land recalculations performed across the time period (kt CO_2 eq.)



For the NID 2025 submission, no recalculations were made to the historical data.

6.9.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

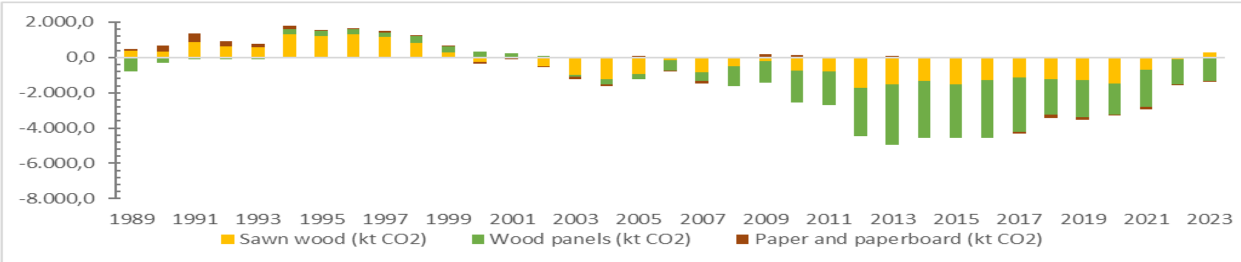
No improvements are planned in this category.

6.10 Harvested wood products (CRT 4G)

6.10.1 Category description

The change in carbon stock within the HWP pool is estimated by employing the production approach, which is based on the domestic consumption of wood products. This estimation involves the use of a first–order decay function as outlined in Equation 12.1 from the 2006 IPCC Guidelines, in conjunction with the default half–life values specified by Equation 2.8.5 in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.The annual E/R from the HWP for the 1989–2023 period is shown in Figure 6.38.

Figure 6.38 Net annual E/R from the HWP for each product subcategory's 1989–2023 period



6.10.2 Methodological issues

The international database of FAOSTAT was used to get AD to estimate the carbon stock change in the HWP pool interrogated in December 2023. Queried quantitative data from the database was retrieved regarding the internal production, exports, and imports from 1961, as shown in Table 6.36. Production, imports, and exports values for years before 1961 were estimated using Equation 12.6 from the 2006 IPCC Guidelines, Volume 4, Chapter 12, and using the annual rate of increase for Europe from Table 12.3 from the same document. The value of ‘0' was used for the starting year 1900. To estimate the carbon stock in HWP from domestic sources remaining in the country, the Equations 2.8.1 and 2.8.2 from the 2013 KP Supplement were used to calculate the annual fraction of feedstock for HWP from industrial Roundwood sawn wood and wood-based panels from wood pulp for paper and paperboard products. Further, Equation 2.8.4 was used to estimate the annual amount of HWP entering the accounting.

Table 6.35 HWP values for volume or mass by category and type used to estimate the carbon stocks and carbon stock changes

Type	FAO code	Sub–category	Unit	1990	2000	2015	2020	2023
Production	**1866**	**Industrial Roundwood (Con)**	m^3	3,801,000	4,586,500	5,006,838	6,061,405	4,927,637
	1867	**Industrial Roundwood (Broad)**	m^3	6,924,000	5,529,500	5,228,561	5,567,275	5,975,269
	1632	**Sawnwood (Con)**	m^3	1,357,000	2,076,500	4,599,709	4,580,495	2,900,000
	1633	**Sawnwood (Broad)**	m^3	1,554,000	1,319,200	1,700,000	1,615,000	1,200,000
	1873	**Wood-based panel**	m^3	1,044,000	286,900	4,991,171	3,812,738	3,626,789
	1876	**Paper and paperboard (t)**	m t	547,000	339,600	389,954	503,839	606,010

Type	FAO code	Sub–category	Unit	1990	2000	2015	2020	2023
	1875	**Wood-PULP**	m t	481,000	292,700	0	0	0
Import	**1866**	**Industrial Roundwood (Con)**	m^3	205,119	10,900	1,643,651	1,600,439	2,025,317
	1867	**Industrial Roundwood (Broad)**	m^3	214,809	9,500	148,789	43,489	104,229
	1875	**Wood-PULP**	m t	71,000	3,800	121,552	140,950	152,222
Export	**1866**	**Industrial Roundwood (Con)**	m^3	64	234,200	73,170	20,798	117,475
	1867	**Industrial Roundwood (Broad)**	m^3	1,746	296,600	96,487	97,570	122,047
	1875	**Wood-PULP**	m t	3,000	31,200	109	16,311	2,363

The annual quantities of wood products were converted into carbon stocks using a Tier 2 approach, which incorporates first-order decay functions for the calculation. The default conversion factor, referenced from Table 6.37, was employed to estimate the Annual Data (AD) of carbon stock at the start of each year, denoted as C(i), and the annual inflow of Harvested Wood Products (HWP), denoted as Inflow(i). These calculations are based on parameters outlined in Table 2.8.1 of the 2013 KP Supplement. To determine the change in carbon stock over the course of a year, as required by Equation 2.8.5 in the 2013 KP Supplement, half-life values from Table 2.8.2 of the same document were utilized (also referenced in Table 6.36). This methodology ensures a precise estimation of carbon stock changes in HWPs, taking into account the decay rate and carbon conversion factors specific to different wood product categories.

Table 6.36 Emission factors and half-life time used to estimate the carbon stock change in the HWP pool

HWP category	*Default half-life (years)*	*Density (oven-dry mass over air dry volume) [Mg / m^3]*	*C conversion factor (per air dry volume) [Mg C / m^3]*
Sawn wood (Con)	35	-	0.225
Sawn wood (Broad)	35	-	0.280
Wood-based panel	25	-	0.269
Paper and paperboard	2	0.9	0.386

The carbon pools of HWP encompass the products derived from wood production in the FL-FL category. For wood harvested in the transition from FL-L, instant oxidation is assumed, meaning that the carbon contained in the wood is considered to be immediately released into the atmosphere upon harvest. Similarly, wood that ends up in solid waste disposal sites is also treated under the assumption of instant oxidation, where the carbon it contains is considered to be immediately emitted to the atmosphere. This accounting approach distinguishes between carbon stored in wood products for varying durations and carbon released immediately due to land use changes or disposal practices.

6.10.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG’s do not apply for Romania.

6.10.4 Uncertainty assessment and time-series consistency

To estimate the Activity Data (AD) series, data from the FAO is utilized, with an assumed uncertainty of 15%. For the calculation of carbon conversion factors, a higher uncertainty of 50% is considered. When these uncertainties are combined for the HWP category, the total combined uncertainty is calculated to be 52%. This combined uncertainty reflects the compounded effects of uncertainties in both the activity data derived from FAO sources and the assumptions made in calculating carbon conversion factors, highlighting the challenges in precisely estimating carbon stocks and changes within the HWP category.

6.10.5 Category–specific QA/QC and verification, if applicable

The CO_2 emissions from the HWP category were analyzed at the sector level by cross-check of various procedures to avoid errors associated with different data processing stages or calculations.

6.10.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

- The FAO database, used for activity data (AD), was queried for this year's submission, triggering some corrections to historical values and necessitating a recalculation of the E/R in the time series.
- On average, the differences in E/R across the time series between different submissions were 1.2%. The highest discrepancies occurred in 2021 and 2022, due to the incorporation of new activity data (AD).

6.10.7 Category–specific planned improvements, if applicable (i.e., methodologies, activity data, emission factors, etc.), including those in response to the review process

The continuous scrutiny of the AD used for estimating carbon stock changes in the HWP pool is crucial. This ongoing review ensures the accuracy and reliability of the data, for precise carbon stock change assessments in the HWP category.

6.11 Nitrous oxide emissions from runoff associated to land conversions

6.11.1 Description of sources of indirect emissions in GHG inventory

Under land use change, indirect CO_2 and NO_x emissions from leaching and run–offs are considered negligible, thus reported as not occurring (NO) in CRT. Organic soils area is very small, thus leaching is also negligible.

6.11.2 Methodological issues

Default factors from Tier 1 and Equation 11.10 are tested. The amount of N_2O emissions from runoff/ leaching is negligible.

6.11.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

6.11.4 Uncertainty assessment and time-series consistency

Not applicable.

6.11.5 Category–specific QA/QC and verification, if applicable

Not applicable.

6.11.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Not applicable.

6.11.7 Category–specific planned improvements, if applicable (i.e., methodologies, activity data, emission factors, etc.), including those in response to the review process

Further research has to be implemented in order to estimate such sources and emissions. A potential GHG source may be erosion of agricultural soils.

6.12 GHG emissions from LULUCF sources

6.12.1 Direct N_2O emissions from N fertilization of Forest Land and Other (CRT Table 4(I))

For the Forest land category, there are no direct N_2O emissions from N fertilization on FL-FL, as there is no information or reporting of the practice of nitrogen fertilization of forest stands in Romania. In some cases, fertilizers can occur under extensive forest management practices in afforestation sites (i.e., they rarely occur in forest nurseries). Moreover, no data is available. Because of this, the fertilizer amount applied statistics are not broken down by land use.

Thus, associated emissions are included in the reported values under Chapter 4 Agriculture of the national GHG inventory. Thus, these emissions are reported as "IE" in CRT Table 4(I). Flooding is considered negligible. All the peatlands in Romania are nature reserves, part of them under Natura 2000, others under other forms. Also, we know from open sources of information, websites, and articles, but also from NID 2023, etc. that in Romania, after 1989, Peatlands are not exploited/ there are NO open exploitations for energy purposes (0 in the Energy Sector), respectively there are no exploitations for the purposes of organic soil fertilization in agriculture and/or grazing (0 in the Agriculture Sector).

6.12.2 Non–CO_2 emissions from drainage of soils and Wetlands (CRT Table 4(II))

Flooding is considered negligible. All the peatlands in Romania are nature reserves, part of them under Natura 2000, others under other forms. Also, we know from open sources of information, websites, and articles, but also from NIR 2023, etc. that in Romania, after 1989, Peatlands are not exploited/ there are NO open exploitations for energy purposes (0 in the Energy Sector), respectively there are no exploitations for the purposes of organic soil fertilization in agriculture and/or grazing (0 in the Agriculture Sector).

6.12.3 Direct N_2O emissions from Nitrogen (N) mineralization/ immobilization associated with loss/gain of soil organic matter resulting from the change of land use or management of mineral soil (CRT Table 4(III))

The N_2O emissions were calculated by default Tier 1 (Equations 11.10 and 11.11 from IPCC 2006 GL).
The emissions were estimated based on the detected changes in mineral soils on FL and GL converted to CL. In 2023 there are no new drained areas, but only areas under the 20 years transition period (since drainage occurred). Drainage leads to soil perturbation which associates with N_2O emissions by humus decomposition. For the changes detected in FL, a default emission factor of 0.01 Kg N_2O–N was used (Table 11.1, 2006 IPCC GL), and C: N ratio of 15 (pg. 11.16, 2006 IPCC GL).

6.12.4 Indirect N_2O emissions from managed soils (CRT Table 4(IV))

There are no conversions on organic soils, and if there are any, these are reported as IE in drained Cropland. Also, conversions from Wetlands to Cropland are assumed to occur only on mineral soils, as lands under temporary flooding are classified as wetlands but not associated with mineral soils.

6.12.5 Biomass Burning (CRT Table 4(V))

For the Forest land category, the area annually affected by wildfires is reported in sectoral forest statistics and by the General Inspectorate of Emergencies Situations (Table 6.38). The reported data demonstrate that the forest fires mainly affect the ground floor burning, dead biomass (i.e., litter and lying deadwood), and in a few cases, the crown. The wood that is not qualitatively affected is harvested and reported in the annual wood harvest statistics. The CO_2, N_2O, and CH_4 emissions from the non-harvested parts of the burnt biomass are all reported in CRT Table 4(V). No separate estimates of those emissions were divided between remaining forests (4.A.1 – Forest Land remaining Forest Land) and lands under conversion to forests (4.A.2 – Land converted to Forest Land), not for AR, from the estimates for FL, as no disaggregated statistics available. All GHG emissions from biomass burning are included in category 4.A.1 and reported IE in other categories.
For 4.A.1 and FM activity, it is assumed that the entire litter and deadwood are burned (both lying and

standing deadwood). Emissions are computed from the nationwide average C stock in the litter (7.42 tC/ha) and deadwood pool (0.74 tC/ha computed from 3.13 m^3/ha of standing deadwood and 0.62 m^3/ha lying deadwood), preliminary available from the NFI. Conversion from deadwood volume to dead mass was done assuming a density of 400 kg/m^3. Finally, the mean total C stock in the dead organic matter we used was the value of 8.16 tC/ha. It was also assumed that there were no emissions from the understory.

Table 6.37 The area affected by forest fires in 4.A. category and the associated emissions

Year	4.A.1			
	Area burned	CO_2 Emissions	CH_4 emissions	N_2O emissions
	ha ha^{-1}	kt CO_2 yr^{-1}	tonnes yr^{-1}	tonnes yr^{-1}
1989	93.00	1.97	5.90	0.33
1990	444.00	9.40	28.15	1.56
1991	277.00	5.86	17.56	0.97
1992	729.00	15.43	46.21	2.56
1993	518.00	10.96	32.84	1.82
1994	312.00	6.60	19.78	1.09
1995	208.00	4.40	13.19	0.73
1996	227.00	4.80	14.39	0.80
1997	68.00	1.44	4.31	0.24
1998	137.00	2.90	8.69	0.48
1999	379.00	8.02	24.03	1.33
2000	3,607.00	76.35	228.71	12.65
2001	1,001.00	21.19	63.47	3.51
2002	3,536.00	74.85	224.22	12.40
2003	762.00	16.13	48.32	2.67
2004	124.00	2.63	7.86	0.43
2005	162.00	3.43	10.27	0.57
2006	946.00	20.03	59.99	3.32
2007	2,529.00	53.54	160.39	8.87
2008	373.00	7.90	23.66	1.31
2009	974.00	20.62	61.77	3.42

Year	4.A.1			
	Area burned	CO_2 Emissions	CH_4 emissions	N_2O emissions
	ha ha^{-1}	kt CO_2 yr^{-1}	tonnes yr^{-1}	tonnes yr^{-1}
2010	206.00	4.36	13.07	0.72
2011	2,195.00	46.48	139.22	7.70
2012	6,624.00	140.26	420.15	23.24
2013	421.00	8.91	26.70	1.48
2014	217.00	4.38	13.13	0.73
2015	1,671.00	33.72	101.01	5.59
2016	675.00	13.78	41.27	2.28
2017	2,459.30	49.80	149.18	8.25
2018	1,341.25	27.42	82.13	4.54
2019	2,495.60	51.23	153.47	8.49
2020	5,151.99	106.25	318.27	17.61
2021	2,101.02	42.42	127.06	7.03
2022	13,152.95	270.86	811.37	44.88
2023	554.25	12.26	36.72	2.03

The GHG emissions from forest fires are estimated using a Tier 1 approach, i.e., Equation 2.27 of the 2006 IPCC GL, and emission factors from Table 2.5.

Emissions from Biomass burning in GL are described in Grassland section above.

6.12.6 Category–specific planned improvements, including those in response to the review process

To estimate emissions due to biomass burning in GL, based on AD(kha) from the analysis of data received from IGSU (General Inspectorate for Emergencies) - 2019, 2020, 2021, 2022, 2023.

6.12.7 Recalculations of non–CO_2 emissions from sources

Activity data of forest areas affected by fires was updated on new data reported.

7 Waste (CRT Sector 5)

7.1 Overview of the sector and background information

This chapter provides information on the estimation of the greenhouse gas emissions from the Waste Sector.

The following direct GHG emissions and source categories are quantified and reported:

- CH_4 and CO_2 emissions from Solid Waste Disposal;
- CH_4 and N_2O emissions from Biological Treatment – Composting;
- CH_4 emissions from Biological Treatment- Anaerobic Digestion at Biogas Facilities
- CH_4 and N_2O emissions from Wastewater Treatment and Discharge;
- CO_2, CH_4 and N_2O emissions from Waste Incineration.

Starting with 2013 submission NMVOC emissions from Solid Waste Disposal on Land were estimated.

Table 7.1 Status of the direct GHG emissions estimation in the Waste Sector

IPCC category	Emissions estimation status		
	CO_2	CH_4	N_2O
5.A Solid Waste Disposal			
5.A.1 Managed Waste Disposal	✓	✓	NA
5.A.2 Unmanaged Waste Disposal	✓	✓	NA
5.A.2.1 deep (>5m)	✓	✓	NA
5.A.2.2 shallow (<5 m)	✓	✓	NA
5.A.3 Other	NA	NA	NA
5.B Biological Treatment of Solid Waste			
5.B.1 Composting	NA	✓	✓
5.B.1 Anaerobic Digestion at Biogas Facilities	NO	✓	NO, NA
5.C Incineration and open burning of waste			
5.C. 1 Waste incineration	✓	✓	✓
5.C.1.1 Biogenic	✓	✓	✓
5.C.1.1.a Municipal Solid Waste	NA	NA	NA
5.C.1.1.b Other-Biogenic Waste other than Municipal Solid Waste	✓	✓	✓
5.C.1.2 Non-biogenic	✓	NE	✓

IPCC category	Emissions estimation status		
	CO_2	CH_4	N_2O
5.C.1.2.a Municipal Solid Waste	NA	NA	NA
5.C.1.2.b Other			
Hazardous waste	✓	NE	✓
Clinical waste	✓	NE	✓
5.C.2 Open Burning Waste	NA	NA	NA
5.C.2.1 Biogenic	NA	NA	NA
5.C.2.2 Non- Biogenic	NA	NA	NA
5D Wastewater Treatment and Discharge 5D			
5.D.1 Domestic Wastewater	NA	✓	✓
5.D.2 Industrial Wastewater	NA	✓	NE
5.D.3 Other (please specify)	NA	NA	NA
6.E Other	NA	NA	NA

* CH_4 emissions from industrial sludge are reported under 6.B.1.a – Industrial wastewater.

In 2023 GHG emissions from the Waste Sector accounted for 6,319.56 kt CO_2 equivalent, which represent 6.08 % of the total national GHG emissions in this year.

In the base year (1989), the total GHG emissions from the waste sector amounted to 5,730.05 kt CO_2 equivalent, which accounted for 1.85% of the total national GHG emissions in this year. Emissions from the waste sector showed an increase from the base year, with 10.29%, due to increasing of incineration activities and waste generation rate in parallel with increasing of living standards (Table 7.2, Figure 7.1).

Table 7.2 The contribution of Waste Sector to the total GHG emissions in Romania, for 1989–2023 period

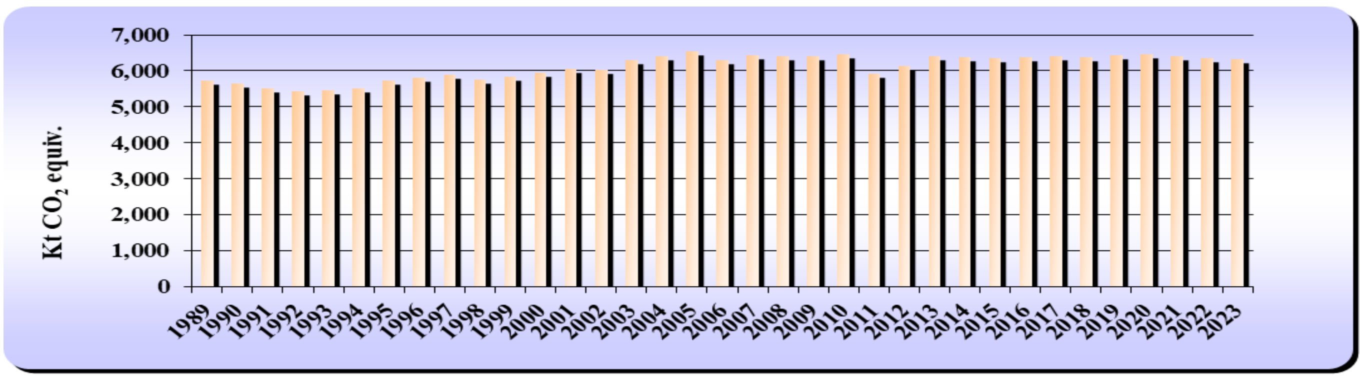
Year	Total GHG emissions (excl. LULUCF) [kt CO_2 equiv.]	GHG emissions from Waste [kt CO_2 equiv.]	Contribution of Waste in total GHG emissions [%]
1989	309,563.96	5,730.05	1.85
1990	256,636.86	5,635.91	2.20
1991	210,154.23	5,520.61	2.63
1992	194,556.74	5,439.97	2.80

Year	Total GHG emissions (excl. LULUCF) [kt CO_2 equiv.]	GHG emissions from Waste [kt CO_2 equiv.]	Contribution of Waste in total GHG emissions [%]
1993	183,982.84	5,469.87	2.97
1994	181,397.47	5,503.39	3.03
1995	188,315.16	5,717.74	3.04
1996	191,357.57	5,803.49	3.03
1997	184,794.26	5,887.22	3.19
1998	167,757.75	5,768.69	3.44
1999	149,860.14	5,839.02	3.90
2000	141,841.50	5,947.09	4.19
2001	145,618.04	6,042.51	4.15
2002	147,380.68	6,032.51	4.09
2003	153,315.24	6,299.61	4.11
2004	151,662.92	6,418.38	4.23
2005	150,375.83	6,534.10	4.35
2006	151,874.09	6,298.75	4.15
2007	154,891.56	6,424.23	4.15
2008	151,566.48	6,402.42	4.22
2009	130,229.60	6,399.70	4.91
2010	124,812.87	6,457.44	5.17
2011	132,250.56	5,906.43	4.47
2012	129,239.42	6,138.13	4.75
2013	117,865.19	6,411.68	5.44
2014	118,110.56	6,379.43	5.40
2015	116,802.10	6,355.66	5.44
2016	114,839.10	6,366.44	5.54
2017	117,804.06	6,415.08	5.45
2018	118,545.09	6,368.29	5.37
2019	115,311.93	6,446.87	5.59
2020	111,521.22	6,450.21	5.78
2021	115,375.00	6,401.91	5.55

Year	Total GHG emissions (excl. LULUCF) [kt CO_2 equiv.]	GHG emissions from Waste [kt CO_2 equiv.]	Contribution of Waste in total GHG emissions [%]
2022	109,667.26	6,340.35	5.78
2023*	103,862.45	6,319.56	6.08

* Preliminary data

Figure 7.1 Total GHG emissions trend from Waste Sector for 1989–2023 period



The most important contribution to GHG emissions from Waste Sector, in 2023 year, has Solid Waste Disposal Subsector, contributing with 69.73% in the total (Figure 7.2), Biological treatment accounts for 1.21%; Incineration and Open Burning of Waste Subsector accounts for only 0.10% and Wastewater Treatment and Discharge Subsector contribute with 28.96%. Solid Waste Disposal and Wastewater Treatment and Discharge Subsectors are key category sources both by level and trend (Table 7.3 and Figure 7.3).

Figure 7.2 Contribution of the sub-sectors in the total GHG emissions from Waste Sector in 2023

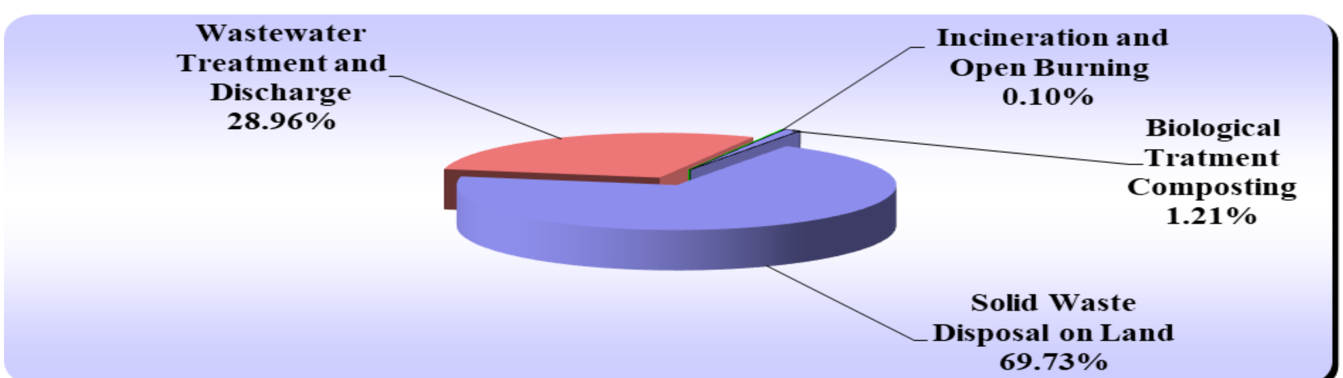
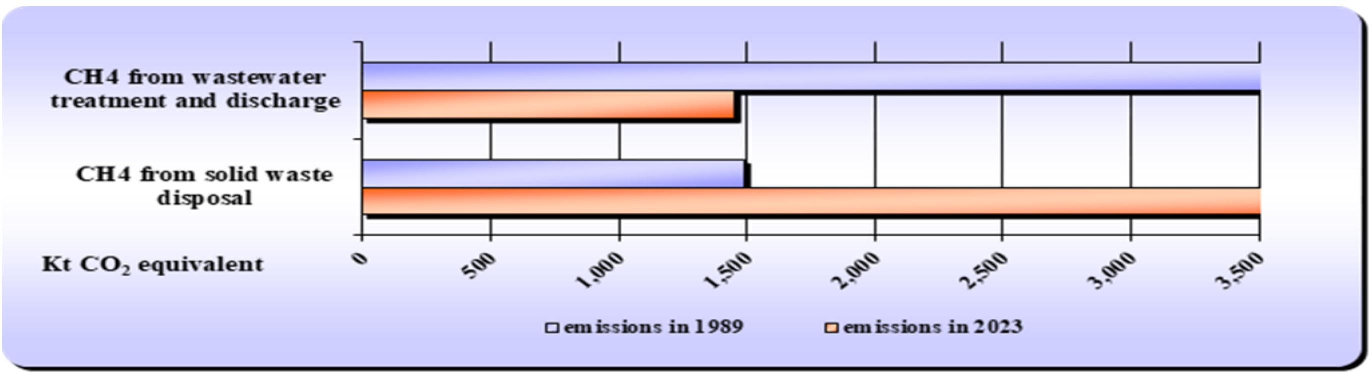


Table 7.3 Key categories in Waste Sector based on the level and trend assessment in 2023

Key category	Direct GHG	Criteria for identification	Contribution of key category in total GHG emissions [%] – (excluding LULUCF)
5.A Solid waste disposal	CH_4	L,T	3.8%
5.D Wastewater Treatment and Discharge	CH_4	L,T	1.3%

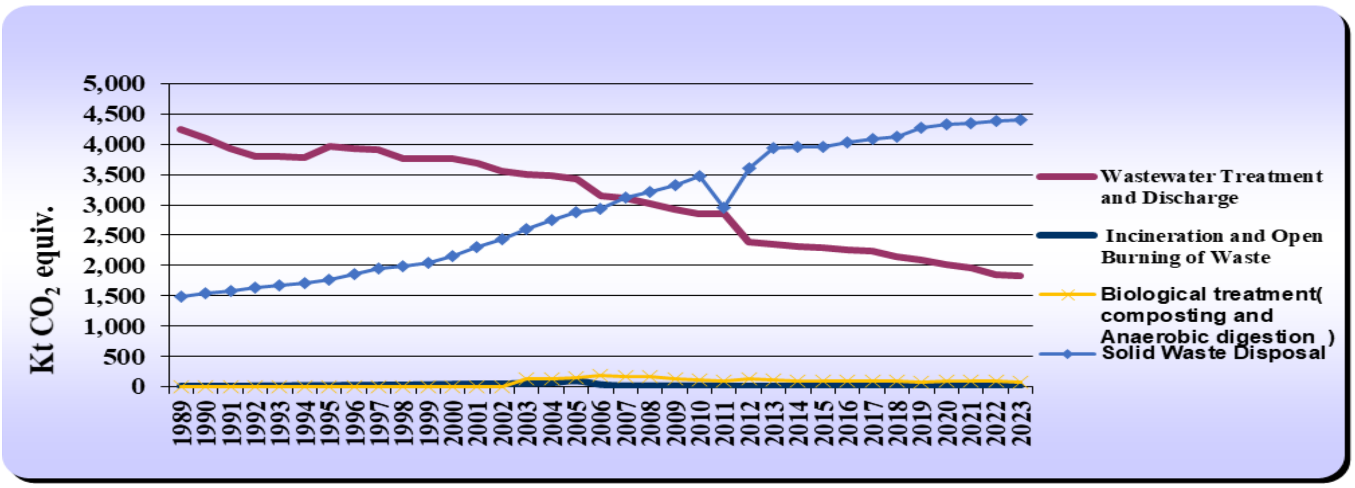
Figure 7.3 Key categories in in Waste Sector both by level and trend criteria, in 2023



Methane represents the major greenhouse gas from Waste sector with a contribution of 23.94 % to the total methane emissions in Romania, in 2023. In the same year, nitrous protoxide has a contribution of 4.30 % to the total N_2O emissions in our country. Only CO_2 emissions from Waste Incineration category are reported, these representing 0.01 % of total net CO_2 emissions in Romania. After 2000, Romania began to comply with EU standards, implementing European legislation both in waste and wastewater treatment management. However, the GHG emissions trend is different for the subsectors of Waste Sector due to improvement of living standards which is reflected differently in the evolution of these subsectors. GHG emissions trend from Solid Waste Disposal category (SWD) increased significantly in 2023 year comparing with the level in the base year, with a percentage of 195.63% (Figure 7.5). This increase is due to the increasing trend of waste generation rate following the relatively increased trend of population consumption. Emissions from wastewater treatment and discharge decreased with 56.83% in 2023 compared to 1989. The decrease is due to the increase in the number of inhabitants connected to the sewerage system, the decrease in the level of industrial production and the modernization of wastewater treatment plants. GHG emissions trend from Biological treatment (composting and anaerobic digestion) decreased in 2023 year comparing with the level in the base year, with a percentage of 44.46%. Emissions from waste Incineration category increased in 2023 year comparing with the level in 1989 year, with a percentage of 477.53% (Figure 7.4). In Waste Incineration

Subsector the emissions trend has remained almost constant in 2023 year because the amount of waste destined for incineration was constantly, except for the period 2004–2006 when there was intensified burning of industrial hazardous waste due to compliance with Directive 2000/76/CE.

Figure 7.4 GHG emissions trend from Waste Sector, by sub-sectors for 1989–2023 period



7.2 Solid Waste Disposal (CRT 5.A)

7.2.1 Category description

Waste generation rate follows the consumption and production tendency. With increasing of living standards also the amount of generated waste increased. Over time the amounts of waste generated do not have a linear evolution due to variability of production. Solid Waste Disposal is responsible for CH_4 and CO_2 generation. To estimate CH_4 emissions from Solid Waste Disposal category, were used the amounts of Municipal Solid Waste (MSW) deposited in Solid Waste Disposal Sites (SWDS) and also the amounts of sewage sludge deposited to SWDS. The amounts of sewage sludge deposited to managed and unmanaged SWDS were reconsidered by type of sludge, based on the study mentioned above, study finished in 2013. According to the National Waste Management Plan, municipal solid waste includes household and similar waste (from population, economic and commercial units, offices, and institutions), waste from municipal services (waste from street cleaning, markets, gardens, parks and green spaces). The quantities of municipal waste generated in Romania in 2011 followed the evolution of declining consumption due to economic crisis. Also, in this year the quantities of waste deposited, following the implementation of European legislation in this area, have decreased, and according to national legislation requirements, the amounts of waste recovered have increased. In 2006–2011 period, the percentage of MSW collected from total MSW generated ranged between 77% and 86%. From the total amount of MSW collected in 2011, 88.48% was deposited and the rest was recovered. In 2014 year about 66% of the waste collected by sanitation operators was eliminated in landfills, 7% (including R & D and inert) being sent directly to material recovery or energy. The difference from 100% municipal waste collected by the sanitation reaching sorting stations initially and later part recycled is sent for recycling.

Table 7.4 The quantities of municipal waste generated in the period 2018–2022 (final data for 2023 will be provided after statistical survey of the end of this year)

The quantities of municipal waste generated in the period 2018-2022					
Indicator	**2018**	**2019**	**2020**	**2021**	**2022**
Amount of municipal waste generated (tons)	5,296,239	5,296,239	5,619,216	5,777,045	5,767,456
From which:					
Household waste collected from the population and assimilated from economic operators (tons)	4,249,988	4,632,802	4,764,923	4,945,622	4,920,553
Municipal waste (tonnes)	430,097	419,429	499,450	438,152	495,434
Waste generated and uncollected (tonnes)	314,022	178,470	146,873	109,962	58,401
Recyclable waste from the population, collected through authorized economic operators, others than sanitation operators (tonnes)	302,132	199,640	207,970	283,309	293,068
Specific information on municipal waste in the period 2018–2022					
Indicator	**2017**	**2018**	**2019**	**2020**	**2021**
Degree of connection to the sanitation service (%)	88.09	93.07	94.08	95.24	97.04
urban	95.58	97.67	97.09	98.9	99.39
rural	79.38	87.7	89.58	91	95.22
The amount of municipal waste collected separately (tone)	634,536	576,816	716,415	890,707	872,867
The quantity of recycled municipal waste* (tons)	586,406	623,214	683,178	710,389	711,659
Degree of recycling achieved for municipal waste (%)	11.07	11.48	12.16	12.3	12.34
The amount of municipal waste recovered (tons)	241,445	251,277	298,421	317,700	388,713

The quantities of municipal waste generated in the period 2018-2022					
Indicator	**2018**	**2019**	**2020**	**2021**	**2022**
The amount of biodegradable waste from municipal waste disposed (tons)	2,068,288	2,120,022	2,077,089	2,038,908	1,891,093

Source: Waste Directorate of National Agency for Environmental Protection

For 2023 year preliminary data regarding the amount of MSW generated are 5,757,833 tons and the amount of MSW collected 5,645,480 tons. Concerning the ammounts of industrial waste with biodegradable content, in accordance with the study finished in 2013, the result of analyzing the collected data, followed by further discussion with the operators from different industrial activities, reveals that the quantities of biodegradable industry waste reported in questionnaires are temporally deposit on the site. These quantities are reused or deposited on municipal landfills. Therefore, in order to avoid double counting, the reported and estimated quantities of the biodegradable industry waste will not be taken into consideration for estimation of the greenhouse gases emissions. The amount of waste considered as disposed in municipal landfills includes, each year, Household and similar waste from industry (waste from offices/staff) and they are managed together with Household and similar waste. In 2023 year municipal solid waste are deposited in managed SWDS. In accordance with European regulations, the unmanaged SWDS storage activity was stopped. (Table 7.5).

Table 7.5 Number of Solid waste Disposal Sites (Source Waste Directorate of NEPA)

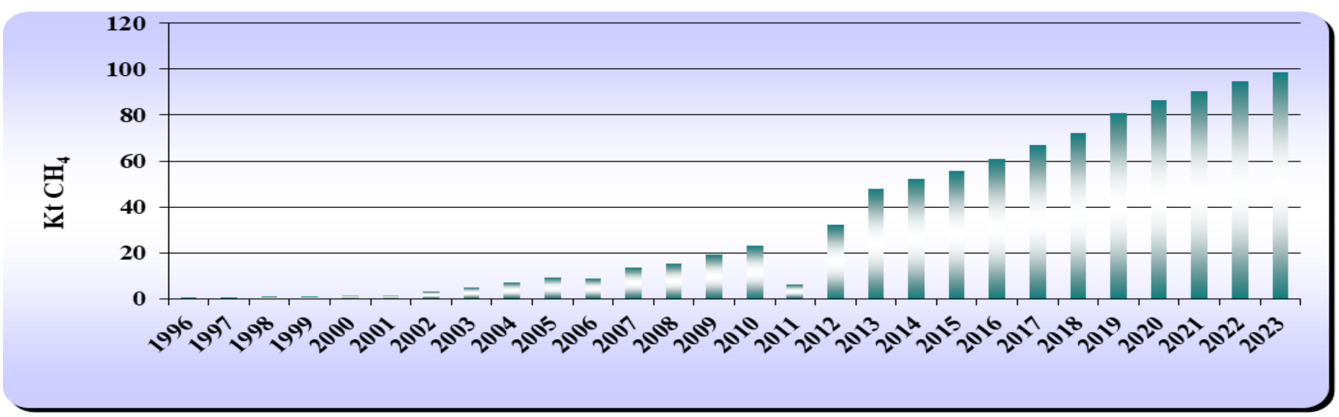
Type of SWDS/Year	Managed	Unmanaged deep	Unmanaged shallow
2013	34	48	
2014	34	33	
2015	35	25	
2016	37	19	
2017	42	7	
2018	43	-	
2019	44		
2020	46		
2021	48		
2022	47		

Type of SWDS/Year	Managed	Unmanaged deep	Unmanaged shallow
2023	47		

CH_4 emissions from SWDS

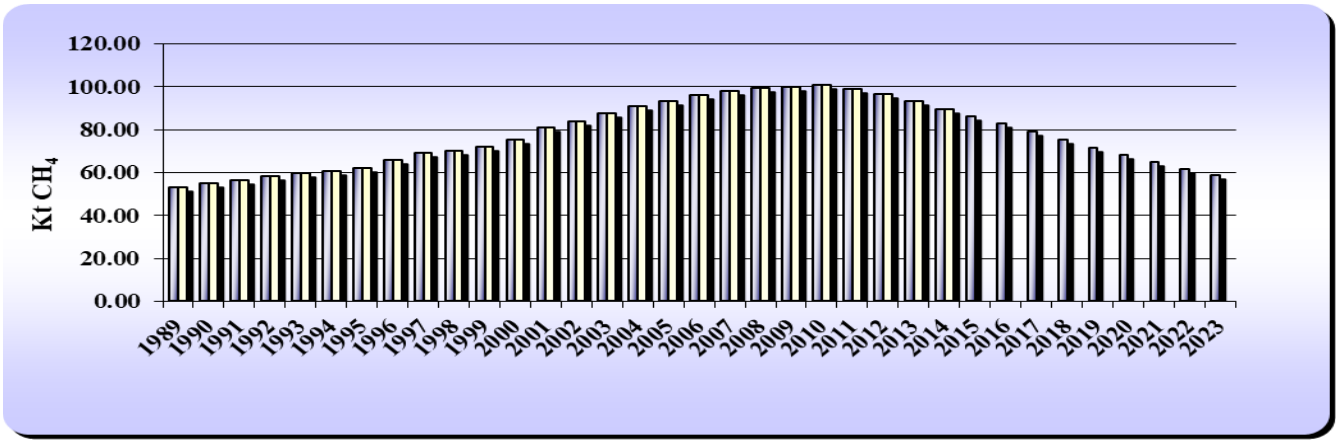
The methane emissions from Solid Waste Disposal Sites to managed landfills were estimated for the period 1996–2023, because in 1995 year was opened the first managed SWDS. The methane emissions from managed SWDS have an increasing trend between 1995–2010 period. The significant difference between the level in 2010 and 2011 years is associated to the amount of CH_4 recovered in 2011 which register a value of 40.80 kt and determine in 2011 a lower level of CH_4 emissions from managed solid waste disposal sites of about 1.78 kt. Starting 2013 year, living standards improvement resulted in an increase of the generated waste and thus of emissions. However, the increase of recycling along with the exploitation of CH_4 recovery limits the increase of methane emissions

Figure 7.5 CH_4 emissions trend from waste disposed to managed sites for 1995–2023 period



During 1950–2009, CH_4 emissions from unmanaged deep SWDS had an increasing trend similar to the trend associated with the emissions from unmanaged shallow SWDS (Figure 7.6), following the increasing of the amounts of waste generated and storage in unmanaged landfills. After 2009 the CH_4 emissions had a decreasing trend due to the decrease of the amounts of waste stored in unmanaged landfills. In accordance with European regulations, the unmanaged SWDS storage activity was stopped.

Figure 7.6 CH_4 emissions trend from waste disposed to unmanaged sites for 1989–2023 period



7.2.2 Methodological issues

Methodology

Given the key category status both by level and trend, CH_4 emissions from managed and unmanaged SWDS were estimated by applying First Order Decay Model, in accordance with IPCC 2006. To estimate methane emissions from managed landfills historical data prior to those associated with the 1995 year were not necessary, because the first managed landfill was opened in 1995 year. For unmanaged SWDS methane emissions were estimated based on data associated with the 1950–2023 period, according to the IPCC 2006 provisions, to achieve an acceptably accurate result. In order to estimate CH_4 emissions from managed and unmanaged sites, were taken into account also the amount of sewage sludge deposited to SWDS.

Emission factors

Municipal solid waste

Except Degradable Organic Carbon (DOC), country specific emissions factors and parameters were not available to estimate CH_4 emissions. DOC was calculated based on municipal waste composition, using estimated data associated with 1950–2003 period and data provided by NEPA Waste Directorate for period 2003–2023. (see the Table 7.6).

Table 7.6 The percentage composition of municipal solid waste

Year	Paper and textiles [%]	Garden & park waste/ other non–food organic	Food waste [%]	Wood/straw [%]
1989	8.64	10.33	26.51	0.66
1990	8.74	10.45	26.8	0.67
1995	11.92	14.25	36.55	0.91
2000	13.68	16.36	41.96	1.04
2005	12.76	14.5	38.6	1.00
2007	11.48	13.77	34.45	1.00
2008	8.32	6.03	45.29	1.58
2009	10.18	5.54	44.4	1.97
2010	9.88	20.31	32.19	2.11
2011	8.81	20.54	31.55	1.64
2012	11.06	20.7	36.49	1.77
2013	10.42	20.47	33.22	1.71
2014	9.23	15.71	36.53	0.73
2015	10.17	18.25	34.45	1.71
2016	10.34	16.83	34.74	1.72
2017	10.3	17.44	37.92	1.71
2018	11.16	17.44	33.49	1.95
2019	10.59	14.84	36.62	1.81
2020	9.93	12.95	37.53	1.74
2021	9.22	13.72	33.75	1.71
2022	8.63	11.38	33.09	1.66
2023*	8.63	11.38	33.09	1.66

* Preliminary data

In order to calculate the CH_4 emissions from municipal solid waste, default values associated with the other parameters, provided through IPCC 2006, taking into account the national circumstances, were used (Table 7.7 and 7.8). First Order Decay Model worksheet calculates a weighted average MCF from the estimated distribution of site types. IPCC default values for MSW disposed to unmanaged sites were included into the yellow MCF cells in row 12. Then, the approximate distribution of waste disposals (by mass) between site types were entered. Default parameters of the IPCC waste model typical of dry temperate climate were used. The methane generation rate constants (k) was chosen based on table 3.3 of the IPCC GL 2006. In Romania, according to information provided by the National Meteorological Administration, MAP/PET for 1981–2010 period is 0.87. Therefor it were used default parameters of the IPCC waste model typical of dry temperate climate.

Table 7.7 Other parameters used to calculate the emission factors (SWDS) for municipal solid waste disposed to SWDS

Type of site	**MCF**	**DOC_F**	**F**	**k**	**OX**
MSW disposed to managed SWDS	1.00	0.50	0.50	0.05	0.1
MSW disposed to unmanaged-deep	0.80	0.50	0.50	0.05	0.00
MSW disposed to unmanaged-shallow	0.40	0.50	0.50	0.05	0.00
Source	**IPCC 2006**				

Table 7.8 Parameters used to calculate the emission factors (SWDS) for sewage sludge disposed to SWDS

Type of site	**MCF**	**DOC**	**DOC_F**	**F**	**k**	**OX**
Sewage sludge disposed to managed SWDS	1.00	0.05	0.50	0.5	0.06	0.1
Sewage sludge disposed to unmanaged-deep	0.80	0.05	0.50	0.05	0.06	0.00
Sewage sludge disposed to unmanaged-shallow	0.40	0.05	0.50	0.05	0.06	0.00
Source	**IPCC 2006**					

Activity data

Municipal solid waste

For 2003–2023 period, the data on the amounts of MSW disposed to managed and unmanaged SWDS were provided by Waste Directorate from National Environmental Protection Agency, as a result of surveys conducted each year. For 2023 the statistical survey on waste has not yet finalised in this case data estimated based on the waste generation rate being used. The historical data on MSW storage were estimated in the context of implementing the study *"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",* in 2011 year (see the Table 7.9).

Table 7.9 Total annual MSW disposed to Solid Waste Disposal Sites

Year	managed	unmanaged deep sites	unmanaged shallow sites
1989	NO	2,545.70	1,630.70
1990	NO	2,573.86	1,648.74
1995	150.00	3,418.33	2,189.67
2000	565.66	3,684.89	2,360.43
2005	2,079.84	3,020.00	1,780.00
2007	2,841.68	2,874.98	1,132.44
2008	3,187.59	3,344.19	754.62
2009	3,158.06	3,022.59	574.24
2010	3,522.27	1,556.33	372.64
2011	3,697.73	1,156.85	213.96
2012	3,802.51	667.38	164.69
2013	3,788.67	449.03	108.98
2014	3,899.88	554.69	89.97
2015	4,202.90	432.32	146.21
2016	4,643.89	309.17	22.02
2017	4,456.60	58.23	3.99
2018	4,918.28	0.00	
2019	5,072.67		
2020	4,811.81		
2021	5,236.95		
2022	4,964.26		
2023*	5,000.78		

*Preliminary data (final data for 2023 will be provided after statistical survey of the end of this year)

Sewage sludge disposed to SWDS

Data associated with the amounts of sewage sludge disposed to managed and unmanaged SWDS, were reconsidered through the 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). Determining the types/quantities of incinerated waste and the parameters specific to the incineration thereof, for 1989–2012. Assesing the N_2O emissions resulting from waste incineration"*, implemented in 2013 year, based on the available data provided by National Institute of Statistics (NIS), regarding the total amounts of sewage sludge disposed to SWDS, for period 2006–2012 period. The estimation of industrial and domestic sludge disposed, for the period 1950–2005, was calculated by applying at the amount of industrial and domestic sludge reported by the operators of the average index obtained based on the average of annual index. The amounts of sewage sludge disposed in managed landfills are based on the results of the study finished in 2012 and were reported by the operators. The sewage sludge disposed in landfills is generated in the municipal/industrial sewage treatment plants. The NIS data on the total quantities of sewage sludge landfilled in the period 2006–2022 were considered in the emission estimation. Taking into account that the statistical survey on waste has not yet finalized for 2023 year, was considered the preliminary value for sewage sludge landfilled, data provided by NIS.

The Table 7.10 shows the activity data for the period 1989–2023.

Table 7.10 Total annual sewage sludge disposed to Solid Waste Disposal Sites

Year	managed	unmanaged deep sites	unmanaged shallow sites
1989	NO	21.78	50.82
1990	NO	21.73	50.70
1995	72.23	33.97	49.07
2000	123.39	38.65	55.82
2005	443.50	31.13	44.96
2007	572.07	4.99	5.91
2008	1,186.75	6.17	6.81
2009	308.48	4.20	0.68
2010	271.61	2.05	1.80
2011	692.50	2.06	1.54
2012	93.11	1.08	0.81
2013	130.49	37.97	9.22
2014	403.22	57.35	9.30
2015	258.85	26.63	9.00

Year	managed	unmanaged deep sites	unmanaged shallow sites
2016	305.88	20.36	1.45
2017	428.76	5.60	0.38
2018	380.04	0	
2019	345.02		
2020	338.32		
2021	379.85		
2022	362.30		
2023*	360.91		

*Preliminary data (final data for 2023 will be provided after statistical survey of the end of this year)

CH_4 recovery

Data on CH_4 recovery are provided annually by the operators of managed SWDS. Considering the available information, the amount of CH_4 flared is reported by 20 managed SWDS and the amount of CH_4 for energy purposes is reported by 3 managed SWDS. For the 2023 year, according to the questionnaire completed by the operators, data on CH_4 recovered are both measured, 3.93 kt, and estimated, 3.23. Since 1996 to 2001, only a single landfill began to recover the CH_4 emitted. In period 2001–2011 the amounts of methane recovered recorded a significant increase, because many more operators have reported their activity, except 2012 year, when certain operators has stoped the recovery of CH_4 emissions due to the rearrangement of sites. The analysis of methane recovered data showed that there was an increased amount in 2006 which is coming from a single operator. According to the explanations provided by this operator, the increased amount of methane recovered comes from the increased amount of MSW deposited in 2006 compared to 2005 (476,380.27 tones in 2005 and 561,427.36 tones in 2006) with a higher content of biodegradable waste due to increasing recovery activities of waste. In 2014 the quantity of methane recovered from landfill register a decrease, determining a large difference between the CH_4 recovered in 2011 and 2012. The differences between 2010 and 2011 year are due to the CH_4 recovery data reported by an important operator for 2011 year. For 2013 year the share of methane recovery decreased because certain waste disposal sites stopped the recovery of methane due to the rearrangement of landfill; therefore, the methane emissions increased again in 2014 year. The significant difference between 2018 and 2019 years is associated to the amount of CH_4 recovered in 2019 year, reported by two economic operators. The reasons for this decrease are described below:

- operator 1: the difference is motivated by the change in the characterization of CH_4 recovered; in the period prior to 2019 year the CH_4 recovered was estimated based on a study and in 2019 year it was measured.

- operator 2: the difference is due to the average percentage of CH_4 present in the composition of the storage gas captured and neutralized by combustion, as in 2019 year was 38.5% and in 2018 year 66.5%.The composition of landfill gas is influenced by various factors, such as the composition of waste, the age of the cells in the body from which biogas is extracted, the opening of new biogas wells and their connection to the centralized system which brings a large intake of young gas in composition for methane.

According to the data sources used there is no CH_4 recovery from the unmanaged sites and the emissions are reported as NO (see Table 7.11).

Table 7.11 The amounts of CH_4 recovered from managed SWDS (Source: operators of landfills)

Year	Amount of CH_4 flared kt/year	Amount of CH_4 for energy recovery kt/year
1989–1995	-	-
1996	0.43	NO
2000	1.97	NO
2005	8.91	NO
2007	13.09	NO
2008	15.91	NO
2009	15.99	NO
2010	16.37	NO
2011	38.32	2.48
2012	14.79	2.77
2013	3.79	2.99
2014	4.92	2.99
2015	4.94	4.28
2016	5.56	3.29
2017	4.81	3.9
2018	6.41	3.08
2019	3.4	2.67
2020	3.42	3.01
2021	3.99	3.11
2022	4.20	3.31
2023	4.60	2.55

CO_2 emissions from solid waste disposal on land

CO_2 emissions from managed and unmanaged SWDS were estimated based on the study "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", finished in 2011. In accordance with 1996 IPCC Guidelines:

- ”In addition to CH_4, solid waste disposal sites can also produce substantial amounts of CO_2. Decomposition of organic material derived from biomass sources (e.g., crops, forests) which are reground on an annual basis is the primary source of CO_2 released from waste. Hence, these CO_2 emissions are not treated as net emissions from waste in the IPCC Methodology“.
- “Organic waste in SWDS is broken down by bacterial action in a series of stages that result in the formation of CH_4 and CO_2 (termed biogas or landfill gas) and further bacterial biomass.

In the initial phase of degradation, organic matter is broken down to small soluble molecules including a variety of sugars. These are broken down further to hydrogen, CO_2 and a range of carboxylic acids. These acids are then converted to acetic acid which, together with hydrogen and CO_2, forms the major substrate for growth of methanogenic bacteria. Landfill gas consists of approximately 50 per cent CO_2 and 50 per cent CH_4 by volume. However, the percentage of CO_2 in landfill gas may be smaller because of decomposition of substrates with a high hydrogen/oxygen ratio (e.g., fats, hemicelluloses) and because some of the CO_2 dissolves in water within the site.”

Taking into account these issues and considering the expert judgement, according to which CO_2 represent about 40% from landfill gas, there were estimated CO_2 emissions from SWDS, using CH_4 emissions already calculated (see Table 7.12). These emissions come mainly from biodegradable waste and a small part from waste with content of fossil C (plastics, certain textiles, rubber, waste oil, liquid solvents). On the other hand, according to the studies in this field, degradation of, is done in time periods of hundreds years. In consequence, CO_2 emissions from waste with fossil carbon content are insignificant and were not included in total emissions from Waste Sector.

Table 7.12 Percentage of direct and indirect Greenhouse Gas emissions from waste category 5A (Source: International Solid Waste Association – "Landfill Operational Guideline, 2nd Edition")

Year	**Greenhouse Gas**			
	CH_4		**CO_2**	
	kt	**%**	**kt**	**%**
1989	53.24	50.00	42.59	40.00
1990	54.86	50.00	43.89	40.00
1995	62.83	50.00	50.26	40.00
2000	76.87	50.00	61.50	40.00
2005	102.60	50.00	82.08	40.00
2007	111.38	50.00	89.10	40.00
2008	114.53	50.00	91.62	40.00
2009	118.82	50.00	95.06	40.00
2010	124.09	50.00	99.27	40.00
2011	105.33	50.00	84.26	40.00
2012	128.83	50.00	103.06	40.00
2013	140.91	50.00	112.73	40.00
2014	141.39	50.00	113.11	40.00
2015	141.52	50.00	113.22	40.00
2016	143.78	50.00	115.02	40.00
2017	146.19	50.00	116.95	40.00
2018	147.39	50.00	117.91	40.00
2019	152.72	50.00	122.17	40.00
2020	154.70	50.00	123.76	40.00
2021	155.47	50.00	124.37	40.00
2022	156.64	50.00	125.31	40.00
2023*	157.38	50.00	125.90	40.00

* Preliminary data

7.2.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

7.2.4 Uncertainty assessment and time-series consistency

Accuracy in CH_4 and CO_2 emissions estimates from SWDS is determined by the available data on collected, recovered and stored municipal waste. The uncertainty values were elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. The uncertainties associated to CH_4 emissions estimates on managed and unmanaged SWDS are presented in Table 7.13.

Table 7.13 Uncertainties associated with CH_4 emissions estimates from managed and unmanaged SWDS

IPCC source category	**CH_4 from managed and unmanaged solid waste disposal**
GHG	CH_4
AD uncertainty (%)	30
EF uncertainty (%)	36.06
Combined uncertainty (%)	41.20

The percentages associated with the overall uncertainty, are based on the aggregation of AD and EF related uncertainties, according to the equation 3.1 in Chapter 3, Volume 1 of the IPCC 2006. Due to the fact that most of activity data are provided by NEPA and the contractor of the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*" and to the fact that they were obtained using the same method (the use of two methods for obtaining the quantities of MSW disposed in managed landfills in years 1996–1998 and 2000 is ensuring the consistency of data series considering the national circumstances), emission factors were obtained using the same method and the fact that the same estimation method was used for the whole period, the data series 1989–2023 is consistent.

7.2.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Agriculture Sector*, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

The data regarding total municipal solid waste deposited in SWDS in period 1995–2002 and total municipal solid waste deposited in period 1995–1997 are provided by EUROSTAT, other data sources not being available. Therefore, no difference between national and international data exist. For 2003–2023 period, the data regarding total municipal solid waste deposited in SWDS were provided by Waste Directorate from National Environmental Protection Agency and for this reason has not made any comparison with other data source.

7.2.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The CH_4 emissions have been recalculated for 2021 and 2022 year taking into account the final data provided by NEPA (National Environmental Protection Agency).
Following the TERT recommendation the CH_4 emissions from 5.A.1 Managed Waste Disposal Sites were recalculated for 1995 year.

7.2.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No improvements are planned for the next submission.

7.3 Biological Treatment of Solid Waste (CRT 5.B)

7.3.1 Category description

The category includes calculation of emissions in the atmosphere from biological treatment of solid waste 5.B.1 Composting and 5.B.2 Anaerobic digestion. According to the Waste Directorate, at the 2023 year level, 38 municipal waste composting facilities were in operation. The activity data regarding home composting were estimated using 56.73% biodegradable from generated and not collected waste by sanitation companies.

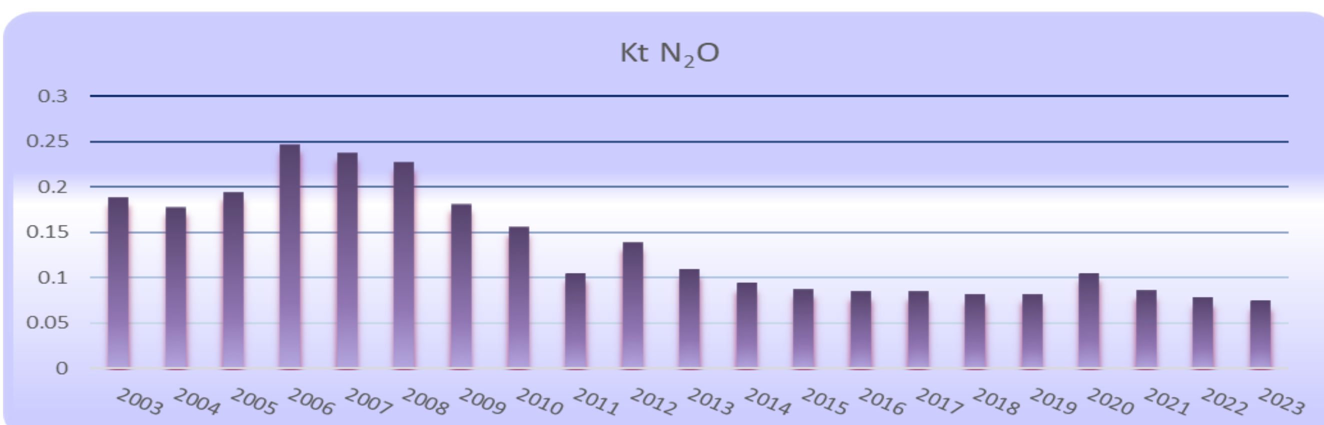
Table 7.14 Number of municipal waste composting facilities that reported activity data (Source Waste Directorate of NEPA)

Year	Number of municipal waste composting facilities
2014	24
2015	25
2016	28
2017	33
2018	30

Year	Number of municipal waste composting facilities
2019	38
2020	38
2021	37
2022	37
2023	38

Figure 7.7 CH_4 emissions trend from composting, for 2003–2023 period

Figure 7.8 N_2O emissions trend from composting , for 2003–2023 period



7.3.2 Methodological issues

Methodology

The default IPCC 2006 methodology was used for emission estimations in this category.

Emissions factor

Default IPCC emission factors for dry weight were used for emission estimations from composting:

- Emission factor 10 g CH_4/kg of waste treated;
- Emission factor 0.6 g N_2O/kg of waste treated.

The CH_4 and N_2O emissions from composting were estimated using default method given in Equations 4.1 and 4.2.

Activity data

For 2003–2023 period, the data on the amounts of MSW composted were provided by Waste Directorate from National Environmental Protection Agency (NEPA). The CH_4 and N_2O emissions were calculated starting with 2003 year, because since this year we have activity data. Emissions for the previous period (1990-2002) are not estimated because activity data are not available. For estimating CH_4 emission from anaerobic digestion at biogas facilities it is used the produced biogas from anaerobic digestion from the energy statistics (Annex V.6.5 Energy Balance 1990_2023_renewables). The energy values (TJ) were converted to mass of methane (kt) using the default calorific value of biogas, 50.4 TJ/Gg (Table 1.2, p. 1.19, 2006 IPPC Guidelines). Emissions of CH_4 due to unintentional leakages at biogas facilities were assumed to be 5% as suggested by the 2006 IPPC Guidelines. N_2O emissions from anaerobic digestion of organic waste are assumed to be negligible (vol. 5, p.4.4 and table 4.1).

Table 7.15 Activity data and emissions from biological treatment of solid waste

Year	Composting				Biogas facilities		
	Amount composted kt	CH_4 kt	N_2O kt	Source	Biogas (TJ)	CH_4 kt	Source
2002	NE	NE	NE	NEPA	30.00	0.60	Annex V.6.5 Energy Balance 1990_2023_renewables– biogas from anaerobic digestion from the energy statistics
2003	314.33	3.14	0.19		NO	NO	
2004	297.36	2.97	0.18		NO	NO	
2005	323.65	3.24	0.19		NO	NO	
2006	411.88	4.12	0.25		NO	NO	
2007	396.47	3.96	0.24		53.00	1.05	
2008	378.17	3.78	0.23		25.00	0.50	
2009	302.72	3.03	0.18		45.00	0.89	
2010	259.82	2.60	0.16		129.00	2.56	

Year	Composting				Biogas facilities		
	Amount composted	CH_4	N_2O	Source	Biogas	CH_4	Source
	kt	kt	kt		(TJ)	kt	
2011	174.45	1.74	0.10		547.00	10.85	
2012	231.97	2.32	0.14		1143.00	22.68	
2013	181.90	1.82	0.11		822.00	16.31	
2014	156.59	1.57	0.09		810.00	16.07	
2015	146.05	1.46	0.09		767.00	15.22	
2016	140.96	1.41	0.08		739.00	14.66	
2017	141.03	1.41	0.08		755.47	14.99	
2018	135.09	1.35	0.08		864.94	17.16	
2019	136.44	1.31	0.08		794.29	15.76	
2020	174.54	1.75	0.10		772.08	15.32	
2021	143.00	1.43	0.09		970.04	19.25	
2022	129.70	1.30	0.08		1100.13	21.83	
2023	123.62	1.24	0.07		765.32	15.18	

7.3.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

7.3.4 Uncertainty assessment and time-series consistency

Accuracy in CH_4 and N_2O emissions estimates is determined by the available data on composted waste. In the table below are presented the uncertainties associated to CH_4 and N_2O emissions from Composting.

Table 7.16 Uncertainties for estimation of CH_4 and N_2O emissions from composting

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty
Amount of composted municipal waste	CH_4	30.00	100
Amount of composted municipal waste	N_2O	30.00	110

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty
Produced biogas from anaerobic digestion	CH_4	30.00	100

The uncertainty value for AD is estimated as 30.0% based on Table 3.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 3. The value for the uncertainty associated with the emission factors was estimated using the ranges given in Table 4.1.page 4.6 in the Waste chapter of 2006 IPCC GL.

7.3.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Agriculture Sector*, the results of these being mentioned on the Checklists level.
Following these activities there were no unconformities recorded.
Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.
In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.
Recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

7.3.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The CH_4 and N_2O emissions associated to 5.B.1 Composting have been recalculated for 2022 year taking into account the final data provided by NEPA (National Environmental Protection Agency).

7.3.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No improvements are planned for the next submission.

7.4 Waste Incineration and Open Burning of Waste (CRT 5.C)

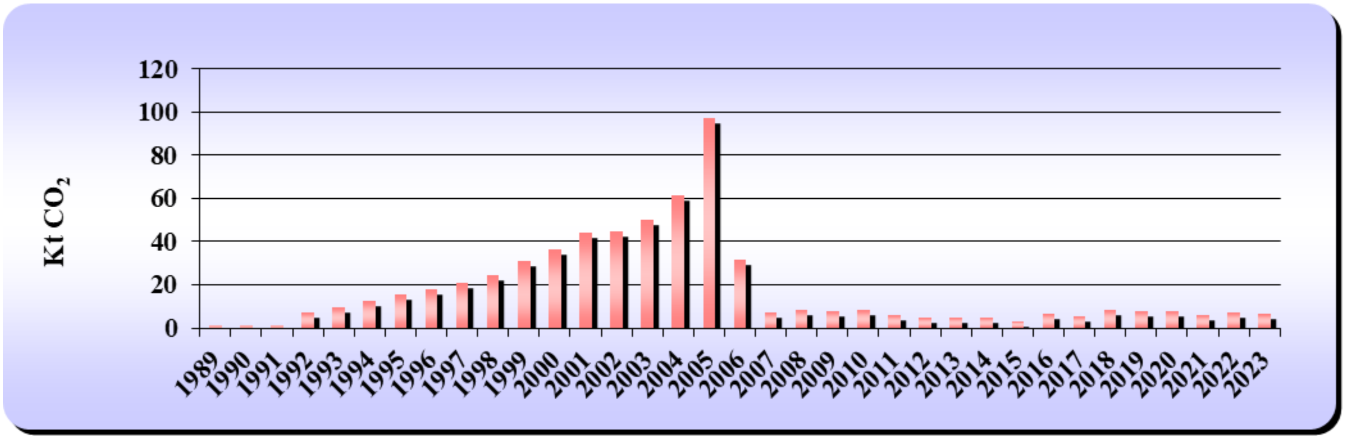
7.4.1 Category description

Waste incineration includes emissions resulted from the incineration of clinical waste,hazardous waste, biogenic waste and, like other types of combustion, is a source of CO_2, CH_4 and N_2O emissions. Based on the 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). Determining the types/quantities of incinerated waste and the parameters specific to the incineration thereof, for 1989–2012. Assesing the N_2O emissions resulting from waste incineration" finalized in 2013, were estimated the N_2O emissions by type of waste: industrial hazardous waste, industrial unhazardous waste, clinical waste, sewage sludge and other types of waste (slaughter waste, veterinary waste, waste from aircraft handling). The biogenic emissions from waste incineration were estimated based on the study finalised in 2013, using the amounts of industrial unhazardous waste, veterinary waste, waste from aircrafts handling, sewage sludge and slaughter waste. In case of Romania, MSW are not incinerated due to the higher costs implied by this method in specific conditions of our country (humidity about 50% and calorific power < 8400 kJ/kg). As regards the clinical waste, this contain biogenic and fossil Carbon but we cannot determine with accurately in which proportion are each of these.

Starting this 2020 year CO_2 emissions from biogenic waste were estimated.

Romanian law prohibits open burning of waste, therefore, no data on open burning are present in National statistics and no estimation of GHG emissions for this subsector is calculated.

Figure 7.9 CO_2 emissions trend from waste incineration, for 1989–2023 period



The CO_2 emissions from waste incineration were calculated for hazardous, clinical and biogenic waste. In the estimation of CO_2 emissions from clinical waste incineration were used the amounts of waste incinerated without energy recovery, data provided by NEPA (National Environmental Protection Agency).

It can observe a period of increasing activity between 1999 and 2007. Since 2008 all health units crematoria used to burn hazardous medical waste were closed, in according with European regulations. Based on the quantities of hazardous waste incinerated reported by NEPA (which include both with energy recovery and incineration without energy recovery), the study finalized in 2013 estimated the quantities of waste incinerated at national level without heat recovery, as follows:

- based on data reported in questionnaires was determined the share of incinerators without heat recovery from the total incinerators for every year of the period 1997–2012 for which there were reports;
- based on these percentages, given that data are collected from a representative sample area, was estimated following percentages, that have been applied to estimate the total quantity of waste incinerated in national incinerators without heat recovery:
  - 1992–1996 period: retrospective estimation of the percentage for last year 's historical survey (1997);
  - 1997–2002 period: according to the questionnaire;
  - 2003–2009 period: was maintained a constant percentage of 97.58 % corresponding for 2002;
  - 2010–2013 period: was used a percentage of 7.95 % which is the arithmetic average of the values for the years 2009–2010.

Figure 7.10 CO_2 emissions trend from clinical waste incineration, for 1989–2023 period

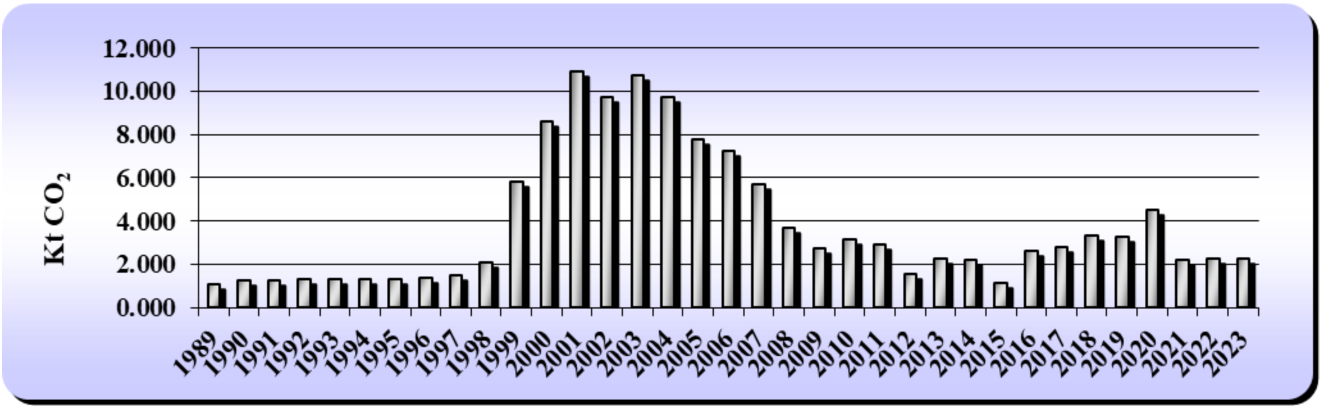


Figure 7.11 CO_2 emissions trend from hazardous waste incineration, for 1992–2023 period

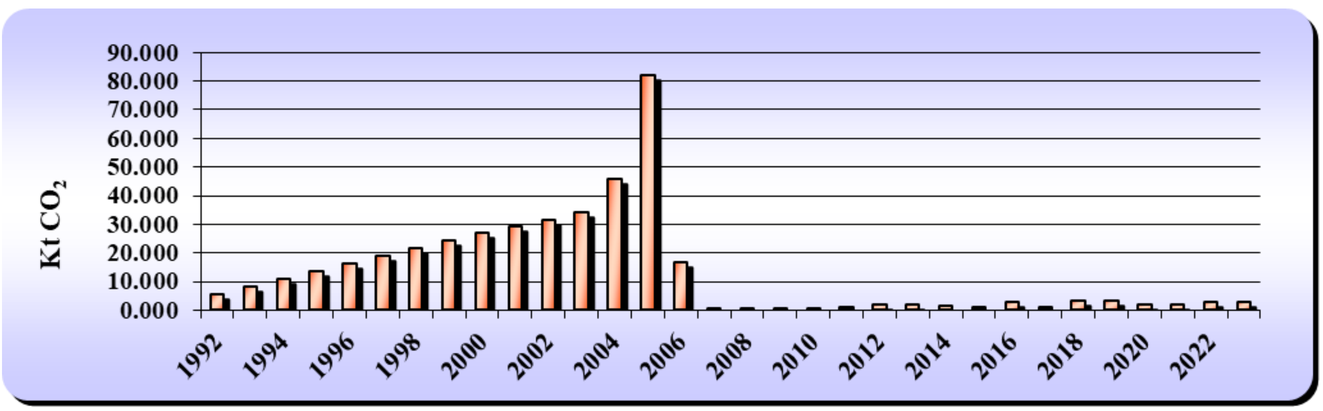


Figure 7.12 CO_2 emissions trend from biogenic waste incineration, for 2001–2023 period

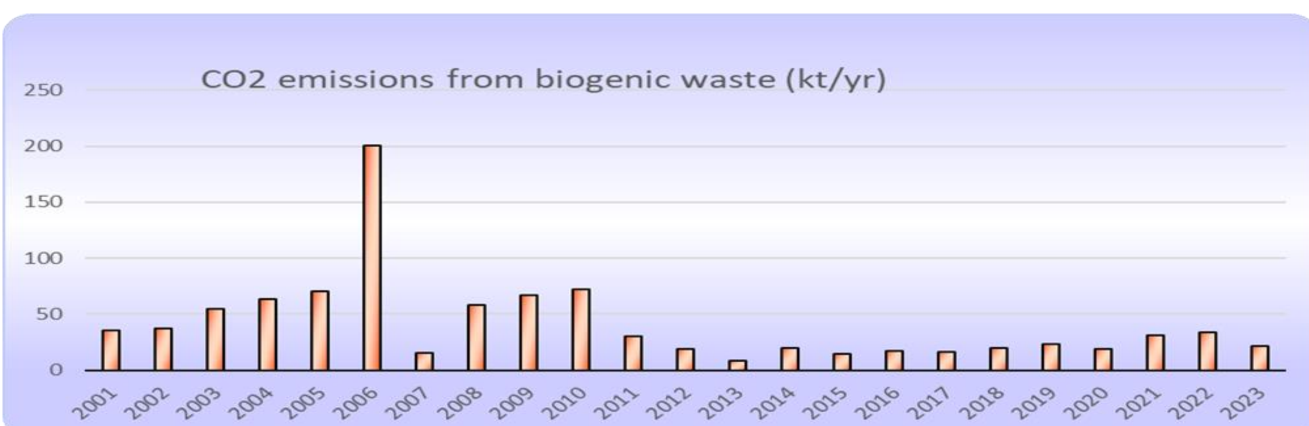


Figure 7.13 N_2O emissions trend from waste incineration, for 1992–2023 period

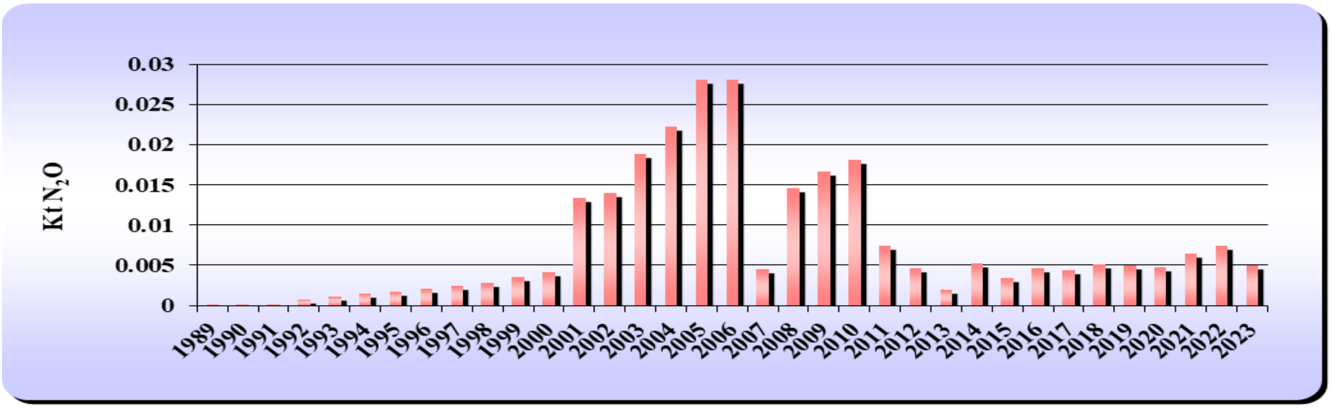
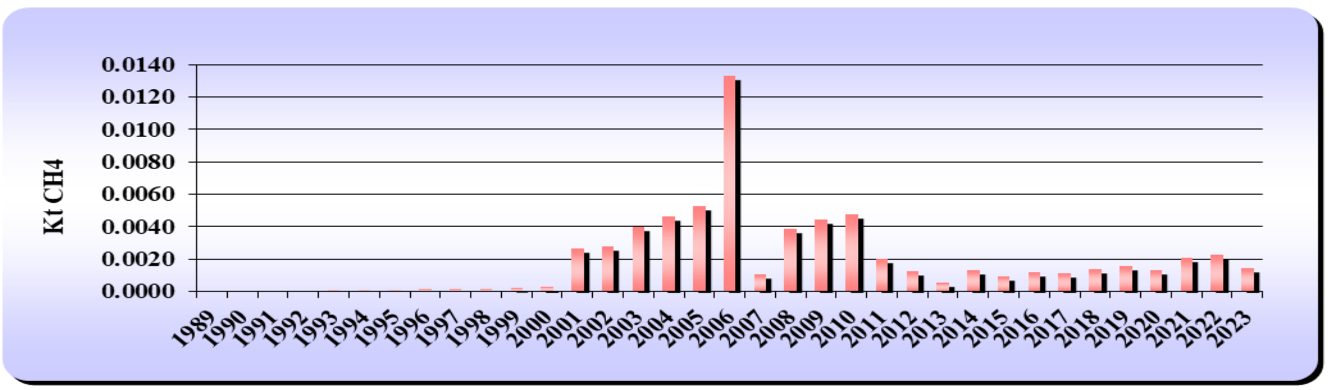


Figure 7.14 CH_4 emissions trend from waste incineration, for 1989–2023 period



The N_2O and CH_4 emissions from waste incineration were calculated for hazardous , clinical and biogenic waste. For 1989–1996 period, the amounts of clinical waste incinerated were provided through the 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; for the period 2000–2011 the data were provided by the National Institute for Public Health and for the period 2012–2023 the data are provided by NEPA (National Environmental Protection Agency). The amounts of hazardous and biogenic waste were provided by the study mentioned above. There were determined the types/quantities of incinerated waste and the parameters specific to the incineration thereof, for 1989–2012 and the N_2O and CH_4 emissions resulting from waste incineration were assessed, based on data provided by Waste Directorate of NEPA for 2003–2013 and the amounts of incinerated hazardous waste estimated for 1992–2002 period, using backward trend extrapolation, by expert judgment. For 2013–2023 period the amounts of incinerated hazardous waste without heat recovery were provided by Waste Directorate of NEPA. For 2023 year the statistical survey is not yet finalised, the preliminary data were used. In 2007, quantity of industrial waste incinerated was much smaller than in previous years because many incinerators were closed, and the existing ones incinerated medical waste, that are reported at clinical waste incineration.

Figure 7.15 N_2O emissions trend from clinical waste incineration, for 1989–2023 period

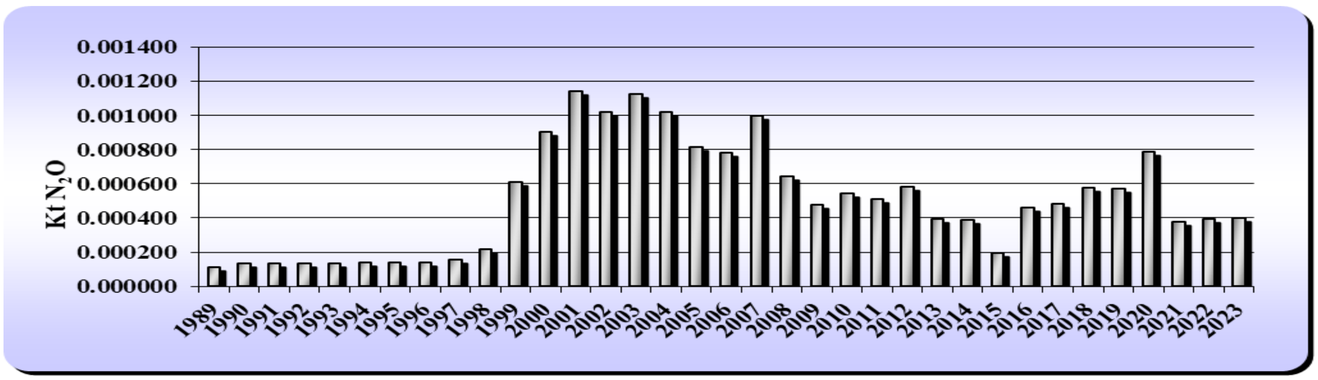


Figure 7.16 N_2O emissions trend from hazardous waste incineration, for 1992–2023 period

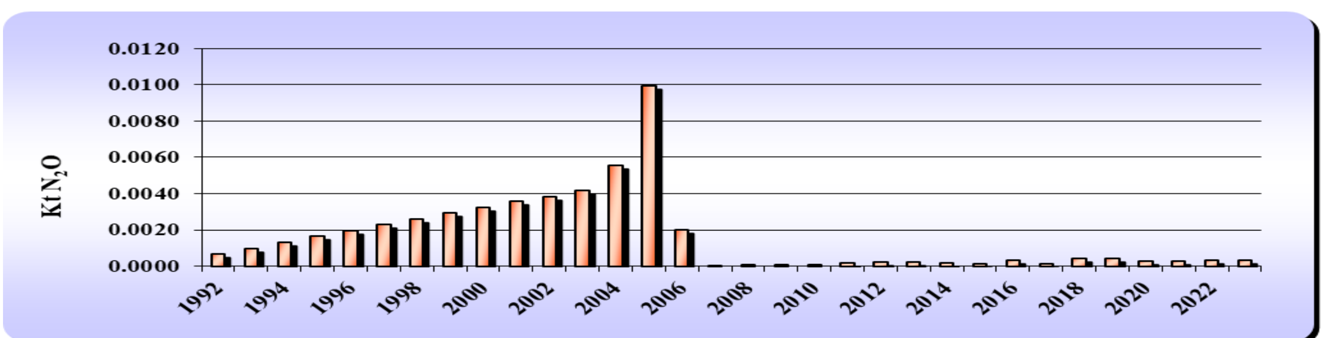


Figure 7.17 N_2O emissions trend from biogenic waste incineration, for 2001–2023 period

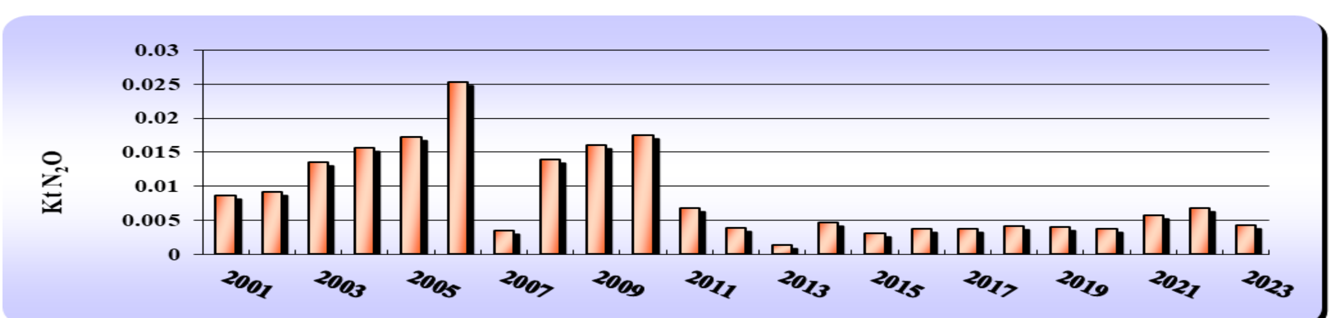


Figure 7.18 CH_4 emissions trend from clinical waste incineration, for 1989–2023 period

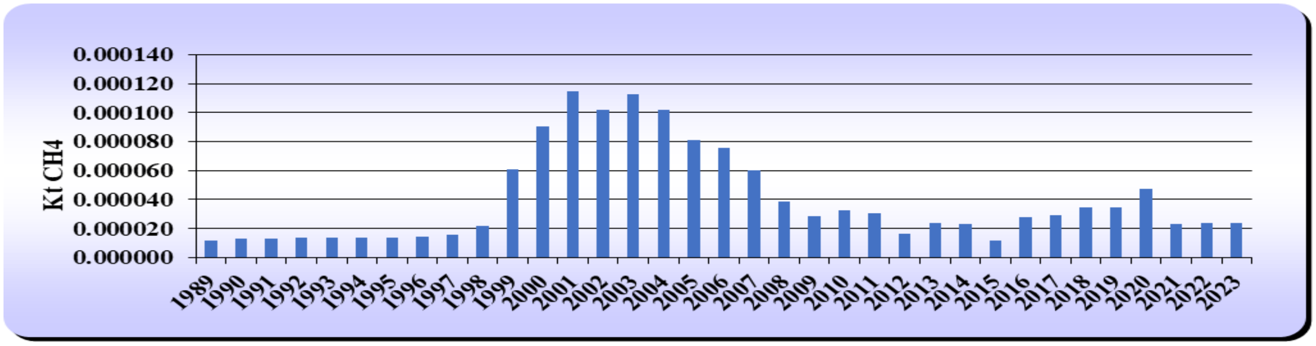


Figure 7.19 CH_4 emissions trend from hazardous waste incineration, for 1992–2023 period

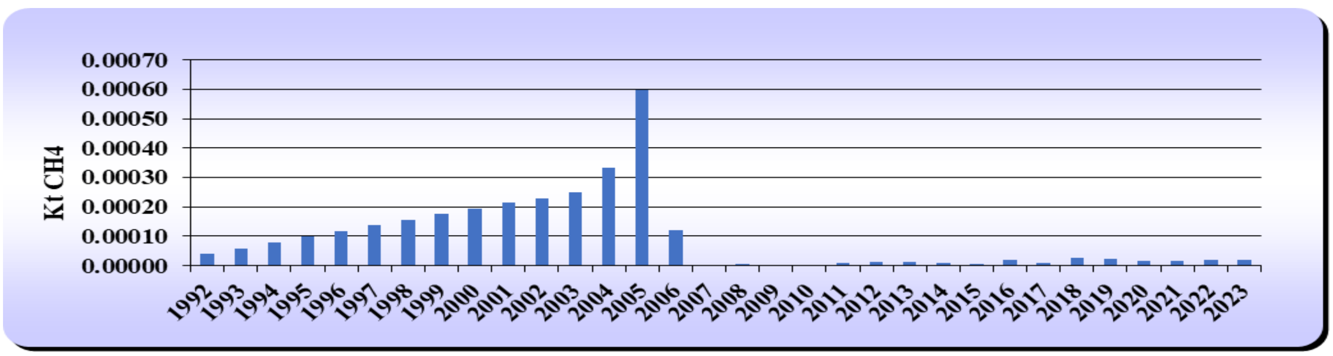
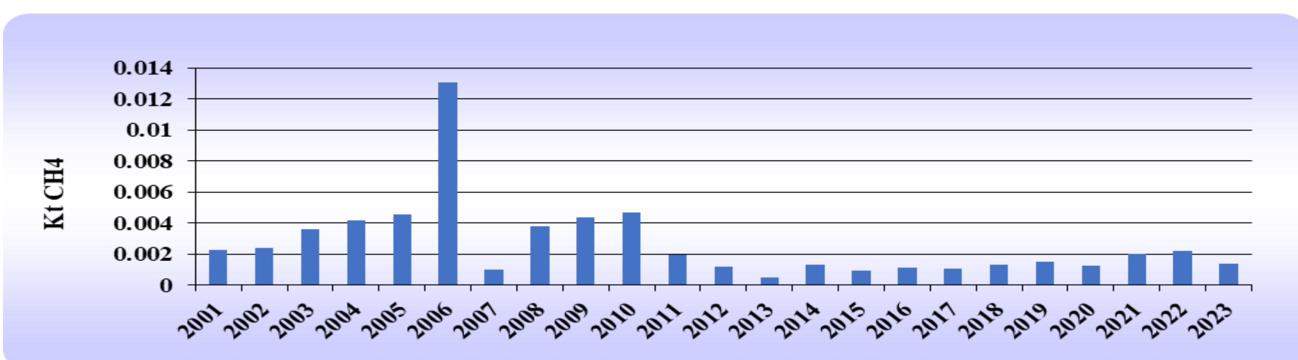


Figure 7.20 CH_4 emissions trend from biogenic waste incineration, for 2001–2023 period



7.4.2 Methodological issues

Methodology

To calculate CO_2 emissions from waste incineration, the equation 5.1 from page 5.7 of IPCC 2006. To calculate N_2O emissions from waste incineration, the Equation 5.5 from IPCC 2006 was used. To calculate CH_4 emissions from waste incineration, the Equation 5.4 (2006 IPCC, Vol.5: Waste p.5.12) was used.

Emissions factor

Default emission factors according to the provisions in IPCC 2006 have been used. The emissions factors for CO_2 and N_2O are presented in Table 7.17, Table 7.18. Due to the lack of other available data, was assumed that the values for MSW incineration from the Table 5.3, IPCC 2006 p.5.20, applies for hazardous, clinical and biogenic waste. The type of incineration process was revealed following an analysis based on data and information submitted by operators.

CO_2 emissions from Incineration of other organic waste were taking into account making a rough estimate using a water content of 50% and a Carbon content in dry matter of 50%.

Table 7.17 Default data for estimation of CO_2 emissions from waste incineration (Source: IPCC 2006. table 5.2)

Emission Factors	Clinical Waste	Hazardous Waste
C content of Waste	60%	50%
Fossil Carbon as % of Total Carbon	40%	90%
Efficiency of Combustion	100%	100%

Table 7.18 Default data for estimation of N_2O emissions from waste incineration (Source: IPCC 2006)

Type of incinerated waste	N_2O emission factors, in gN_2O/t_{waste}	Source
Clinical waste	100	IPCC 2006, for industrial waste, all incinerator types
Industrial waste	100	IPCC 2006, for industrial waste, all incinerator types
Animal cremation waste	226	Study “Danish Emissions Inventory for Waste Incineration and other Waste”
Sludge from waste water treatment	900 (wet condition)	IPCC 2006, for incinerator plants

Table 7.19 Default data for estimation of CH_4 emissions from waste incineration (Source: IPCC 2006, Vol.5: Waste, p.5.20,Table 5.3).

Type of incinerated waste	**CH_4 emission factors, in kg/Gg waste incinerated on a wet weight basis**	**Source**
Clinical waste	6	IPCC 2006, Semi–continuous incineration, stoker
Industrial waste	6	IPCC 2006, Semi–continuous incineration, stoker
Biogenic waste	60	IPCC 2006, Batch type incineration, stoker

Activity data

Public Health Institute of Bucharest (ISPB) is providing the data on amounts of clinical waste generated and NEPA (National Environmental Protection Agency) the amount of clinical waste incinerated without energy recovery. From 2008, this type of waste was not burnt in improper installation. The data for 1996–1998 period, were provided by National Research and Development Institute for Environmental Protection (see the Table 7.20) and for the 1989–1996 period, through the study mentioned above.

Table 7.20 Amounts of clinical waste generated and incinerated (Source: ISPB and ICIM)

Year	**Clinical waste generated**	**Clinical waste incinerated**	**Source**
	Unit [kt/yr]		
1989	–	1.90	Study 2013
1990		2.20	
1991		2.22	
1992		2.24	
1993		2.27	
1994		2.31	
1995	3.97	2.32	
1996	4.05	2.35	
1997	4.96	2.63	National Research and Development Institute for Environmental Protection
1998	6.47	3.63	
1999	10.15	10.15	Interpolation

Year	Clinical waste generated	Clinical waste incinerated	Source
	Unit [kt/yr]		
2000	15.03	15.03	ISPB
2001	19.06	19.06	
2002	17.60	17.03	
2003	18.98	18.79	
2004	17.55	17.03	
2005	15.49	13.55	
2006	14.84	12.61	
2007	14.08	10.00	
2008	11.11	6.44	
2009	9.78	4.79	
2010	10.50	5.46	
2011	8.85	5.13	
2012	8.93	2.72	NEPA (National Environmental Protection Agency)
2013	7.94	3.95	
2014	8.95	3.86	
2015	9.93	1.92	
2016	10.93	4.62	
2017	12.52	4.84	
2018	13.03	5.77	
2019	14.05	5.72	
2020	16.56	7.86	
2021	21.90	3.80	
2022	18.70	3.95	
2023*	19.11	3.98	

Hazardous waste is generated by industrial sector. The amounts of hazardous waste incinerated without heat recovery were estimated by study finalized in 2013, based on data provided by Waste Directorate of NEPA for 2003–2011 and for 1992–2002 period, was used the backward trend extrapolation, by expert judgment. For 2012–2022 period the amounts of hazardous waste incinerated without heat recovery are provided by Waste Directorate of NEPA. For 2023 year the statistical survey is not finalized, therefore the preliminary data was used. 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 hazardous industrial waste.

Table 7.21 Amounts of hazardous, clinical and biogenic waste incinerated

Year	Hazardous waste		Biogenic	
	Incinerated waste[kt/yr]	Source	Incinerated waste[kt/yr]	Source
1995	16.35	Study 2013	-	-
2000	32.53		-	-
2005	99.54		76.33	Study 2013
2007	0.45		17.04	
2008	0.75		63.18	
2009	0.53		73.31	
2010	0.56		78.58	
2011	1.50		32.76	
2012	2.35	NEPA	20.09	
2013	2.34		8.76	
2014	1.63		21.75	
2015	1.19		15.38	Operators
2016	3.20		18.91	
2017	1.41		17.73	
2018	4.18		21.62	
2019	3.96		24.87	
2020	2.63		20.69	
2021	2.64		33.42	
2022	3.20		36.63	
2023*	3.43		23.52	

* Preliminary data (final data for 2023 will be provided after statistical survey of the end of this year)

7.4.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG’s do not apply for Romania.

7.4.4 Uncertainty assessment and time-series consistency

The values were elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. In the table below are presented the uncertainties associated to CO_2, CH_4 and N_2O emissions from waste incineration.

Table 7.22 Uncertainties for estimation of CO_2 emissions from waste incineration

IPCC source category	CO_2 from waste incineration	N_2O from waste incineration	CH_4 from waste incineration
GHG	**CO_2**	**N_2O**	**CH_4**
AD uncertainty (%)	5.00	5.00	5.00
EF uncertainty (%)	20.00	50.00	100
Combined uncertainty (%)	20.62	50.20	100.12

The percentages are associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation equation 3.1 in Chapter 3, Volume 1 of the IPCC 2006.

7.4.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Agriculture Sector*, the results of these being mentioned on the Checklists level. Following these activities there were no unconformities recorded.

Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

7.4.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

The CH_4 and N_2O emissions have been recalculated for 2021-2022 years taking into account the final data provided by NEPA (National Environmental Protection Agency).

7.4.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

No improvements are planned for the next submission.

7.5 Wastewater Treatment and Discharge (CRT 5.D)

7.5.1 Category description

This sector covers CH_4 emissions from domestic and industrial wastewater as well as indirect N_2O emissions from domestic wastewater. In 2023 year, greenhouse gas emissions from 5.D Wastewater Treatment and Discharge contributed 28.96 % to greenhouse gas emissions from the Waste sector. From 1989 to 2023, greenhouse gas emissions from this category decreased by 79.29%. According to the results of the national situation assessment conducted by National Administration "Romanian Waters", Synthesis of the water quality in Romania, the total volume evacuated in 2023 was 3,976.12 million m3 of which 2,268.38 million m3 (57.05%) represents cooling water, water classified in the category of wastewater which does not require treatment. The situation regarding the volumes of wastewater discharged in 2023 is presented in the table below.

Table 7.23 Wastewater evacuated Romania, in 2023 (Source: National Administration "Romanian Waters")

Wastewater category	Volume (mil. mc)	Percentage (%)
Total wastewater evacuated	1,707.74	-
Total domestic wastewater evacuated	1,084.93	63.53
Total industrial wastewater evacuated	589.74	34.53
Domestic wastewater treated	1,067.00	62.48
Industrial wastewater treated	469.63	27.50
Total wastewater requiring treatment	1,707.74	100.00
Sufficient(appropriate) treated wastewater	1,214.70	71.13
Insufficient treated wastewater	347.24	20.33
Untreated wastewater	145.79	8.54

Urban wastewater treatment plants can receive for treatment: wastewater from households or commercial institutions; water from streets cleaning; water from rainfall, and industrial wastewater. Industrial wastewater treatment plants are built on industrial sites and treats only industrial wastewater. Discharge conditions of industrial wastewater in the sewage system and maximum concentrations of water quality indicators used are given in Standard NTPA 002 (specific annex of the national specific legislation created to transpond the wastewater European legislation – https://lege5.ro/Gratuit/hezdanjq/normativ-ntpa-002-privind-conditiile-de-evacuare-a-apelor-uzate-in-retelele-de-canalizare-ale-localitatilor-si-direct-in-statiile-de-epurare-hotarare-352-2005?dp=gi3dknzrgmzdm). Wastewater treatment processes are: mechanical, mechanical – chemical and mechanical – biological methods, most of the times using a combination of these. The public sewage system in Romania includes both the old network made before 1990, by simple concrete, reinforced and centrifuged concrete or pressurised concrete and networks that are currently running by polyvinyl chloride (PVC), polyethylene (PE), fibreglass reinforced polyester (GRP). Unfortunately, for the period 1989–2000 there are insufficient data on sewage systems characteristics for our country. Of the little information held shows that most public sewerage system were combined, a large number of households on the edge of cities were not connected to the sewerage system and the sewerage condition was unsatisfactory. Between 2000 and 2023 the public sewerage system in Romania was characterized as follows:

- Development of sewerage networks, particularly those in rural areas.
- Crossing, where possible, the sewerage system separation.

- Execution of sewerage from modern materials, reliable, fitted with modern technology.
- Improving the functioning of existing drainage.
- Sizing sewers using computer programs.

The study *"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"* shows that in addition to households connected to public sewage systems, in Romania, are the following types of dwellings whose number is decreasing continuously:

- households without own sewage, with disposal of sewage into the ground, without treatment;
- households with its own sewage, connected to wastewater tanks that is periodically cleaned and wastewater is sent to urban wastewater treatment plants;
- dwellings owned stations with evacuation of treated wastewater in soil;
- households with their own treatment plants with discharge of wastewater in septic tanks which is regularly cleaned.

For 2023 year, the number of municipal and industrial wastewater treatment plants, classified by appropriate treatment stage are as follows:

- Municipal treatment plants:

- primary stage: 52 treatment plants;
- secondary stage: 1078 treatment plants;
- advanced stage: 268 treatment plants.

- Industrial treatment plants:

- primary stage: 516 treatment plants;
- secondary stage: 464 treatment plants;
- advanced stage: 35 treatment plants.

This situation is changing every year because the sewage system extends under projects financed by government programs, enhancing the connection to the sewerage and wastewater treatment.

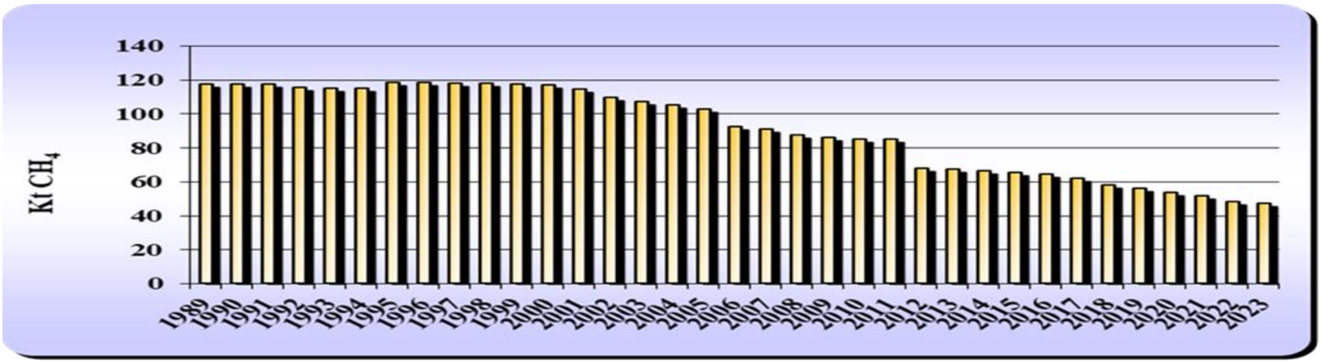
CH_4 emissions from wastewater

CH_4 emissions from domestic and commercial wastewater and sludge (CRT 5.D. 1)

In estimation of CH_4 emissions from domestic/commercial wastewater and sludge, was considered a large category of population including both the population connected to sewerage with treatment and population unconnected to sewerage. Domestic wastewater collected from the population connected to sewerage without treatment suffers a self-cleaning aerobic process with minor methane emissions. This wastewater is directly discharged into the environment (rivers or underground). Analysing the chart below, it can observe a mainly decreasing trend due to the increasing number of population connected to sewerage.

The methane emissions level of 2023 compared to base year (1989) is decreasing with 59.62%.

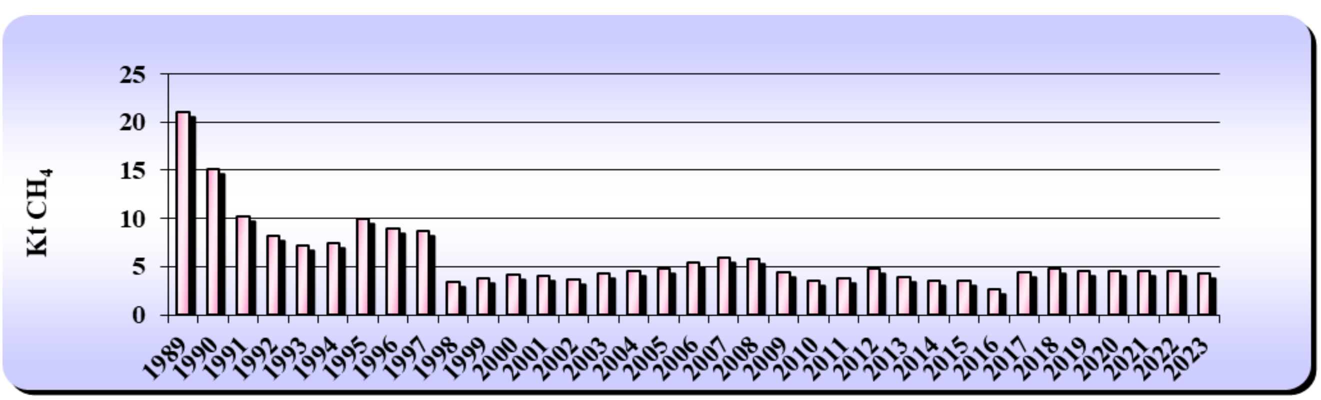
Figure 7.21 CH_4 emissions trend from domestic/commercial wastewater and sludge treatment for 1989–2023 period



CH_4 emissions from industrial wastewater (CRT 5.D2)

Depending on the industry of origin, industrial wastewaters have a different composition. The sensitive issues of industrial wastewater treatment are associated with time–varying flows, extreme temperatures and excessive quantities of the following substances: petroleum products, organic oils, fats; acids and bases; materials in suspension; organic and inorganic substances; explosives and flammable materials; corrosive or volatile smelling gases. Analysing the trend of methane emissions from industrial wastewater handling it can remark several periods when the emissions increased or decreased. During 1989-1997 period, biological treatment plants used aerobic technology and sometimes functioned poorly, from 1998-2023 period, biological treatment plants with aerobic technology are being modernized. In the beer industry, treatment plants with anaerobic technology and methane gas recovery appear.

Figure 7.22 CH_4 emissions trend from industrial wastewater handling for 1989–2023 period



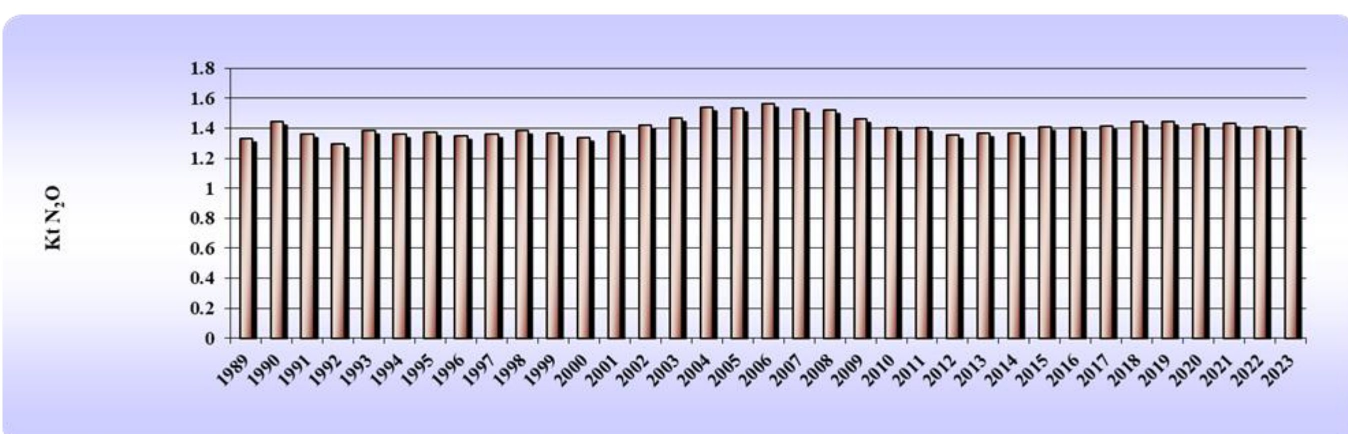
Compared with the base year (1989), CH_4 emissions from industrial wastewater treatment decreased with 42.74%.

Table 7.24 Explanations on methane emissions estimates

Period	Methane emissions from industrial wastewater treatment – Explanations
1989–1997	Values between 21.01– 8.65kt; The values are decreasing following decreasing industrial production.
1998–2023	Values between 3.47– 4.35 kt; The values are lower than the previous period due to: • biological treatment plants with aerobic technology are being modernized. • In the beer industry, treatment plants with anaerobic technology and methane gas recovery appear.

For estimate N_2O emissions from domestic wastewater was used the total population of our country. The fluctuations are in generally due to the population consumption values. Over the 1989–2009 period, N_2O emissions from Human sewage category have maintained an increasing trend, due to the decreasing number of population, on the one hand and on the other hand due to the increasing values of protein consumption. Additional, the increasing trend of N_2O emissions recorded in 2003, compared with 2002 year is due to the increasing values of protein consumption. After 2009 year, the emissions register a sharply decrease, being influenced by the several decrease of protein consumption values, reflecting so the impact of economic crisis. In 2015-2023 period the emissions increased due to the increasing values of protein consumption.

Figure 7.23 N_2O emissions trend from domestic wastewater for 1989–2023 period



7.5.2 Methodological issues

CH_4 emissions from domestic and commercial wastewater (CRT 5.D.1)

Domestic wastewater is treated in municipal treatment plants wastewater by the following processes: mechanical treatment, chemical-mechanical treatment or biological-mechanical treatment. In biological treatment are two types of processes:

- aerobic processes, when result energy by oxidation of organic substances. Aerobic processes depend on the existence of aerobic bacteria, and these on the presence of dissolved oxygen. By aerobic treatment process organic material is removed from the wastewater.
- anaerobic processes, characterized by reducing oxygen and energy consumption. Anaerobic treatment of wastewater leads to nitrogen removal by nitrification and denitrification processes.

During anaerobic processes occur methane emissions. Aerobic treatment process required oxygen is transferred from the mass flow by air into water O_2 flow - requested by vital needs of the treatment process. The oxygen is necessary for:

- a metabolic degradation process of organic matter (biochemical oxidation) to carbon dioxide and water.
- maintaining a living microorganisms
- an oxidation of inorganic substances.

There is a correlation between O_2 and age requirements sludge. The O_2 concentration must be higher than the critical concentration calculated for a sludge age. In addition to this required O_2, it should be provided that in each point of the aeration tank to be an excess of O_2 dissolved. In aerobic biological treatment tank air is introduced. At each point in the aeration tank maintain a dissolved O_2 in excess of 1-3 mg O_2 / l. The concentration of O_2 in excess refers to liquid suspension (Liquid Suspension), which is known as Mixed Liquor. The solids present in the biological treatment tank are known as Mixed Liquor Suspended Solids – MLSS. The Wastewater Treatment Directive has been fully transposed in the Romanian legislation by the Decision of Government no. 352/2005 regarding the modification and completion Government Decision no. 188/2002 for the approval of some rules on the conditions of discharge into the aquatic environment of wastewater. Thus, they were introduced into the legislation including compliance requirements negotiated transition deadlines for collection and treatment assumed by Romania by the Treaty – Environment, Water Quality. Government Decision no. 352/2005 includes three technical regulations regarding: collection, treatment and municipal wastewater disposal (NTPA 011-https://lege5.ro/gratuit/gqytamjy/norma-tehnica-privind-colectarea-epurarea-si-evacuarea-apelor-uzate-orasenesti-ntpa-011-din-28022002), conditions sewage disposal in sewer networks localities and directly in wastewater treatment plants (NTPA 002-https://lege5.ro/gratuit/gqydqnzx/normativul-privind-conditiile-de-evacuare-a-apelor-uzate-in-retelele-de-canalizare-ale-localitatilor-si-direct-in-statiile-de-epurare-ntpa-002-2002-din-28022002) and pollutant loading limits for wastewater industrial and urban waste disposal natural (NTPA 001-https://lege5.ro/gratuit/hezteobu/normativul-privind-stabilirea-limitelor-de-incarcare-cu-poluant apelor-uzate-industriale-si-orasenesti-la-evacuarea-in-receptorii-naturali-ntpa-001-2002-din28022002). According to the data of the National Administration “Romanian Waters”, regarding water / water infrastructure networks used, at national level, the levels of collection and treatment of biodegradable organic loading (expressed as%) of human agglomerations with more than 2,000 l.e. grew in recent years. In 2022, the values of the collection levels and treatment of biodegradable organic loading were 73.2% for wastewater collection, respectively 72.1% for wastewater treatment. In human agglomerations larger than 2000 l.e., the degree of connection to the collection system of wastewater recorded an increase of approx. 32% at the end of 2022 compared to 2007. Regarding the degree of connection to the urban treatment plants, it increased by approx. 26% in the period 2007-2021. There is an increase in collection and treatment at the national level compared to 2020 which has the main causes: changing the number and size of agglomerations, following the development of feasibility studies for European funding for the period 2014-2023. The number of wastewater treatment plants for each category in 2023 year:

- municipal treatment plants: 1398;
- industrial treatment plants: 1015.

Methodology

To estimate CH_4 emissions from domestic and commercial wastewater, it is taking into account the decisions tree from IPCC 2006, page 6.10 and the equation used is 6.1 page 6.11. The following wastewater treatment pathways are considered: unconnected to sewerage, connected to centralised aerobic treatment, connected without treatment. For calculation of Total Organic Wastewater were used equation 6.3 from IPCC 2006.

Emission factor

For Emission Factor calculation it was used the equation 6.2 from IPCC 2006. According to methodology it was taking in consideration only the fraction of domestic/ commercial wastewater treated anaerobically because only in this case methane issue. As respects MCF-centralised WWTP, the values derived from the UWWTD website (https://uwwtd.eu/Romania/uwwtps/compliance) have been used. The website gives information on the implementation of the UWWTD per member state and as a result, the proportion of wastewater treated in by WWTP, where BOD_5 meets the UWWTD can be found. Using this data, it was calculated the share of total load entering, treated in WWTP that pass the BOD5-criterion:

- sum the total load entering for the WWTP that pass BOD5;
- sum the total load entering for all WWTP;
- calculate the fraction of total load entering, treated in WWTP that pass the BOD5-criterion by dividing the

result of total load entering for the WWTP that pass BOD5, by the result of total load entering for all WWTP.

It was assumed that this value represents the share of wastewater, treated at well managed WWTP. The website shows that in 2018 (latest available), only 57% of WWTPs were compliant, but only 2% were overloaded, which results in an average MCF of 0.0065 for 2018-2023 years. In the 2006 IPCC GL, methane generation is correlated to removal of BOD5. Therefore the best practical indicator of the WWTP being well managed in the context of quantifying methane emissions is, whether the WWTP meets the criteria for BOD5 in its effluent. The percentages of domestic/commercial wastewater treated are presented in the table below.

Table 7.25 The percentage of population connected and wastewater treated

Year	The percentage of population connected to sewerage and wastewater treated							
	Population connected to sewerage without treatment		Population connected to centrazed, aerobic treatment plant		Population unconnected to sewerage		Population connected to sewerage	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
1989	45%	100%	55%	0%	55%	90%	45%	10%
1990	45%	100%	55%	0%	55%	90%	45%	10%
1993	45%	100%	55%	0%	55%	90%	45%	10%
1994	45%	100%	55%	0%	55%	90%	45%	10%
1995	40%	100%	60%	0%	60%	92%	40%	8%
2000	60%	100%	40%	0%	56%	92%	44%	8%
2005	39%	100%	61%	0%	40%	92%	60%	8%
2006	33%	100%	67%	0%	23%	92%	77%	8%
2007	33%	100%	67%	0%	20%	92%	80%	8%
2008	33%	100%	67%	0%	17%	92%	83%	8%
2009	33%	100%	67%	0%	16%	92%	84%	8%
2010	30%	100%	70%	0%	14%	92%	86%	8%
2011	8%	100%	92%	0%	14%	92%	86%	8%
2012	8%	100%	92%	0%	13%	92%	87%	8%
2013	5%	100%	95%	0%	13%	92%	87%	8%
2014	4%	100%	96%	0%	12%	92%	88%	8%
2015	4%	100%	96%	0%	11%	92%	89%	8%
2016	3%	100%	97%	0%	8%	92%	92%	8%
2017	3%	100%	97%	0%	5%	92%	95%	8%
2018	3%	100%	97%	0%	2%	92%	98%	8%

Year	The percentage of population connected to sewerage and wastewater treated							
	Population connected to sewerage without treatment		Population connected to centrazed, aerobic treatment plant		Population unconnected to sewerage		Population connected to sewerage	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
2019	2%	100%	98%	0%	0%	92%	100%	8%
2020	2%	100%	98%	0%	0%	92%	100%	8%
2021	2%	100%	98%	0%	0%	92%	100%	8%
2022	2%	100%	98%	0%	0%	92%	100%	8%
2023	2%	100%	98%	0%	0%	92%	100%	8%

Table 7.26 Calculation of Emission Factors domestic/commercial wastewater, for 1989–2023 period

Parameter		B_{oi} (kg CH_4/kg BOD)	MCF_j	EFs
Population connected to sewerage without treatment	**1989–2019**	0.6	0	**0**
Centrazed, aerobic treatment plant	**1989–2011**	0.6	0.1893	0.1136
	2012–2013		0.0004	0.0002
	2014–2015		0.0005	0.0003
	2016–2017		0.0152	0.0091
	2018–2023	0.6	0.0065	0.0039
Source:		**IPCC 2006**	**Expert opinion/http://uwwtd.oieau.fr/**	**-**

Activity data

To estimate methane emissions from domestic/commercial wastewater were used data provided by study “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”. The number of population connected to sewerage with treatment was calculated using total population and fraction of population connected to sewerage with treatment. The data on total population, the urban population and the population in rural areas were obtained from National Institute for Statistics (NIS). The fraction of total population connected to sewerage with treatment is obtained by different sources (Table 7.27). The data regarding population unconnected to sewerage were obtained making the difference between total population and population connected to sewerage.

Table 7.27 The sources of activity data used in methane emissions estimates from domestic/commercial wastewater treatment

Activity Data	Source
Total population [1000 persons]	*National Institute for Statistics*
Total population connected to sewerage with treatment [1000 persons] – $P_{tot\ tr}$	*1989 -2005 period:* $P_{tot\ tr} = P_{urb\ tr} + P_{rur\ tr}$; *2006 – 2023: National Institute for Statistics*
Urban population	*National Institute for Statistics*
Population in rural areas	*National Institute for Statistics*

For the calculation of Total Organic Wastewater, the parameters provided by the study mentioned above are used. (Table 7.28).

Table 7.28 Parameters used to estimate Total organic domestic/commercial wastewater (Source: Study finished in 2011)

Parameters		Years				
		1989–1999	**2000–2005**	**2006**	**2007**	**2008–2021**
Degradable Organic Component – BOD [kg/1000 persons/yr]		21,900	21,900	21,438	21,900	21,900
Fraction of BOD removed as sludge		0.35	0.6	0.6	0.6	0.63
Co–discharge of industrial WWH	Unconnected to sewerage	1.00				
	Connected to Centralised aerobic treatment	1.25				
	Connected without treatment	1.25				

The value of degradable organic component for year 2006 is a single national value and was provided by the National Institute for Statistics (NIS). The other value of degradable organic component is assumed by expert Prof. Dr. Vladimir Rojanschi and is provided through the study finished in 2011 (“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”). The biochemical oxygen demand was provided by NIS. The fraction of BOD removed as sludge for 1989–2007 was provided by expert Prof. Dr. Vladimir Rojanschi and for 2008–2023 period according to ISPE study "Elaboration of the national policy for the management of sewage sludge", page 100. The other value of BOD is assumed by expert judgement and is provided through the study finalized in 2011. Wastewater from industrial or commercial sources that is discharged into the sewer may contain protein (e.g., from grocery stores and butchers). According to IPCC 2006, the default for this fraction was used. CH_4 from domestic/commercial wastewater recovered and/or flared are reported NO.

N_2O emissions from domestic wastewater

Direct emissions of N_2O from domestic wastewater are minor and only occur in advanced centralised treatment plants. It will be reported only indirect N_2O emissions.

Methodology

To estimate N_2O emissions from domestic wastewater, we used the equations 6.7 and 6.8 from IPCC 2006. Default parameters according to IPCC 2006 have been used. Fraction of nitrogen in protein (0.16 kg N/kg protein), the factor for non–consumed protein discharged to wastewater (1.1), the factor for industrial and commercial co-discharged protein into the sewer system (1.25), nitrogen removed with sludge (0 kg N_2O–N/kg N), emission factor (0.005 kg N_2O – N/kg N).

Table 7.29 Values of Protein Consumption for Romania in period 1989–2023

Year	Protein consumption [kg protein/person/yr]	Source
1989	33.22	Statistical Yearbook 2004–2006
1990	33.91	National Institute for Statistics
1993	35.15	
1994	34.71	
1995	35.00	
2000	34.57	
2005	41.54	
2007	41.87	
2008	42.6	
2009	41.43	
2010	39.93	
2011	40.15	
2012	38.95	
2013	39.57	
2014	39.64	
2015	40.99	

Year	Protein consumption [kg protein/person/yr]	Source
2016	41.03	
2017	41.65	
2018	42.85	
2019	42.96	
2020	42.60	
2021	43.25	
2022	42.74	
2023*	43.11	

CH_4 emissions from industrial wastewater and sludge (CRT 5.D.2)

Methane is the result of anaerobic processes that occur during treatment of industrial wastewater in wastewater industrial treatment plants. To establish the approach to estimate methane emissions from this sub-category it was used the Decision Tree from IPCC 2006, figure 6.3, according which it is necessary to identify three or four industries that produce large quantities of wastewater with high content of degradable organic component. By study "The estimation of methane emissions in industrial wastewater in accordance with the IPCC 2006 methodology", finished in 2014, has been identified three industrial sectors with the greatest potential for methane emissions from wastewater treatment: brewing, pulp and paper, oil refining. These sectors have wastewater treatment plants containing potential biological treatment step in CH_4 emissions. Classical procedures of wastewater treatment, available in almost all cases to municipal wastewater, offer limited opportunities for industrial wastewater treatment. Thus, these methods are not able to lower the dissolved mineral impurities content in wastewater, some organic substances, especially synthetic, are not being degraded by microorganisms and pass unchanged through wastewater treatment. These impurities remain in the water emissaries and are not eliminate during natural self-cleaning processes. The methods to remove pollutants from industrial wastewater are: physical, chemical and biological methods. Application of these methods depends on the composition of wastewater.

Methodology

Default method was used for calculating CH_4 emissions from industrial wastewater, according to the IPCC 2006. After recent investigation, experts identified that only in several breweries wastewater is treated in anaerobic conditions. In pulp, paper and petroleum refining industries as well as in the most of breweries wastewater is treated in aerobic conditions. For methane emissions from industrial wastewater calculation, the equation 6.4 from IPCC 2006. The following steps were considered:

1. Calculation of Total Organic Wastewater for each of the three industrial branches, using equation 6.6 from IPCC 2006.
2. Calculation of Total Industrial Organic Wastewater for pulp, paper and petroleum refining, by summing TOW obtained for each industry in step 1.

Emission factor

The emission estimation method and system was determined according to figure 6.1. Romanian industrial wastewater are collected and treated by aerobic and/or anaerobic methods. Formula 6.5 was used to calculate the emission factor for each industrial sector, by using the methane maximum production capacity and the methane correction factor specific to the industry. Formula 6.4 was used to estimate emissions corrected for potential removed sludge or for the recovered CH_4 and the summation of the results. The values of Methane Conversion Factor are used taking into account the following: the technology of biological treatment of wastewater (aerobic or anaerobic) that produces methane and the condition of the installations. In the period 1989–1997, biological treatment plants used aerobic technology and sometimes malfunctioned, for this reason MCF 0.05 was used. For the period 1998-2023, investigations have been made and after consulting the operators resulted that the aerobic treatment plants are well managed, therefore MCF 0 has been used. In the beer industry, purification installations with anaerobic technology and methane recovery are utilized. For Maximum methane producing capacity (Boi) it was used the default value of 0.25 kg CH_4/kg COD (Chemical Oxygen Demand) from IPCC 2006.

Table 7.30 The Emissions Factors for aerobic and anaerobic treatment

Emission Factor			
Beer industry – Period	**Methane Conversion Factor – MCF**	**Maximum methane producing capacity – Bo (kg CH_4/kg COD)**	**Emission factor for industrial wastewater – EF (kg CH_4/kg COD)**
1989 - 1997; anaerobic treatment, study 2014	0.05	0.25	0.01
1998 - 2023; anaerobic treatment	0.80	0.25	0.20
Pulp, paper and petroleum refinery – Period	**Methane Conversion Factor – MCF**	**Maximum methane producing capacity – Bo (kg CH_4/kg COD)**	**Emission factor for industrial wastewater – EF (kg CH_4/kg COD)**
1989 - 1997; aerobic treatment, study 2014	0.05	0.25	0.01
1998 - 2023; aerobic treatment	0.00	0.25	**0.00**

	Expert judgement based on data provided by economic operators	**IPCC 2006, page 6.21**	

Activity data

Activity data associated to industrial production are provided by the National Institute of Statistics (table 7.31).

Table 7.31 Industrial production of the industrial sectors with the greatest potential for methane emissions (source: NIS – Statistical Yearbook 2023)

Year	**Production (t/year)**			
	Beer	**Paper**	**Pulp**	**Petroleum Refining**
1989	1,151,300	552,000	574,000	30,615,000
1990	1,052,700	427,000	380,000	23,664,000
1991	980,300	307,000	235,000	15,191,000
1992	1,001,400	262,000	171,000	13,299,000
1993	992,900	248,000	132,000	13,191,000
1994	904,600	262,000	128,000	14,744,000
1995	876,800	332,000	194,000	15,259,000
1996	811,800	299,000	177,000	13,426,000
1997	765,100	306,000	154,000	12,429,000
1998	998,900	281,000	129,000	12,520,000
1999	1,113,300	276,000	144,000	9,894,000
2000	1,266,400	328,000	187,000	10,532,000
2001	1,266,300	388,000	172,000	10,948,000
2002	1,162,700	421,000	199,000	11,906,000
2003	1,329,200	457,000	212,000	10,736,000
2004	1,440,600	492,000	187,000	12,371,000

Year	Production (t/year)			
	Beer	Paper	Pulp	Petroleum Refining
2005	1,529,500	385,000	103,000	13,890,000
2006	1,748,400	401,000	80,000	13,237,000
2007	1,921,300	461,000	86,000	13,006,000
2008	2,024,000	369,000	22,000	13,095,000
2009	1,809,000	310,000	*	11,340,000
2010	1,665,600	325,000	*	9,931,000
2011	1,723,900	335,000	*	9,516,000
2012	1,832,500	343,000	*	9,142,000
2013	1,751,900	372,000	*	9,366,000
2014	1,658,100	398,000	*	10,620,000
2015	1,809,100	459,000	*	10,477,000
2016	1,802,900	505,000	*	11,443,000
2017	1,810,100	500,000	*	11,085,000
2018	1,822,200	505,000	*	11,579,000
2019	1,790,100	423,000	*	12,154,000
2020	1,772,908	355,343	*	10,343,391
2021	1,758,200	491,000	*	9,952,000
2022	1,662,399	750,764	*	11,754,939
2023	1,636,156	582,184	*	11,754,939

* Confidential data

For Degradable Organic Component and Wastewater generated, were used the default values from IPCC 2006 (Table 7. 32).

Table 7.32 Parameters used to estimate Total organic industrial wastewater (Source:IPCC 2006, table 6.8)

Default Parameters	Industry type		
	Beer	Pulp &Paper	Petroleum Refineries
Degradable Organic Component – COD [g/l]	2.9	9	1

Default Parameters	Industry type		
	Beer	Pulp &Paper	Petroleum Refineries
Wastewater Generation [m^3/Mg]	6.3	162	0.6

In estimation of methane emissions from industrial wastewater Degradable Organic Component removed as sludge was considered zero.

CH_4 recovery

Data on methane recovered from industrial wastewater treatment are available. Considering information that we have at this time, the methane is recovered by most important 5 operators of breweries. For the 2023 year, according to the questionnaire completed by the operators, data on CH_4 recovered are both measured, 1.37 kt, and estimated, 0.26 kt.

Table 7.33 The amounts of CH_4 recovered from industrial wastewater treatment (Source: economic operators)

Year	Amount of Methane flared Gg/year	Amount of Methane for energy recovery Gg/year
1989–1997	-	-
1998	0.18	
1999	0.28	
2000	0.41	
2001	0.54	
2002	0.60	
2003	0.61	
2004	0.74	
2005	0.84	
2006	1.02	
2007	1.14	
2008	1.62	
2009	2.17	
2010	2.54	
2011	2.51	
2012	1.84	

Year	Amount of Methane flared Gg/year	Amount of Methane for energy recovery Gg/year
2013	0.94	1.53
2014	1.03	1.45
2015	1.99	1.09
2016	0.78	3.13
2017	0.74	1.40
2018	0.51	1.35
2019	0.56	1.39
2020	0.50	1.49
2021	0.70	1.16
2022	0.56	0.99
2023	0.51	1.12

CH_4 emissions from industrial sludge

CH_4 emissions from industrial sludge are reported IE because the emissions are included at the industrial wastewater level.

7.5.3 Description of any flexibility applied

Information on any flexibility applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

7.5.4 Uncertainty assessment and time-series consistency

CH_4 emissions from industrial wastewater

The values were elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. The uncertainties associated with CH_4 emissions from industrial wastewater are presented in the next table:

Table 7.34 Uncertainties for estimation of CH_4 emissions from industrial wastewater

IPCC source category	CH_4 from industrial wastewater
GHG	CH_4
AD uncertainty (%)	30.00
EF uncertainty (%)	42.40
Combined uncertainty (%)	52.00

The percentages are associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to equation 3.1 in Chapter 3, Volume 1 of the IPCC 2006.

CH_4 from domestic and commercial wastewater

The values were elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. In the table below are presented the uncertainties associated CH_4 emissions from domestic/commercial wastewater treatment.

Table 7.35 Uncertainties for estimation of CH_4 emissions from domestic/commercial Wastewater

IPCC source category	CH_4 from domestic and commercial wastewater
GHG	CH_4
AD uncertainty (%)	30.00
EF uncertainty (%)	42.40
Combined uncertainty (%)	52.00

The percentages are associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to according to Chapter 3, Volume 1 of the IPCC 2006.

N_2O from domestic wastewaster

The values were elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium; additional information are included in Annex V.10. In the table below are presented the uncertainties associated to N_2O emissions from human sewage.

Table 7.36 Uncertainties for estimation of N_2O emissions from domestic wastewaster

IPCC source category	N_2O from wastewater handling
GHG	N_2O
AD uncertainty (%)	30.00
EF uncertainty (%)	50.00
Combined uncertainty (%)	58.03

The percentages are associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to Chapter 3, Volume 1 of the IPCC 2006.

7.5.5 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Agriculture Sector, the results of these being mentioned on the Checklists level.
Following these activities there were no unconformities recorded.
Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.
In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

The number of population was provided by National Institute for Statistics the same parameter being reported to EUROSTAT. The comparison between the two data sources is presented in the Table 7.37.

Table 7.37 Comparison between data provided by EUROSTAT and data provided by NIS

Year	**Total number of population (1000 persons)**		**Difference**
	NIR 2025 (*Source NIS*) *1 January*	**EUROSTAT *1 January***	
1989	23,151,564	23,111,521	-40,043
1990	23,206,720	23,211,395	4,675
1995	22,680,951	22,712,394	31,443
2000	22,435,205	22,455,485	20,280
2005	21,382,354	21,382,354	0
2007	21,130,503	21,130,503	0
2008	20,635,460	20,635,460	0
2009	20,440,290	20,440,290	0
2010	20,294,683	20,294,683	0
2011	20,199,059	20,199,059	0
2012	20,095,996	20,095,996	0
2013	20,020,074	20,020,074	0
2014	19,953,089	19,947,311	-5,778
2015	19,875,542	19,870,647	-4,895
2016	19,760,585	19,760,585	0
2017	19,643,949	19,643,949	0
2018	19,533,481	19,533,481	0
2019	19,425,873	19,414,458	-11,415
2020	19,354,339	19,328,838	-25,501
2021	19,229,519	19,201,662	-27,857
2022	19,043,098	19,042,455	-643
2023	19,054,548	19,054,548	0

7.5.6 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

Recalculations have been performed for CH_4 and N_2O emissions from domestic and commercial wastewater, for 2022 year due to updated data regarding total population by NIS.

Following the analysis in regard to the use of a higher tier method, recalculation have been performed for CH_4 emissions from industrial wastewater for 1998 -2022 years, since for this period more acurrate data from the operators are available.

The following changes have been made:

Table 7.38 The changes on Methane correction factor for the estimation of CH_4 emissions estimates from Industrial Wastewater

Year	MCF	
	NIR 2024	NIR 2025
1998-2022 Beer industry- anaerobic treatment	0.70	0.80
1998-2022 Pulp, paper and petroleum refinery- aerobic treatment	0.30	0.00
after consulting the operators, resulted that pulp, paper and petroleum refinery uses aerobic treatment with well managed treatment plants, therefore MCF 0 was used according to 2006 IPCC Guidelines, Table 6.8.		

Table 7.39 The changes on Total organic product for the estimation of CH_4 emissions estimates from Industrial Wastewater

Year	Effects of changes in CH_4 emission estimates		
	NIR 2024	NIR 2025	Difference [%]
	Total organic product		
1998	623.54	18.25	605.29
1999	638.64	20.34	618.30
2000	780.33	23.14	757.19
2001	846.18	23.14	823.05
2002	932.35	21.24	911.10

Year	Effects of changes in CH_4 emission estimates		
	NIR 2024	NIR 2025	Difference [%]
	Total organic product		
2003	1006.13	24.28	981.84
2004	1023.72	26.32	997.40
2005	747.78	27.94	719.84
2006	741.18	31.94	709.24
2007	840.43	35.10	805.33
2008	614.91	36.98	577.94
2009	491.83	33.05	458.78
2010	510.24	30.43	479.81
2011	525.64	31.50	494.14
2012	539.06	33.48	505.58
2013	580.00	32.01	548.00
2014	616.95	30.29	586.66
2015	708.56	33.05	675.51
2016	776.09	32.94	743.16
2017	768.72	33.07	735.65
2018	776.53	33.29	743.24
2019	656.73	32.71	624.03
2020	556.82	32.39	524.43
2021	754.34	32.12	722.22
2022	1132.85	30.37	1102.48
only beer industry was considered in industrial emissions estimation treated on site since it uses anaerobic treatment			

Table 7.40 Effects of changes in CH_4 emission estimates from Industrial Wastewater

Year	Effects of changes in CH_4 emission estimates		
	NIR 2024	NIR 2025	Difference [%]
	CH_4 emissions		
1998	6.04	3.47	2.57
1999	6.37	3.79	2.58
2000	7.42	4.22	3.21
2001	7.62	4.09	3.54
2002	9.95	3.65	6.30
2003	11.00	4.25	6.76
2004	11.35	4.52	6.82
2005	9.45	4.75	4.70
2006	9.89	5.37	4.52
2007	11.04	5.88	5.16
2008	9.19	5.78	3.41
2009	7.05	4.44	2.61
2010	6.38	3.55	2.84
2011	6.71	3.79	2.92
2012	7.70	4.75	2.95
2013	7.24	3.93	3.31
2014	7.22	3.58	3.64
2015	7.77	3.53	4.24
2016	7.43	2.68	4.75
2017	9.17	4.48	4.69
2018	9.54	4.80	4.74
2019	8.46	4.59	3.86
2020	7.61	4.49	3.12
2021	9.17	4.56	4.61
2022	12.03	4.52	7.51

7.5.7 Category–specific planned improvements, if applicable, including tracking of those identified in the review process

Romania continues its analysis in regard to to CH_4 emissions from 5.D.2 Industrial wastewater in order to improve the emission estimates.

7.6 Other (CRT 5.E)

This category is not occurring in Romania.

7.7 Memo items (CRT 5.F)

This category is not occurring in Romania.

8 Other (CRT Sector 6)

There are no additional GHG emissions, removals or activities characterized.

9 Indirect carbon dioxide and nitrous oxide emissions

9.1 Description of sources of indirect emissions in the GHG inventory

9.1.1 Energy Sector (CRT Sector 1)

9.1.1.1 Stationary Combustion

9.1.1.1.1 Description of sources of indirect emissions Stationary Combustion

The activity categories where the fuels are combusted in the stationary combustion, sources for the precursors gases, are as follows:

❖ 1.A.1. Energy Industries;

❖ 1.A.2. Manufacturing Industries and Construction;

❖ 1.A.4. Other Sectors;

❖ 1.A.5. Other.

The reported precursor gases which results from these activities are NO_x, CO, NMVOC and SO_2.

9.1.1.1.2 Methodological issues

Activity Data

The activity data required for calculation of the precursor emissions from stationary combustion is based on the National Energy Balances, which provide information about the indigenous consumption, by subsector, for all types of fuels: solid, liquid, gaseous, peat, other and biomass fuels. According to the sectoral approach methodology for stationary combustion, only the fuel quantities that are combusted are relevant and thus considered for the emission calculations. The considered energetic consumption of the fuels is the same analysed for the direct GHG gas emission estimations see the Energy sector–stationary combustion chapter 3.2.4.1.

NO_x, CO, NMVOC, SO_2 emission factors for stationary sources

The following tables present the values of the emission factors used for the emissions estimations of the NO_x, CO and NMVOC indirect gases.

Table 9.1 NO_x emission factors for different fuels

EF NO_x [Kg/TJ]	Coal	Natural Gas	Oil	Wood/Wood Waste	Charcoal	Other Biomass and Wastes
Public electricity and heat production	300**	150**	200**	100**	100**	100**
Petroleum Refineries	300**	150**	200**	100**	100**	100**
Manufacture of Solid Fuels and Other Energy Industries	22*	150**	200**	100**	100**	100**
Manufacturing Industries and Construction	173*	70*	100*	150*	100**	100**
Commercial/Institutional	173*	70*	100*	150*	100**	100**
Residential	110*	57*	68*	74.5*	100**	100**
Agriculture/Forestry/Fishing	173*	70*	100*	150*	100**	100**

Table 9.2 CO emission factors for different fuels

CO [kg/TJ]	Coal	Natural Gas	Oil	Wood/Wood Waste	Charcoal	Other Biomass and Wastes
Public electricity and heat production	113*	39*	5*	258*	1000**	1000**
Petroleum Refineries	20**	39*	5*	1000**	1000**	1000**
Manufacture of Solid Fuels and Other Energy Industries	525*	20**	15**	1000**	1000**	1000**
Manufacturing Industries and Construction	931*	25*	40*	1596*	4000**	4000**
Commercial/Institutional	931*	25*	40*	1600*	7000**	5000**
Residential	4600*	31*	46*	5300*	7000**	5000**
Agriculture/Forestry/Fishing	931*	25*	40*	1600*	7000**	5000**

Table 9.3 NMVOC emission factors for different fuels

NMVOC [Kg/TJ]	Coal	Natural Gas	Oil	Wood/Wood Waste	Charcoal	Other Biomass and Wastes
Public electricity and heat production	1.7*	1.5*	0.8*	7.3*	100**	50**
Petroleum Refineries	5**	1.5*	0.8*	50**	100**	50**
Manufacture of Solid Fuels and Other Energy Industries	2.4*	5**	5**	50**	100**	50**
Manufacturing Industries and Construction	88.8*	2.5*	10*	146.4*	100**	50**
Commercial/Institutional	88.8*	2.5*	10*	146*	100**	600**
Residential	484*	10.5*	15.5*	925*	100**	600**
Agriculture/Forestry/Fishing	88.8*	2.5*	10*	146*	100**	600**

Notes: ** For the indirect gases, NO_x, CO, NMVOC, the emissions factors provided by the National, Inventory of Air Pollutants under the CLRTAP, were used.*

*** The above default NOx, CO, NMVOC emission factors are in accordance with the IPCC 1996 Guidelines.*

For the 1990–2023 period, the NO_x emissions under CLRTAP reporting (based on measured emissions reported by the Large Combustion Plants), in the 1A1a activity category, were used. In the 1A1c activity category, 1A2, 1A4 subsectors, 1A5a activity category, for the estimation of the NO_x emissions, the emission factors provided by the National Inventory of Air Pollutants under the CLRTAP, were used.

SO_2 Emission Factors

For the estimation of the SO_2 emissions, the default EFs from the site EMEP/EEA Air Pollutant Emission Inventory Guidebook–2009 (bellow table), were analyzed.

Table 9.4 Default Emission Factors for SO_2 Emissions

EF SO_2 [g/GJ]	Hard Coal	Brown Coal	Natural Gas	Derived Gases	Heavy Fuel Oil	Other Liquid Fuels	Biomass
1.A.1.a Electricity and Heat Production	820	820	0.3	0.3	485	460	11
1.A.1.b Petroleum Refining	–	–	–	0.3	–	–	–
1.A.1.c Manufacture of Solid Fuels	55	55	–	–	–	–	–
1.A.2.a Manufacturing and Construction-Iron and Steel	900	900	0.5	0.5	140	140	38.4
1.A.4.b Residential combustion	900	900	0.5	0.5	140	140	20
1.A.4.a, 1.A.4.c, 1.A.5 Non-residential combustion	900	900	0.5	0.5	140	140	38.4

In order to have consistency in estimation of SO_2 emissions with the National Inventory of Air Pollutants under the CLRTAP, in the 1.A.1.a Electricity and Heat Production activity category, the country specific emission factors for solid fuels (being the most used type of fuel), calculated taking account national circumstances, were used. Therefore, based on the reporting of the Large Combustion Plants, for 2005 year, the SO_2 country specific emission factor was determined and used for the 1989–2004 time-series. For the 2005–2023 period, the SO_2 emissions estimation, the reporting under CLRTAP (based on measured emissions reported by the Large Combustion Plants), in the 1A1a activity category, were used. In the 1.A.1.c activity category, 1.A.2, 1.A.4 subsectors, 1.A.5.a activity category, for the estimation of the SO_2 emissions, the emission factors provided by the National Inventory of Air Pollutants under the CLRTAP, were used.

Table 9.5 Country Specific SO_2 emission factors – 1.A.1.a, solid fuel

EF SO_2 [Kg/GJ]	1989–2003	2004
COAL combusted in 1.A.1.a Electricity and Heat Production	1.782	1.782

9.1.1.1.3 Uncertainty assessment and time-series consistency

The values for the uncertainty of the activity data were collected/elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency–University of Graz consortium. Based on the above background information, the results of the uncertainties associated to the used activity data, are as follows:

AD uncertainty

❖ Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

❖ Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 7%.

❖ Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 3%;

EFs uncertainty *– averages of the ranges provided through the EMEP/EEA emission inventory guidebook 2016, were used.*

- ***NO_X, CO gases:***
  - ❖ 1A1, 1A2,: 40%;
  - ❖ 1A4 and 1A5a: 125%;
- ***NMVOC gas:***
  - ❖ 1A1, 1A2, 1A4 and 1A5a: 125%;
- ***SO_2 gas:***
  - ❖ 1A1: 5%;
  - ❖ 1A2: 20%;
  - ❖ 1A4 and 1A5a: 40%.

Aggregated uncertainty

The overall uncertainties, as result of the aggregation of AD and EF related uncertainties, according to the equation 3.1 in Chapter 3 of the IPCC 2006 Guidelines, Vol. 1, are as follows:

- ***NO_X, CO gases:***
  - Liquid fuels, CRT categories 1A1, 1A2: 40%;
  - Solid fuels, CRT categories 1A1, 1A2: 40%;
  - Gaseous fuels, CRT categories 1A1, 1A2: 40%;
  - Peat, CRT categories 1A1, 1A2: 40%;
  - Other fuels, CRT categories 1A1, 1A2: 41%.

- Biomass, CRT categories 1A1, 1A2: 40%;
- Liquid fuels, CRT categories 1A4 and 1A5a: 125%;
- Solid fuels, CRT categories 1A4 and 1A5a: 125%;
- Gaseous fuels, CRT categories 1A4 and 1A5a: 125%;
- Peat, CRT categories 1A4 and 1A5a: 125%;
- Other fuels, CRT categories 1A4 and 1A5a: 125%.
- Biomass, CRT categories 1A4 and 1A5a: 125%;

- ***NMVOC gas:***
- Liquid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 125%;
- Solid fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 125%;
- Gaseous fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 125%;
- Peat, CRT categories 1A1, 1A2, 1A4 and 1A5a: 125%;
- Other fuels, CRT categories 1A1, 1A2, 1A4 and 1A5a: 125%.
- Biomass, CRT categories 1A1, 1A2, 1A4 and 1A5a: 125%;

- ***SO_2 gas:***
- Liquid fuels, CRT categories 1A1: 6%;
- Solid fuels, CRT categories 1A1: 6%;
- Gaseous fuels, CRT categories 1A1: 6%;
- Peat, CRT categories 1A1: 6%;
- Other fuels, CRT categories 1A1: 9%.
- Biomass, CRT categories 1A1: 6%;
- Liquid fuels, CRT categories 1A2,: 20%;
- Solid fuels, CRT categories 1A2: 20%;
- Gaseous fuels, CRT categories 1A2: 20%;
- Peat, CRT categories 1A2: 20%;
- Other fuels, CRT categories 1A2: 21%.
- Biomass, CRT categories 1A2: 20%;
- Liquid fuels, CRT categories 1A4 and 1A5a: 40%;
- Solid fuels, CRT categories 1A4 and 1A5a: 40%;
- Gaseous fuels, CRT categories 1A4 and 1A5a: 40%;
- Peat, CRT categories 1A4 and 1A5a: 40%;
- Other fuels, CRT categories 1A4 and 1A5a: 41%.

- Biomass, CRT categories 1A4 and 1A5a: 40%;

9.1.1.1.4 Category–specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Program were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Fugitive Emissions from Fuels and Transport (excluding Road Transport) subsector*, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

QA activities are implemented annually under the procedures for the compilation of the European Union GHG Inventory, described in the Regulation (EU) no. 1999/2018 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) no. 663/2009 and (EC) no. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) no. 525/2013 of the European Parliament and of the Council and, respectively, in the Commission Implementing Regulation (EU) no. 1208/2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) no. 749/2014.

In 2012, 2016, 2017, 2018, 2019, 2020, 2021 and 2022, the GHG emissions estimates have been subject to a thorough review within the European Union, in the context of implementing the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Additionally, in 2020 and 2023, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

No recalculations were implemented following the QA activities mentioned in the previous two paragraphs.

9.1.1.1.5 Category–specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

Activity Data

See the recalculations of the activity data, by some Energy stationary combustion activity categories, chapter 3.2.4.6.

NO_x and SO_2 Emissions

For NOx and SO_2 emissions have been performed recalculation for 1990-2022 period due to the updated values of the emissions from 1.A.1.a Electricity and Heat Production activity category, emissions reported under CLRTAP (based on measured emissions reported by the Large Combustion Plants).

9.1.1.1.6 Category–specific planned improvements, including tracking of those identified in the review process

It is planned continue to use the country specific IPPC Directive reported data for the NO_x and SO_2 emissions.

9.1.1.2 Domestic Aviation (1.A.3.a)

9.1.1.2.1 Description of sources of indirect emissions in GHG inventory

The sources of indirect emissions are provided from international and domestic civil aviation, including take-offs and landings. Comprises civil commercial use of airplanes, including: scheduled and charter traffic for passengers and freight, air taxiing, and general aviation. The activity and emission values for the precursors (NOx, CO, NMVOC and SO_2) are found in the CRT Reporter GHG inventory [1. Energy] [1.AA Fuel Combustion - Sectoral approach] [1.A.3 Transport] [1.A.3.a Domestic Aviation]. The emission factors are default and *provided i*n the Revised 1996 IPCC Guidelines and IPCC 2006.

9.1.1.2.2 Methodological issues

This section provides the estimation methods for emissions of precursors (NOx, CO, NMVOC and SO_2) from combustion of aviation fuel. The NOx, CO, NMVOC and SO_2 emissions from the specified sources were calculated by multiplying the fuel consumption converted to net calorific value by the default emission factors.

9.1.1.2.3 Uncertainty assessment and time-series consistency

NOx, CO, NMVOC, SO_2 emissions

- *activity data:* jet fuels: 5 %.
- *emision factors:* Jet fuels: 150%.
- 1.5% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016.

9.1.1.2.4 Category–specific QA/QC and verification

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach.

9.1.1.2.5 Category–specific recalculations, including changes made in response to the review process and impact on emission trend

For NOx, CO, NMVOC and SO_2 emissions have been performed recalculation for 2022 year due to the updated value of Jet kerosene fuel consumption, data provided by NIS.

9.1.1.2.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.1.3 Road Transport (1.A.3.b)

NO_X, CO, NMVOC, and SO_2 emissions

9.1.1.3.1 Description of sources of indirect emissions in GHG inventory

This section provides the estimation methods for emissions of precursors and other substances (NO_X, CO, NMVOC, and SO_2) from fuel combustion of vehicles.

9.1.1.3.2 Methodological issues

NO_X, CO, SO_2 and NMVOC

- ***Estimation Method***

Exhaust emissions from road transport are reported according to the four different NFR codes listed: 1.A.3.b.i passenger cards, 1.A.3.b.ii light duty trucks, 1.A.3.b.iii heavy duty trucks and buses, 1.A.3.b.iv mopeds and motorcycles. NO_X, CO, SO_2 and NMVOC emissions from the specified mobile sources were calculated by multiplying the distance traveled per year for each vehicle type by fuel consumed and own emission factor.

- ***Emission factors for period 1989–2004***

For exhaust emissions of precursors NO_X, CO, NMVOC are used emission factors from EMEP/EEA air pollutant emission inventory guidebook 2016. Model Copert 4, Tier 1 was used in the absence of more detailed fleet data (for the period 1989–2004). Tier 1 emission factors of Copert 4 will give somewhat higher emission values as is the case of Romania than Tier 2 or 3 methodology for countries whose fleet comprises vehicles which comply with more recent (i.e. Euro 2 / Euro II and later) emission standards. The maximum values for the emission factors used correspond to uncontrolled vehicle technology.

Table 9.6 Emission Factors for Tier 1 method of Copert 4

Category	Fuel	CO (g/kg fuel)	NMVOC (g/kg fuel)	NOx (g/kg fuel)
Passenger Cars	Gasoline	269.5	34.42	29.89
Passenger Cars	Diesel	8.19	1.88	13.88
Passenger Cars	LPG	117	25.66	34.30
Light–Duty Vehicles	Gasoline	238.3	26.08	25.46
Light–Duty Vehicles	Diesel	11.71	1.96	18.43
Heavy–Duty Vehicles	Diesel	10.57	3.77	38.29
Two–Wheel Vehicles	Gasoline	664.5	364.8	10.73

CO, NOx, ch. Road transport GB 2013, table 3–5 and table 3–6 pag.25–26; NMVOC ch. Gasoline evaporation GB 2013, pag.8–9; SO_2 IPCC 1996, Vol.III, pag.1.44 Guidelines table 1–12 Default Values of Sulphur Content in gasoline (road), diesel (road) and jet kerosene). The emissions of sulphur oxides (SO_2) are directly related to the sulphur content of the fuel:

Equation 9.1 The Emission Factor for SO_2

$$EF_{SO2}\ [kg/TJ] = 2 \times (s/100) \times 1/Q \times 10^6 \times (100 - r/100) \times (100 - n/100)$$

where:

- EF = Emission Factor (kg/TJ);
- 2 = SO_2/S [kg/kg];
- s = Sulphur content in fuel [%];
- r = Retention of sulphur in ash [%];
- Q = Net calorific value [TJ/kt];
- n = Efficiency of abatement technology and/or reduction efficiency [%].

Table 9.7 Default values of sulphur content (s) in fuel

Fuel (IPCC grouping)	Default value [%]
Diesel (road)	0.3
Gasoline (road)	0.1
Jet kerosene	0.05

- ***Emission factors for period 2005–2023***

Model Copert 4, Tier 3 was used for the period 2005–2023, detailed statistics necessary to use higher level methods have allowed. For period 2005–2023 the emission calculations of road transport have been performed with the use of the COPERT 4 software, methodology corresponding to Tier 3, according to the IPCC 2006.

9.1.1.3.3 Uncertainty assessment and time-series consistency

Table 9.8 Uncertainties for road transport

Road Transport 1.A.3.b.	Uncertainty					Combined uncertainty			
	AD	EF CO	EF SO_2	EF NMVOC	EF NOx	EF CO	EF SO_2	EF NMVOC	EF NOx
Motor Gasoline	3	50	50	50	50	0.5009	0.5009	0.5009	0.5009
Gas Diesel Oil	3	50	50	50	50	0.5009	0.5009	0.5009	0.5009
Liquefied Petroleum Gases (LPG)	3	50	50	50	50	0.5009	0.5009	0.5009	0.5009
Other Liquid Fuels (Other Kerosene)	3	50	50	50	50	0.5009	0.5009	0.5009	0.5009
Gaseous Fuels	3	50	50	50	50	0.5009	0.5009	0.5009	0.5009

Road Transport 1.A.3.b.	Uncertainty					Combined uncertainty			
	AD	EF CO	EF SO_2	EF NMVOC	EF NOx	EF CO	EF SO_2	EF NMVOC	EF NOx
Biomass	3	50	50	50	50	0.5009	0.5009	0.5009	0.5009

9.1.1.3.4 Category–specific QA/QC and verification

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Industrial Processes and Product Use Sector, the results of these being mentioned on the Checklists level.

9.1.1.3.5 Category–specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculations were implemented.

9.1.1.3.6 Category–specific planned improvements, including tracking of those identified in the review process

No source–specific planned improvements are envisaged.

9.1.1.4 Railways (1.A.3.c.)

9.1.1.4.1 Description of sources of indirect emissions in GHG inventory

The sources of indirect emissions are provided from railway transport for both freight and passenger traffic routes. The activity data and emission values for the precursors (NOx, CO, NMVOC and SO_2) are found in the CRT Reporter GHG inventory [1. Energy][1.AA Fuel Combustion – Sectoral approach] [1.A.3 Transport] [1.A.3.c Railways]. The emission factors are default and provided in the *Revised 1996 IPCC Guidelines* and EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.

9.1.1.4.2 Methodological issues

This section provides the estimation methods for emissions of precursors (NOx, CO, NMVOC and SO_2)

caused by combustion of railway fuel. The NOx, CO, NMVOC and SO_2 emissions from the specified sources were calculated by multiplying fuel consumption converted to net calorific value by the default emission factors provided in the *Revised 1996 IPCC Guidelines* and EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.

9.1.1.4.3 Uncertainty assessment and time-series consistency

NOx, CO, NMVOC, SO_2 emissions

- *activity data:* Liquid: 5%

  Solid: 3%

- *emision factors:* Fuel consumption: 150%.
- 1.5008% liquid and 1.5003% solid associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016.

9.1.1.4.4 Category–specific QA/QC and verification

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach.

9.1.1.4.5 Category–specific recalculations, including changes made in response to the review process and impact on emission trend

❖ ***activity data***: recalculations of the activity data values for 1989–2022 time period have been made because the activity data values from the IEA/Eurostat Questionnaire 2023 have been updated;

❖ ***emissions:*** recalculations of the NOx emissions, CO emissions and NMVOC emissions for the 1989–2022 time period have been made due to updates of the Activity Data, specific emission factors for liquid fuels, solid fuels and solid biomass, and also due to the updates of Net Calorific Values.

The implications of all changes made on emission estimates are described in the Tables below:

Table 9.9 Change made at emissions and their effects on NO_x, CO emissions estimates at Railways category (CRT 1.A.3.c)

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for NO_x [Gg]		Diff [%]	Effects of changes on emission estimates for CO [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	5,564.07	5,564.69	0.01	6.88	6.88	0.00	1.40	2.00	42.12
1990	6,327.61	6,327.61	0.00	8.13	7.40	-8.99	1.66	2.25	35.69
1995	12,134.22	12,126.95	-0.06	14.95	14.79	-1.06	3.09	3.52	13.68
2000	12,473.41	12,473.41	0.00	15.42	15.44	0.13	3.15	3.27	3.91
2005	3,332.67	3,332.67	0.00	4.10	4.12	0.53	0.84	0.99	17.15
2007	7,831.78	7,831.78	0.00	9.48	9.61	1.34	1.95	2.69	37.88
2008	7,151.83	7,151.83	0.00	8.88	8.94	0.76	1.81	2.18	20.26
2009	5,362.23	5,362.27	0.00	6.62	6.68	0.90	1.35	1.68	24.00
2010	6,032.34	6,033.77	0.02	7.53	7.64	1.50	1.54	2.14	38.96
2015	4,765.62	4,769.83	0.09	5.88	6.12	3.98	1.20	2.44	102.90
2016	4,634.29	4,638.82	0.10	5.72	5.92	3.56	1.17	2.24	91.79
2017	4,837.28	4,837.28	0.00	5.97	5.97	-0.01	1.22	1.22	0.14
2018	3,954.05	3,956.69	0.07	4.88	4.99	2.21	1.00	1.56	56.74
2019	5,431.39	5,434.13	0.05	6.70	6.81	1.56	1.37	1.92	40.01
2020	4,714.13	4,718.61	0.10	5.82	5.99	2.94	1.19	2.08	75.12
2021	5,516.92	5,523.13	0.11	6.81	7.01	2.90	1.39	2.42	73.67
2022	4,303.74	4,307.99	0.10	5.31	5.43	2.24	1.09	1.70	56.79

Table 9.10 Change made at emissions and their effects on NMVOC emissions estimates at Railways category (CRT 1.A.3.c)

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for NMVOC [Gg]		Diff [%]	Effects of changes on emission estimates for SO_2 [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	5,564.07	5,564.69	0.01	0.61	0.67	9.24	1.31	0.26	-79.92
1990	6,327.61	6,327.61	0.00	0.72	0.73	0.79	1.79	0.67	-62.68
1995	12,134.22	12,126.95	-0.06	1.32	1.40	5.87	2.88	0.65	-77.43
2000	12,473.41	12,473.41	0.00	1.37	1.38	1.11	2.93	0.63	-78.46
2005	3,332.67	3,332.67	0.00	0.36	0.38	5.82	0.75	0.17	-76.98

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for NMVOC [Gg]		Diff [%]	Effects of changes on emission estimates for SO_2 [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
2007	7,831.78	7,831.78	0.00	0.34	0.36	6.56	0.71	0.14	-79.96
2008	7,151.83	7,151.83	0.00	0.84	0.93	10.19	0.72	0.36	-49.89
2009	5,362.23	5,362.27	0.00	0.79	0.82	4.65	0.36	0.37	2.35
2010	6,032.34	6,033.77	0.02	0.67	0.73	8.57	0.29	0.29	0.02
2015	4,765.62	4,769.83	0.09	0.52	0.64	22.76	0.22	0.22	0.09
2016	4,634.29	4,638.82	0.10	0.51	0.61	20.56	0.22	0.22	0.10
2017	4,837.28	4,837.28	0.00	0.53	0.53	0.30	0.23	0.23	0.00
2018	3,954.05	3,956.69	0.07	0.43	0.49	12.62	0.19	0.19	0.07
2019	5,431.39	5,434.13	0.05	0.59	0.65	8.89	0.26	0.26	0.05
2020	4,714.13	4,718.61	0.10	0.52	0.60	16.64	0.22	0.22	0.09
2021	5,516.92	5,523.13	0.11	0.60	0.70	16.31	0.26	0.26	0.11
2022	4,303.74	4,307.99	0.10	0.47	0.53	12.65	0.20	0.20	0.10

9.1.1.4.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.1.5 Navigation (1.A.3.d.)

9.1.1.5.1 Description of sources of indirect emissions in GHG inventory

The sources of indirect emissions are provided from fuels used to propel water–borne vessels, including hovercraft and hydrofoils, but excluding fishing vessels. The activity data and emission values for the precursors (NOx, CO, NMVOC and SO_2) are found in the CRT Reporter GHG inventory [1. Energy][1.AA Fuel Combustion – Sectoral approach] [1.A.3 Transport] [1.A.3.d Domestic Navigation]. The emission factors used for each precursor are default and they are provided within EMEP/EEA Air Pollutant emission inventory Guidebook 2019 – Update Dec. 2021.

9.1.1.5.2 Methodological issues

This section provides the estimation methods for emissions of precursors (NOx, CO, NMVOC and SO_2)

caused by combustion of fuel. The NOx, CO, NMVOC and SO_2 emissions from the specified sources were calculated by multiplying fuel consumption with net calorific value and specific emission factors.

9.1.1.5.3 Uncertainty assessment and time-series consistency

NOx, CO, NMVOC, SO_2 emissions

- *activity data:* Residual Fuel Oil:5.0 %
  Diesel oil: 5.0%
  Gasoline:3.0%
- *emision factors:* Fuel consumption: 150%.

- 0.0583% residual fuel and diesel oil, 0.0310% gasoline, associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.

9.1.1.5.4 Category–specific QA/QC and verification

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach.

9.1.1.5.5 Category–specific recalculations, including changes made in response to the review process and impact on emission trend

In order to improve the quality of emissions estimates some important recalculations were made at:

- ***activity data***: recalculations of the activity data values for 1989 year have been made due to the updating of the activity data in IEA/Eurostat Questionnaire 2023;
- ***emissions***: recalculations of the NO_x emissions, CO emissions, NMVOC emissions and SO_2 emissions for the 1989 year have been made due to the updates mentioned above.

Table 9.11 Change made in estimation of precursors at Domestic navigation category level (CRT 1.A.3.d)

Gas / Efs by Fuel type		NOx (kg/t)	CO (kg/t)	NMVOC (kg/t)	S %
Fuel without gasoline content	Efs for Diesel oil	72.2 (EMEP 2019, tab. 0–2 (pg.17))	3.84 (EMEP 2019, tab. 0–2 (pg.17))	1.75 (EMEP 2019, tab. 0–2 (pg.17))	0.0931 (EMEP 2019 (Table B1 – MDO/MGO, pg. 47))
	Efs for Residual fuel oil				1,42 (EMEP 2019 (Table B1 – Bunker Fuel Oil, pg. 47))
Fuel with gasoline content	Efs for Gasoline	9.4 (EMEP 2019, tab. 3–4 (pg. 18))	573.9 (EMEP 2019, tab. 3–4 (pg. 18))	181.5 (EMEP 2019, tab. 3–4 (pg. 18))	0.1 (national value accordingly with GD no. 346/2016, pg. 14)

The impact of recalculations made on emission estimates are presented in the Tables below:

Table 9.12 Change made at emissions and their effects on NO_x, CO emissions estimates at Domestic navigation category (CRT 1.A.3.d)

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for NO_x [Gg]		Diff [%]	Effects of changes on emission estimates for CO [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	20,309.27	20,306.72	-0.01	36.26	36.26	0.00	2.08	2.08	0.00
1990	14,719.94	14,719.94	0.00	26.19	26.19	0.00	1.58	1.58	0.00
1995	4,299.69	4,299.69	0.00	7.51	7.51	0.00	0.42	0.42	0.00
2000	4,808.90	4,808.90	0.00	8.23	8.23	0.00	0.69	0.69	0.00
2005	1,738.79	1,738.79	0.00	2.96	2.96	0.00	0.19	0.19	0.00
2010	3,585.35	3,585.35	0.00	5.92	5.92	0.00	0.46	0.46	0.00
2015	3,263.46	3,263.46	0.00	5.06	5.06	0.00	0.55	0.55	0.00
2016	2,306.12	2,306.12	0.00	3.90	3.90	0.00	0.42	0.42	0.00
2017	2,496.66	2,496.66	0.00	4.20	4.20	0.00	1.02	1.02	0.00
2018	1,830.95	1,830.95	0.00	3.11	3.11	0.00	0.25	0.25	0.00
2019	1,712.86	1,712.86	0.00	2.89	2.89	0.00	0.36	0.36	0.00
2020	1,715.07	1,715.07	0.00	2.88	2.88	0.00	0.47	0.47	0.00
2021	1,725.59	1,725.59	0.00	2.88	2.88	0.00	0.63	0.63	0.00
2022	1,862.40	1,862.40	0.00	3.11	3.11	0.00	0.68	0.68	0.00

Table 9.13 Change made at emissions and their effects on NMVOC and SO_2 emissions estimates at Domestic navigation category (CRT 1.A.3.d)

Year	Changes at AD level [TJ]		Diff [%]	Effects of changes on emission estimates for NMVOC [Gg]		Diff [%]	Effects of changes on emission estimates for SO_2 [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	20,309.27	20,306.72	-0.01	0.93	0.93	0.00	13.38	13.38	0.00
1990	14,719.94	14,719.94	0.00	0.69	0.69	0.00	9.35	9.35	0.00
1995	4,299.69	4,299.69	0.00	0.19	0.19	0.00	1.63	1.63	0.00
2000	4,808.90	4,808.90	0.00	0.28	0.28	0.00	1.83	1.83	0.00
2005	1,738.79	1,738.79	0.00	0.08	0.08	0.00	0.10	0.10	0.00
2010	3,585.35	3,585.35	0.00	0.19	0.19	0.00	0.15	0.15	0.00
2015	3,263.46	3,263.46	0.00	0.21	0.21	0.00	0.13	0.13	0.00
2016	2,306.12	2,306.12	0.00	0.16	0.16	0.00	0.10	0.10	0.00
2017	2,496.66	2,496.66	0.00	0.35	0.35	0.00	0.11	0.11	0.00
2018	1,830.95	1,830.95	0.00	0.10	0.10	0.00	0.08	0.08	0.00
2019	1,712.86	1,712.86	0.00	0.13	0.13	0.00	0.08	0.08	0.00
2020	1,715.07	1,715.07	0.00	0.17	0.17	0.00	0.08	0.08	0.00
2021	1,725.59	1,725.59	0.00	0.22	0.22	0.00	0.08	0.08	0.00
2022	1,862.40	1,862.40	0.00	0.24	0.24	0.00	0.08	0.08	0.00

9.1.1.5.6 Category–specific planned improvements, including tracking of those identified in the review process

No improvements are planned for the next submission.

9.1.1.6 Other Transportation (1.A.3.e.)

9.1.1.6.1 Description of sources of indirect emissions in GHG inventory

The sources of indirect emissions are provided from combustion emissions from all remaining transport activities including pipeline transportation, ground activities in airports and harbours, and off-road activities. The activity data and emission values for the precursors (NOx, CO, NMVOC and SO_2) are found in the CRT Reporter GHG inventory [1. Energy] [1.AA Fuel Combustion – Sectoral approach] [1.A.3 Transport]

[1.A.3.e Other Transportation (please specify)]. The emission factors are default and provided in the Revised 1996 IPCC Guidelines and EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.

9.1.1.6.2 Methodological issues

This section provides the estimation methods for emissions of precursors (NOx, CO, NMVOC and SO_2) caused by combustion of railway fuel. The NOx, CO, NMVOC and SO_2 emissions from the specified sources were calculated by multiplying fuel consumption converted to net calorific value by the default emission factors.

9.1.1.6.3 Uncertainty assessment and time-series consistency

NOx, CO, NMVOC, SO_2 emissions

- *activity data:* Liquid: 3.0%
  Solid: 3.0%
  Gaseous: 3.0%
  Biomass: 3.0%
- *emision factors:* Fuel consumption: 150%.
- 1.5% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016.

9.1.1.6.4 Category–specific QA/QC and verification

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach.

9.1.1.6.5 Category–specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculations were made relative to previous submission.

9.1.1.6.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.1.7 Fugitive Emissions from Fuels (1.B)

Emissions from Oil Production (1.B.2.a)

9.1.1.7.1 Description of sources of indirect emissions in GHG inventory

The sources of indirect Fugitive emissions from oil production occur at the oil wellhead or at the oil sands or shale oil mine through to the start of the oil transmission system. This includes fugitive emissions related to well servicing, oil sands or shale oil mining, transport of untreated production to treating or extraction facilities, activities at extraction and upgrading facilities, associated gas re-injection systems and produced water disposal systems.

Activity data

According with the methodological provisions, activity data level used for emissions of precursors (NOx, CO, NMVOC and SO_2) from *Oil production* (1.B.2.a) is the "crude oil throughput" from the National Institute of Statistics.

Emission Factors

The default emission factors from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 have been used (1.B.2.a.iv Fugitive emissions oil: refining / storage, Table 3-1 Tier 1 emission factors for source category 1.B.2.a.iv Refining, storage).

Default EFs used to estimate emissions for Oil Production (1.B.2.a.2) category (kg /t crude oil throughput)			
NO_x	***CO***	***NMVOC***	***SO_2***
0.035	0.041	0.110	0.245

9.1.1.7.2 Methodological issues

This section provides the estimation methods for emissions of precursors (NOx, CO, NMVOC and SO_2) from *Production and upgrading Oil*. The NOx, CO, NMVOC and SO_2 emissions from the specified sources were calculated by multiplying the fuel consumption with the default emission factors.

9.1.1.7.3 Uncertainty assessment and time-series consistency

NOx, CO, NMVOC, SO_2 emissions

- *activity data:* 7 %.
- *emission factors:*125%.
- 125,20% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023.

9.1.1.7.4 Category–specific QA/QC and verification

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the categories associated with the Stationary Combustion, Reference Approach, Comparison between the Reference Approach and the Sectorial Approach.

9.1.1.7.5 Category–specific recalculations, including changes made in response to the review process and impact on emission trend

In order to improve the emissions estimates quality some important recalculations were made at:

Emissions from Oil Production (CRT 1.B.2.a):

❖ ***emissions***: Recalculations of NOx, CO, NMVOC and SO_2 emissions in 1.B.2.a Oil Subcategory, for the 1989-2022 period, are due to update of the emission factors; the default EFs from the EMEP/EEA air pollutant emission inventory guidebook 2023 were used.

The implications of all changes made on emission estimates are described in the Tables below:

Table 9.14 Change made at emissions and their effects on NO_x and CO emissions estimates at Fugitive emissions – Oil and natural gas – Oil (CRT 1.B.2.a)

Year	Effects of changes on emission estimates for NO_x [Gg]		Diff [%]	Effects of changes on emission estimates for CO [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	7.35	1.07	-85.42	2.76	1.26	-54.44
1990	5.68	0.83	-85.42	2.13	0.97	-54.44
1991	3.65	0.53	-85.42	1.37	0.62	-54.44
1992	3.19	0.47	-85.42	1.20	0.55	-54.44
1993	3.17	0.46	-85.42	1.19	0.54	-54.44
1994	3.54	0.52	-85.42	1.33	0.60	-54.44
1995	3.66	0.53	-85.42	1.37	0.63	-54.44
1996	3.22	0.47	-85.42	1.21	0.55	-54.44
1997	2.98	0.44	-85.42	1.12	0.51	-54.44
1998	3.00	0.44	-85.42	1.13	0.51	-54.44
1999	2.37	0.35	-85.42	0.89	0.41	-54.44
2000	2.53	0.37	-85.42	0.95	0.43	-54.44
2001	2.63	0.38	-85.42	0.99	0.45	-54.44
2002	2.86	0.42	-85.42	1.07	0.49	-54.44
2003	2.58	0.38	-85.42	0.97	0.44	-54.44
2004	2.97	0.43	-85.42	1.11	0.51	-54.44
2005	3.33	0.49	-85.42	1.25	0.57	-54.44
2006	3.18	0.46	-85.42	1.19	0.54	-54.44
2007	3.12	0.46	-85.42	1.17	0.53	-54.44
2008	3.14	0.46	-85.42	1.18	0.54	-54.44
2009	2.72	0.40	-85.42	1.02	0.46	-54.44
2010	2.38	0.35	-85.42	0.89	0.41	-54.44
2011	2.28	0.33	-85.42	0.86	0.39	-54.44
2012	2.19	0.32	-85.42	0.82	0.37	-54.44
2013	2.25	0.33	-85.42	0.84	0.38	-54.44
2014	2.55	0.37	-85.42	0.96	0.44	-54.44
2015	2.51	0.37	-85.42	0.94	0.43	-54.44
2016	2.75	0.40	-85.42	1.03	0.47	-54.44

Year	Effects of changes on emission estimates for NO_x [Gg]		Diff [%]	Effects of changes on emission estimates for CO [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025	
2017	2.66	0.39	-85.42	1.00	0.45	-54.44
2018	2.78	0.41	-85.42	1.04	0.47	-54.44
2019	2.92	0.43	-85.42	1.09	0.50	-54.44
2020	2.48	0.36	-85.42	0.93	0.42	-54.44
2021	2.39	0.35	-85.42	0.90	0.41	-54.44
2022	2.82	0.41	-85.42	1.06	0.48	-54.44
2023		0.36			0.42	

Table 9.15 Change made at emissions and their effects on NMVOC and SO_2 emissions estimates at Fugitive emissions – Oil and natural gas – Oil (CRT 1.B.2.a)

Year	Effects of changes on emission estimates for NMVOC [Gg]		Diff [%]	Effects of changes on emission estimates for SO_2 [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025	
1989	6.12	3.37	-45.00	18.98	7.50	-60.48
1990	4.73	2.60	-45.00	14.67	5.80	-60.48
1991	3.04	1.67	-45.00	9.42	3.72	-60.48
1992	2.66	1.46	-45.00	8.25	3.26	-60.48
1993	2.64	1.45	-45.00	8.18	3.23	-60.48
1994	2.95	1.62	-45.00	9.14	3.61	-60.48
1995	3.05	1.68	-45.00	9.46	3.74	-60.48
1996	2.69	1.48	-45.00	8.32	3.29	-60.48
1997	2.49	1.37	-45.00	7.71	3.05	-60.48
1998	2.50	1.38	-45.00	7.76	3.07	-60.48
1999	1.98	1.09	-45.00	6.13	2.42	-60.48
2000	2.11	1.16	-45.00	6.53	2.58	-60.48
2001	2.19	1.20	-45.00	6.79	2.68	-60.48
2002	2.38	1.31	-45.00	7.38	2.92	-60.48
2003	2.15	1.18	-45.00	6.66	2.63	-60.48
2004	2.47	1.36	-45.00	7.67	3.03	-60.48
2005	2.78	1.53	-45.00	8.61	3.40	-60.48
2006	2.65	1.46	-45.00	8.21	3.24	-60.48
2007	2.60	1.43	-45.00	8.06	3.19	-60.48

Year	Effects of changes on emission estimates for NMVOC [Gg]		Diff [%]	Effects of changes on emission estimates for SO_2 [Gg]		Diff [%]
	NIR 2024	NIR 2025		NIR 2024	NIR 2025	
2008	2.62	1.44	-45.00	8.12	3.21	-60.48
2009	2.27	1.25	-45.00	7.03	2.78	-60.48
2010	1.99	1.09	-45.00	6.16	2.43	-60.48
2011	1.90	1.05	-45.00	5.90	2.33	-60.48
2012	1.83	1.01	-45.00	5.67	2.24	-60.48
2013	1.87	1.03	-45.00	5.81	2.29	-60.48
2014	2.12	1.17	-45.00	6.58	2.60	-60.48
2015	2.10	1.15	-45.00	6.50	2.57	-60.48
2016	2.29	1.26	-45.00	7.09	2.80	-60.48
2017	2.22	1.22	-45.00	6.87	2.72	-60.48
2018	2.32	1.27	-45.00	7.18	2.84	-60.48
2019	2.43	1.34	-45.00	7.54	2.98	-60.48
2020	2.07	1.14	-45.00	6.41	2.53	-60.48
2021	1.99	1.09	-45.00	6.17	2.44	-60.48
2022	2.35	1.29	-45.00	7.29	2.88	-60.48
2023		1.13			2.52	

9.1.1.7.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.2 Industrial Processes And Product Use Sector (CRT Sector 2)

9.1.2.1 Mineral Industry (CRT 2.A)

9.1.2.1.1 Description of sources of indirect emissions in the GHG inventory

GHG emissions reported include estimates for the Cement Production (CRT 2.A.1) category.

9.1.2.1.2 Methodological issues

9.1.2.1.2.1 Cement Production (CRT 2.A.1)

Methodology

The method for calculating emissions of SO_2 from cement is in line with the 1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories - page 2.7.

Activity data

The AD necessary to estimate emissions from this source category are provided by the National Institute for Statistics (Cement Production). The data set in case of Cement Production is complete.

Emission factors

SO_2 emissions from cement production are estimated using the below equation.

Equation 9.2 The SO_2 emissions from cement production

$$SO_2\ [Gg] = Quantity\ of\ Cement\ Produced\ (t) \times Emission\ Factor \times 10^{-6}$$

The default emission factor of 0.3 kg SO_2/tonne cement is used.

Table 9.16 Cement Production data and SO_2 emissions from Cement Production in the period 1989–2023

Year	Activity data and SO_2 emissions from Cement Production Sub-sector		
	Cement production [kt]	Emission factor [kg SO_2 /t cement]	SO_2 Emissions [kt]
1989	12,225.00	0.30	3.67
1990	9,468.00	0.30	2.84
1995	6,842.00	0.30	2.05
2000	6,058.00	0.30	1.82
2005	7,043.00	0.30	2.11
2007	10,060.00	0.30	3.02
2008	10,660.00	0.30	3.20
2009	7,902.00	0.30	2.37

Year	Activity data and SO_2 emissions from Cement Production Sub-sector		
	Cement production [kt]	Emission factor [kg SO_2 /t cement]	SO_2 Emissions [kt]
2010	6,992.00	0.30	2.10
2011	8,087.00	0.30	2.43
2012	8,223.00	0.30	2.47
2013	7,451.00	0.30	2.24
2014	7,621.00	0.30	2.29
2015	8,356.00	0.30	2.51
2016	8,038.00	0.30	2.41
2017	8,442.00	0.30	2.53
2018	8,951.15	0.30	2.69
2019	9,936.77	0.30	2.98
2020	10,539.05	0.30	3.16
2021	10,676.28	0.30	3.20
2022	10,203.57	0.30	3.06
2023	10,093.24	0.30	3.03

9.1.2.1.3 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 2 %;
- EF: 40 %;
- 40.05 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.1.4 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

9.1.2.1.5 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

9.1.2.1.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.2.2 Chemical Industry (CRT 2.B)

9.1.2.2.1 Description of sources of indirect emissions in GHG inventory

The Chemical Industry subsector (CRT 2.B) includes the following categories: Ammonia Production (CRT 2.B.1), Nitric Acid Production (CRT 2.B.2), Adipic Acid Production (CRT 2.B.3) and Petrochemical and carbon black production (CRT 2.B.8).

9.1.2.2.2 Methodological issues

9.1.2.2.2.1 Ammonia Production (CRT 2.B.1)

Methodology

The CO and SO_2 emissions from Ammonia Production are estimated according to the 1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories.

Activity data

The AD necessary to estimate emissions from this source category are provided by the economic agents.
In 2023, ammonia production decreased by 10.15% compared with 2022 year.

Emission factors

CO emissions from ammonia production are estimated using the below equation.

Equation 9.3 CO emissions from ammonia production

$$CO\ [Gg] = Quantity\ of\ Ammonia\ Produced\ (t)\ x\ Emission\ Factor\ x\ 10^{-6}$$

SO_2 emissions from ammonia production are estimated using the below equation.

Equation 9.4 SO_2 emissions from ammonia production

$$SO_2\ [Gg] = Quantity\ of\ Ammonia\ Produced\ (t)\ x\ Emission\ Factor\ x\ 10^{-6}$$

The default emission factors of 7.9 kg CO/tonne of product and 0.03 kg SO_2/ tonne of product are used (1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories Workbook – page 2.13).

Table 9.17 Ammonia Production data and CO and SO_2 emissions from Ammonia Production in the period 1989–2023

Year	Total annual production [t/an]	Emission Factor (kg CO/t ammonia produced)	Emission Factor (kg SO_2 /t ammonia produced)	CO emissions kt	SO_2 emissions kt
1989	2,360,290.00	7.9	0.03	18.646	0.071
1990	1,757,965.00	7.9	0.03	13.888	0.053
1995	1,641,398.00	7.9	0.03	12.967	0.049
2000	1,245,068.00	7.9	0.03	9.836	0.037
2005	1,601,724.00	7.9	0.03	12.654	0.048
2007	1,365,890.00	7.9	0.03	10.791	0.041
2008	1,273,413.10	7.9	0.03	10.060	0.038
2009	1,022,020.99	7.9	0.03	8.074	0.031
2010	1,379,884.00	7.9	0.03	10.901	0.041
2011	1,542,980.00	7.9	0.03	12.190	0.046
2012	1,525,120.00	7.9	0.03	12.048	0.046
2013	1,123,463.00	7.9	0.03	8.875	0.034
2014	1,188,019.00	7.9	0.03	9.385	0.036
2015	607,971.00	7.9	0.03	4.803	0.018
2016	C	7.9	0.03	4.238	0.016
2017	C	7.9	0.03	5.136	0.020
2018	C	7.9	0.03	5.179	0.020
2019	C	7.9	0.03	9.385	0.036
2020	839,298.00	7.9	0.03	6.630	0.025
2021	C	7.9	0.03	3.471	0.013
2022	C	7.9	0.03	0.422	0.002
2023	C	7.9	0.03	0.379	0.001

9.1.2.2.2.2 Nitric Acid Production (CRT 2.B.2)

Methodology

The nitrogen oxide emissions were estimated according to the “2006 IPCC Guidelines for National Greenhouse Gas Inventories” for each facility and each year of operation between 1989 and 2013, by using, based on the existing activity data, approach level 2 or approach level 3. Approach level 2 was used for nitric acid production facilities that do not have continuous emission monitoring systems. Approach level 3 was used for nitric acid production facilities that have Continuous Emissions Monitoring Systems – CEMS. Emissions have been calculated by multiplying annual Nitric Acid Production (tons HNO_3 100% by each plant) by a default emission factor, which reflects the process, in line with CORINAIR Methodology.

Activity data

There were seven chemical plants in Romania in 1989, with ten nitric acid production plants. In 2014 year seven plants were in operation in five chemical plants. The seven plants were grouped grouped in:

- Medium and high pressure operation facilities (six plants);
- Old facilities, erected before 1975, without NSCR (one plant).

In 2015 year five facilities were in operation in three chemical plants. All installations were equipped with selective catalytic reduction system with continuous emission monitoring system. In the 2016–2020 period, four facilities were in operation in two chemical plants. All installations were equipped with selective catalytic reduction system with continuous emission monitoring system. In the 2021–2022 period two chemical plants (where four production factories are in operation) produced nitric acid. In 2022, nitric acid production decreased by 83.48% compared with 2021 year. In 2023, nitric acid production increased with 4.98% compared with 2022 year. The AD necessary to estimate emissions from this source category are provided by the economic agents.

Emission factors

The emission factors used in the spreadsheets for approach level 2 reflect the nitric acid production process:

a) For medium and high pressure facilities – “dual pressure”:

- The NOx emission factor is 5–12 kg NOx /t HNO_3, according to the 2013/EMEP/EEA Emissions inventory guidebook, chap. 3.3.2.2. The **7.5 kg NOx/t HNO_3** average value was used for the emission estimate, in the absence of continuous emission measurements.

b) For old facilities, commissioned before 1975, without a NSCR, operating under low pressure:

- The NOx emission factor is **12 kg NOx /t HNO_3**, according to the 2013/EMEP/EEA Emissions inventory guidebook.

The analysis of the NOx emission level tend was carried out under the following conditions:

- The HNO_3 production facilities are old, as they were erected between 1963 and 1978;
- The HNO_3 production technologies have not changed in the last 40 years;
- Catalyst repair, maintenance and replacement works were carried out in the facilities;
- Nitrogen oxide reduction systems and emission monitoring systems have been mounted since 2003;
- A facility, shut down its operation in 1990;
- Another facility, shut down its operation in 2008. A NOx reduction system operated between 1997 and 2008;
- There are currently two chemical plants, where four HNO_3 production facilities are in operation;
- Four operating HNO_3 production facilities are fitted with nitrogen oxide reduction and emission monitoring systems;

NOx emission level trend

- The emissions decreased between 1989 and 2007, following the decrease of production.
- A drop of emissions was registered between 2008 and 2013, while the production level was maintained or even increased. Explanation: the mounting of the NOx reduction systems;
- In the period 2015–2017, and respectively for the years 2019, 2021 and 2022, NOx emissions decrease as a result of the decrease in nitric acid production. In the years 2018, 2020 and 2023 there is an increase in NOx emissions as a result of the increase in nitric acid production.

NOx emission monitoring systems

NOx emission monitoring systems use analyzers manufactured by internationally renowned companies, designed according to the U.S. EPA 40 CFR 60875 norms and the 2000/76/EC (WID), 2001/80/EC (LCPD) norms. The type of flow analyzers is the MIR 9000 Multi – Gas InfraRed GFC Analyzer.

Table 9.18 Nitric Acid Production related to the NO_x emissions in the period 1989–2023

Year	**Activity data and emissions from Nitric Acid Production Sub–sector**		
	Nitric acid production [kt]	**plants without NSCR**	**dual pressure type process (ammonia oxidation takes place at medium pressure and absorption takes place at high pressure)**
		NO_x emissions [kt]	**NO_x emissions [kt]**
1989	1,993.70	0.88	14.40
1990	1,260.98	0.67	9.04
1995	1,025.81	0.09	7.64
2000	874.12	0.22	5.42
2005	1,102.14	0.17	2.75

Year	Activity data and emissions from Nitric Acid Production Sub–sector		
	Nitric acid production [kt]	plants without NSCR	dual pressure type process (ammonia oxidation takes place at medium pressure and absorption takes place at high pressure)
		NO_x emissions [kt]	NO_x emissions [kt]
2007	981.38	0.23	2.26
2008	867.39	0.46	1.71
2009	642.48	0.25	1.90
2010	1,055.38	0.41	3.28
2011	1,076.96	0.56	2.72
2012	983.80	0.46	1.47
2013	949.58	0.19	0.62
2014	1,001.15	0.23	0.60
2015	734.50	NO	0.49
2016	C	NO	0.40
2017	C	NO	0.31
2018	C	NO	0.36
2019	C	NO	0.28
2020	C	NO	0.35
2021	C	NO	0.24
2022	C	NO	0.04
2023	C	NO	0.05

9.1.2.2.2.3 Adipic Acid Production (CRT 2.B.3)

Methodology

The NOx, NMVOC and CO emissions from Adipic Acid Production are estimated according to the 1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories – page 2.19.

Activity data

Emissions are estimated based on national statistics for the period 1989–1997, after this year no reports on Adipic Acid Production are made. Based on response from the local Environment Protection Agencies that were requested to provide information on this activity (1998–2001), only one producer has been identified. The facility stopped its activity at the end of 2001. Starting with 2002, this activity is suspended.

Emission factors

Table 9.19 The default EFs used to estimate emissions from Adipic Acid Production

EMISSION FACTORS FOR ADIPIC ACID PRODUCTION (KG/TONNE PRODUCT)		
NO_x	NMVOC	CO
8.1	43.3	34.4

Table 9.20 Adipic Acid Production related to the NO_x, NMVOC and CO emissions in the period 1989–2001

Year	Amount of Adipic Acid Produced	NOx emissions kt	NMVOC emissions kt	CO emissions kt
1989	7,287.00	0.06	0.32	0.25
1990	6,169.00	0.05	0.27	0.21
1991	5,252.00	0.04	0.23	0.18
1992	3,729.00	0.03	0.16	0.13
1993	5,879.00	0.05	0.25	0.20
1994	5,776.00	0.05	0.25	0.20
1995	6,369.00	0.05	0.28	0.22
1996	6,420.00	0.05	0.28	0.22
1997	8,966.00	0.07	0.39	0.31
1998	9,312.00	0.08	0.40	0.32
1999	7,461.00	0.06	0.32	0.26
2000	9,258.00	0.07	0.40	0.32
2001	5,322.00	0.04	0.23	0.18

9.1.2.2.2.4 Petrochemical and carbon black Production (CRT 2.B.8)

Methodology

Emissions of NOx, CO, NMVOC, and SO_2 were estimated in line with the Revised 1996 IPCC Guidelines for National GHG Inventories: Workbook, page 2.21–2.25 and Revised 1996 IPCC Guidelines for National GHG Inventories: Reference Manual, pages 2.22–2.25.

Activity data

National Statistics provided annually the amounts of these production processes (carbon black, ethylene, acrylonitrile, propylene, polystyrene, polyethene-low density, polyethene-high density, sulphuric acid, phthalic anhydride, polypropylena, polyvinylchloride, 1, 2 dichloroethane). Carbon black, ethylene, acrylonitrile, phthalic anhydride and 1, 2 dichloroethane are not produce anymore.

Emission factors

For confidentiality reasons the presentation of emission factors used to estimate emission from those productions are omitted.

Emissions of NO_x, CO, NMVOC, and SO_2 were estimated from those productions.

Table 9.21 The NOx, CO, NMVOC and SO_2 emissions for Petrochemical and carbon black Production Sub-sector

Year	NOx emissions kt	CO emissions kt	NMVOC emissions kt	SO_2 emissions kt
1989	0.03	0.77	6.81	29.76
1990	0.02	0.58	5.32	19.62
1995	0.01	0.22	4.82	8.42
2000	0.01	0.15	5.01	3.21
2005	NO	NO	6.74	0.19
2007	NO	NO	2.90	0.003
2008	NO	NO	2.92	0.001
2009	NO	NO	1.54	0.007
2010	NO	NO	1.31	0.007
2011	NO	NO	1.62	0.035
2012	NO	NO	1.23	0.007
2013	NO	NO	1.59	0.003
2014	NO	NO	1.23	0.006
2015	NO	NO	1.11	0.000
2016	NO	NO	1.25	0.000
2017	NO	NO	1.17	0.006
2018	NO	NO	1.40	0.002
2019	NO	NO	1.40	0.002
2020	NO	NO	1.32	0.002
2021	NO	NO	1.25	0.005
2022	NO	NO	1.33	0.005
2023	NO	NO	1.18	0.0051

9.1.2.2.3 Uncertainty assessment and time-series consistency

9.1.2.2.3.1 Ammonia Production (CRT 2.B.1)

CO emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 125 %;
- 125.10 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

SO_2 emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 40 %;
- 40.31 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.2.3.2 Nitric Acid Production (CRT 2.B.2)

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 125 %;
- 125.10 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.2.3.3 Adipic Acid Production (CRT 2.B.3)

CO, NOx and NMVOC emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 15 %;

- EF: 125 %;
- 125.90 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.2.3.4 Petrochemical and carbon black Production (CRT 2.B.8)

CO, NOx and NMVOC emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 125 %;
- 125.10 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

SO_2 emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 40 %;
- 40.31 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.2.4 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

9.1.2.2.5 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

9.1.2.2.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.2.3 Metal Industry (CRT 2.C)

9.1.2.3.1 Description of sources of indirect emissions in GHG inventory

The emission estimates cover sub-categories Iron and Steel Production (CRT 2.C.1), Aluminium Production (CRT 2.C.3) and Magnesium Production (CRT 2.C.4).

9.1.2.3.2 Methodological issues

9.1.2.3.2.1 Iron and Steel Production (CRT 2.C.1)

Methodology

The NMVOC, NO_x, CO, SO_2 emissions are estimated using the default emission factors applied to the first fusion raw Pig Iron Production.

Activity data

The data collection was performed based on questionnaires sent to the economic agents identified by the Local Agencies for Environmental Protection.

Emission factors

For confidentiality reasons the presentation of NMVOC, NOx, CO and SO_2 emission factor used to estimate emission from pig iron production is omitted.

Table 9.22 NMVOC, NO_x, CO and SO_2 emissions for category CRT 2.C.1 – Iron and Steel Production

Year	Pig Iron production, t	NMVOC emissions, t	NOx emissions, t	CO emissions, t	SO_2 emissions, t
1989	8,495,130	169.90	645.63	951.45	254.85
1990	5,916,270	118.33	449.64	662.62	177.49
1995	4,118,570	82.37	313.01	461.28	123.56
2000	3,041,540	60.83	231.16	340.65	91.25
2005	4,117,920	82.36	312.96	461.21	123.54
2007	3,946,680	78.93	299.95	442.03	118.40
2008	3,238,790	64.78	246.15	362.74	97.16
2009	1,568,860	31.38	119.23	175.71	47.07
2010	1,721,750	34.44	130.85	192.84	51.65
2011	1,581,250	31.63	120.18	177.10	47.44
2012	1,468,160	29.36	111.58	164.43	44.04
2013	C	32.08	121.89	179.63	48.12
2014	C	32.63	123.98	182.71	48.94
2015	C	39.66	150.72	222.11	59.49
2016	C	39.45	149.89	220.90	59.17
2017	C	36.57	138.95	204.77	54.85
2018	C	39.58	150.42	221.67	59.38
2019	C	40.41	153.55	226.29	60.61
2020	C	36.95	140.43	206.95	55.43
2021	C	41.78	158.77	233.97	62.67
2022	C	29.61	112.52	165.82	44.42
2023	C	12.36	46.98	69.23	18.54

9.1.2.3.2.2 Aluminium Production (CRT 2.C.3)

Methodology

The **CO, SO_2 emissions** are estimated according to the 1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories – page 2.33 and are estimated related to primary Aluminium Production.

Activity data

Primary Aluminium Production is carried out in one facility in Romania, where the pre–baked process is used. In 2022, aluminium production decreased by 59.91% compared with 2021 year. In 2023, aluminium production decreased by 19.65% compared with 2022 year.

Emission factors

The default emission factors of 400 kg CO/ tonne of product and 0.9 kg SO_2/ tonne of product are used (1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories – page 2.33, Table 2–18).

Table 9.23 Emission factors for CO and SO_2 from primary Aluminium Production

Gas	Process	Emission Factor [kg/tonne primary Al produced]
CO	Anode baking	400
SO_2	Anode baking	0.9

Table 9.24 The CO and SO_2 emissions from primary Aluminium Production

Year	SO_2 emissions kt	CO emissions kt
1989	0.239	106.217
1990	0.151	67.095
1995	0.127	56.240
2000	0.156	69.308
2005	0.215	95.604
2007	0.236	105.002
2008	0.239	106.095
2009	0.181	80.222
2010	0.186	82.688
2011	0.202	89.802
2012	0.182	80.830
2013	0.178	78.898
2014	0.176	78.0996
2015	0.185	82.352
2016	0.187	82.931
2017	0.186	82.456
2018	0.189	84.214
2019	0.180	80.038

Year	SO_2 emissions kt	CO emissions kt
2020	0.173	76.980
2021	0.182	80.748
2022	0.073	32.373
2023	0.059	26.013

9.1.2.3.2.3 Magnesium Production (CRT 2.C.4)

Methodology

The **SO_2 emissions** are estimated according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – page 4.62 and are estimated related to magnesium casting process.

Activity data

For the secondary magnesium production was identified a magnesium recycling plant which has a production hall – magnesium ingots and anodes. The raw materials used for the production process – melting magnesium are: waste containing magnesium alloy of 90% and primary magnaziu with minimum purity of 93% – waste clean, compact, known composition, waste from casting covered with paint, varnish or coating substances; clean waste from pressing – slags; other magnesium waste. In order to prevent oxidation and ignition of the magnesium using a mixture of nitrogen with SO_2 in a proportion of up to 3% SO_2, rather than inert GHGs.

Emission factors

The default emission factors of 26 kg SO_2/tonne of magnesium produced are used (*https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-7-c-other/view; Table 3.1 Tier 1 emission factors for source category 2.C.7.c Other metal production*).

Table 9.25 The SO_2 emissions from Magnesium Production

Year	SO_2 emissions, kt
2015	0.164
2016	0.234
2017	0.208
2018	0.214

Year	SO_2 emissions, kt
2019	0.311
2020	0.203
2021	0.179
2022	0.159
2023	0.095

9.1.2.3.3 Uncertainty assessment and time-series consistency

9.1.2.3.3.1 Iron and Steel Production (CRT 2.C.1)

CO, NMVOC and NOx emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 125 %;
- 125.10 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

SO_2 emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 40 %;
- 40.31 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.3.3.2 Aluminium Production (CRT 2.C.3)

CO emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 125 %;
- 125.10 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related

uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

SO_2 emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 40 %;
- 40.31 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.3.3.3 Magnesium Production (CRT 2.C.4)

SO_2 emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 5 %;
- EF: 40 %;
- 40.31 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.3.4 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

9.1.2.3.5 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

9.1.2.3.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.2.4 Non–Energy Products From Fuels And Solvent Use (CRT 2.D)

9.1.2.4.1 Description of sources of indirect emissions in GHG inventory

The emission estimates cover sub–categories Road paving with asphalt (CRT 2.D.3.b) and Asphalt roofing (CRT 2.D.3.c).

9.1.2.4.2 Methodological issues

9.1.2.4.2.1 Road Paving with Asphalt (CRT 2.D.3.b)

Methodology

The EMEP/EEA emission inventory guidebook 2019 for estimation the emissions from Road Paving with Asphalt Sub–sector has been used.

Activity data

The data on Road Paving with Asphalt Sub–sector are provided by National statistics. These data are available starting with 1998 year. The activity data taking into account in order to estimate NMVOC emissions are: natural bitumen and asphaltic rocks, bituminous mixtures based on natural or artificial aggregate and bitumen or natural asphalt, petroleum bitumen road. Starting with 2007 the data related with Road Paving with Asphalt are confidential.

Emission factors

The default EF from EMEP/EEA emission inventory guidebook 2023 was used in order to estimate NMVOC emissions: 0.016 kg NMVOC/ tone material used (*https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-b-road/view*).

Table 9.26 The NMVOC emissions from Road Paving with Asphalt Sector

Year	Activity data kt	NMVOC emissions kt
1989	NE	NE
1990	NE	NE
1995	NE	NE
2000	223.196	0.004
2005	676.403	0.011
2007	C	0.038
2008	C	0.009
2009	C	0.022
2010	C	0.026
2011	C	0.025
2012	C	0.029
2013	C	0.032
2014	C	0.033
2015	C	0.034
2016	C	0.025
2017	C	0.007
2018	C	0.019
2019	C	0.031
2020	C	0.032
2021	C	0.027
2022	C	0.026
2023	C	0.020

9.1.2.4.2.2 Asphalt Roofing Production (CRT 2.D.3.c)

Methodology

The default 1996 IPCC methodology for estimation the emissions from Asphalt Roofing Production Sub–sector has been used. According with IPCC 2006 GL and IPCC GPG 2000 Methodology there are no described methods in order to estimate the NMVOC emissions on higher levels, therefore it was followed the methodology from Revised 1996 IPCC Guidelines for National GHG Inventories: Workbook, page 2.9, Tables 2–2 and 2–3.

Activity data

The data on Asphalt Roofing Production Sub–sector are provided by National statistics. The data taking into account in order to estimate CO and NMVOC emissions are: petroleum bitumen for materials insulation, petroleum bitumen for pipelines insulation, products based on bitumen – waterproofing, bitumen oil for industry (the data are available starting with 2007 year), asphalt board (the data are available from 1989 year). Starting with 2007 the data related with Asphalt Roofing Production are confidential.

Emission factors

The default IPCC emission factors were used in order to estimate NMVOC and CO emissions.

Table 9.27 Emission factors for NMVOC, CO from Asphalt Roofing Production Sector

EMISIONS FACTORS FOR ASPHALT ROOFING PRODUCTION–SATURATION PROCES [kg/tone product]	
NMVOC	0.0475
CO	0.0095
EMISIONS FACTORS FOR ASPHALT BLOWING PROCESS – no control [kg/tone product]	
NMVOC	2.4

Table 9.28 The CO and NMVOC emissions from Asphalt Roofing Production Sector

Year	Activity data kt	CO emissions kt	NMVOC emissions kt
1989	109.50	0.0010	0.268
1990	97.50	0.0009	0.239
1995	33.00	0.0003	0.081
2000	23.318	0.0002	0.057
2005	12.144	0.00012	0.030
2007	C	0.00005	0.012
2008	C	0.00004	0.010
2009	C	0.00004	0.010
2010	C	0.00004	0.010
2011	C	0.00094	0.243

Year	Activity data kt	CO emissions kt	NMVOC emissions kt
2012	C	0.00033	0.086
2013	C	0.000002	0.0006
2014	C	0.00013	0.033
2015	C	0.00037	0.095
2016	C	0.00016	0.042
2017	C	0.00007	0.019
2018	C	0.00021	0.054
2019	C	0.00022	0.056
2020	C	0.00026	0.067
2021	C	0.00022	0.057
2022	C	0.00027	0.069
2023	C	0.00026	0.067

9.1.2.4.3 Uncertainty assessment and time-series consistency

9.1.2.4.3.1 Road Paving with Asphalt (CRT 2.D.3.b)

NMVOC emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 300 %;
- EF: 125 %;
- 325 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.4.3.2 Asphalt Roofing Production (CRT 2.D.3.c)

CO and NMVOC emissions

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 300 %;
- EF: 125 %;
- 325 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related

uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2023.

9.1.2.4.4 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

9.1.2.4.5 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

9.1.2.4.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.2.5 Other Production (CRT 2.H)

9.1.2.5.1 Description of sources of indirect emissions in GHG inventory

This sector includes NOx, CO, NMVOC and SO_2 emission resulted from the Pulp and Paper Production (CRT 2.H.1), Food and beverages Industry (CRT 2.H.2). The activity data necessary to estimate these emissions are provided in the Statistical Yearbook. Due to the fact that the IPCC methodologies do not indicate any default calculation formula or default emission factors, also the calculation method and national value for the emission factor are not available, indirect CO_2 emissions from category 2H have not been estimated.

9.1.2.5.2 Methodological issues

Methodology

According with 2006 IPCC Guidelines and IPCC GPG 2000 Methodology there are no described methods in order to estimate the emissions on higher levels, therefore it was followed the methodology from Revised 1996 IPCC Guidelines for National GHG Inventories: Workbook and Revised 1996 IPCC Guidelines for National GHG Inventories: Reference Manual. In the Pulp and Paper Production (CRT 2.H.1) Sub–sector the Pulp Production was broken down by kraft and acid sulphite processes. In the Food and Beverages Industry (CRT 2.H.2) Sub-sector the emission was estimated based on the total annual production of the particular food and drink manufacturing process. The emissions of NOx, CO, NMVOC, and SO_2 within the Production of Pulp and Paper and Food and Beverages Industry Sub–sector are calculated based on the production volume and the emission factors, in line with the IPCC 1996.

Activity data

In the Pulp and Paper Production (CRT 2.H.1) Sub–sector, the emission was estimated based on the total annual production of dried pulp, provided by National Statistics. For the 2009–2019 period, the activity data are NO inside this category. In 2020–2023 period, production of dried pulp took place. In the Food and Beverages Industry (CRT 2.H.2) Sub-sector the AD were provided by the National Statistics. The data set in case of Bread Production is not complete; the data for 1989–2000 are missing. A linear extrapolation was used to estimate Bread Production in order to complete the time series. The NMVOC emissions resulted from: Beer/Whine/Meat/fish and poultry/Sugar/Margarine and solid cooking fast/Cakes, biscuits and breakfast cereals/Bread production.

Emission factors

For confidentiality reasons the presentation of NOx, CO, NMVOC, SO_2 emission factors used to estimate emission from the Production of Pulp and Paper and Food and Beverages Industry Sub–sector are omitted.

9.1.2.5.3 Uncertainty assessment and time-series consistency

Time series is consistent; emissions have been calculated using the same emission factors, the same sources of activity data and the same methods were used for the entire time series 1989–2023.

9.1.2.5.4 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A cross–checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the Road transportation subsector, the results of these being mentioned on the Checklists level.

9.1.2.5.5 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculations were made relative to previous submission.

9.1.2.5.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.3 Agriculture Sector (CRT Sector 3)

9.1.3.1 Non Methane Volatile Organic Compounds (NMVOC)

NMVOC emissions are not estimated in Romania.

9.1.3.2 Field Burning Of Agricultural Residues (3F)

NOx and CO emissions

9.1.3.2.1 Description of sources of indirect emissions in GHG inventory

Burning of agricultural crop residues is a significant source of emissions and of carbon monoxide and nitrogen oxides. However, the burning of crop residues is not thought to be a net source of carbon dioxide because the carbon released to the atmosphere is reabsorbed during the next growing season. Considering legislation which prohibits the burning of crop, were concluded that this the activity happening on a small scale, in the case of crop production (the study „*Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*“.

9.1.3.2.2 Methodological issues

Methodology

For calculation of carbon monoxide, nitrous oxide emissions, the equation on page 2.42 of IPCC 2006, Volume 4, Chapter 2, was used.

Emission factors

According to the provisions in IPCC 2006 was used default emission factors for various of burning in table 2.5, pg. 2.47, Volume 4, Chapter 2. Was used default combustion factor from IPCC 2006, table 2.6, Volume 4, Chapter 2. of 0.9 for rye, wheat and 0.8 for barley and two-row barley, maize grains, sorghum, other cereals.

Table 9.29 Default emission factors for various types of burning

Gas	Default IPCC 2006 emission ratios
Carbon monoxide (CO)	92
Nitrogen oxides (NOx)	2.5

Activity data

Data on Area burnt described in Chapter 5.5.2.

9.1.3.2.3 Uncertainty assessment and time-series consistency

The uncertainty associated to the GHG emissions estimates are as follows:

- AD: 20 %;
- EF: 200%;
- 200.9% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2016.

9.1.3.2.4 Category-specific QA/QC and verification, if applicable

All quality control activities described in the QA/QC Programme were performed. A checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating Waste Sector, the results of these being mentioned on the Checklists level.

9.1.3.2.5 Category-specific recalculations, if applicable, including explanatory information and justifications for recalculations, changes made in response to the review process and impacts on emission trends

No recalculation was made.

9.1.3.2.6 Category–specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.3.3 NMVOC

NMVOC emissions from Field burning of Agricultural residues are not estimated in Romania.

9.1.4 Waste Sector (CRT Sector 5)

9.1.4.1 NMVOC emissions from solid waste disposal on land

9.1.4.1.1 Methodological issues

Methodology

By expert judgement, based on the study "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", finished in 2011, NMVOC emissions from SWDS were considered to 0.7% from landfill gas and were estimated using CH_4 emissions.

Activity data

The AD are presented in the relevant Section 7.2.2 from Chapter 7.

Emission factors

The EF is presented in the relevant Section 7.2.2 from Chapter 7. The NMVOC emissions were updated based on revised methane emissions for the entire time series.

Table 9.30 Percentage of of direct and indirect Greenhouse Gas emissions from waste category 5A (Source: International Solid Waste Association – "Landfill Operational Guideline, 2nd Edition")

Year	Greenhouse Gas			
	CH_4		NMVOC	
	kt	%	kt	%
1989	53.24	50	0.75	0.7
1990	54.86	50	0.77	0.7
1995	62.83	50	0.88	0.7
2000	76.87	50	1.08	0.7
2005	102.60	50	1.44	0.7
2007	111.38	50	1.56	0.7
2008	114.53	50	1.60	0.7
2009	118.82	50	1.66	0.7
2010	124.09	50	1.74	0.7
2011	105.33	50	1.47	0.7
2012	128.83	50	1.80	0.7
2013	140.91	50	1.97	0.7
2014	141.39	50	1.98	0.7
2015	141.52	50	1.98	0.7
2016	143.78	50	2.01	0.7
2017	146.19	50	2.05	0.7
2018	147.39	50	2.06	0.7
2019	152.72	50	2.14	0.7
2020	154.70	50	2.17	0.7
2021	155.47	50	2.18	0.7
2022	156.64	50	2.19	0.7
2023	157.38	50	2.20	0.7

9.1.4.1.2 Uncertainty assessment and time-series consistency

The uncertainties are presented in the relevant Section 7.2.3 from Chapter 7.

9.2 Indirect CO_2 and nitrous oxide emissions

9.2.1 Sources of indirect emissions in GHG inventory

9.2.1.1 Indirect CO_2 and nitrous oxide emissions

Under paragraph 29 of the UNFCCC Inventory Reporting Guidelines and under paragraph 52 of the MPGs, Romania did not choose to report indirect CO_2 emissions from the atmospheric oxidation of CH_4, CO and NMVOCs, or indirect N_2O emissions arising from sources other than those in the agriculture and LULUCF sectors.

10 Recalculations and improvements

This chapter presents the changes in GHG emissions/removals between the 2024 Greenhouse Gas Inventory submission and 2025 Greenhouse Gas Inventory submission. Since the 2024 submission, recalculations have been performed for almost all sectors. The recalculations have been carried out in order to account for better activity data (AD) and emission factors (EF) and to correct for some errors in the calculations.

10.1 Explanations and justifications for recalculations, including in response to the review process

Recalculations by categories

The inventory contains improvements in the following sectors:

<u>**Energy**</u>

➢ **Energy sector – Stationary Combustion**

Recalculations performed on Feedstock's and non-energy use of fuels (1.AD category)

Activity data

Liquid Fuels

Recalculations were made for Petroleum coke for the period 1990–2022 due to the update of activity data (Net Calorific Value); this resulted in the updating of emissions for this period.

For the current submission the following sectoral emissions recalculations were performed:

1. Activity data

Due to the methodological provisions and compliance with the reporting rules and to avoid double accounting of data from the inventory, recalculations were made for the activity data of natural gas and refinery gas fuels as described below:

Recalculations were made for *Refinery gas*, due to the decrease in energy consumption from the *Energy sector - Stationary combustion - 1.A.1.b Petroleum Refining category - liquid fuels* for the period 2014-2022, consumption that was added to the IPPU sector; in this case the CO_2, CH_4 and N_2O emissions are updated;

Recalculations were made for *Natural gas*, due to the decrease in energy consumption from the *Energy sector - Stationary combustion - 1.A.1.b Petroleum Refining category - gaseous fuels* for the period 1989-2022, consumption that was added to the IPPU sector; in this case the CO_2, CH_4 and N_2O emissions are updated;

Recalculations were made for *Natural gas*, due to the decrease in energy consumption from the *Energy* *sector - Stationary combustion - 1.A.2.c Chemicals category - gaseous fuels* for the period 2014-2022, consumption that was added to the IPPU sector; in this case the CO_2, CH_4 and N_2O emissions are updated; In addition to the elements provided initially, the fact that the changes are related to the decrease in energy emissions associated with hydrogen production from the emissions associated with the Energy Sector, and with their reallocation in the IPPU Sector.

Solid fuels

- ✓ In *1.A.2.d Pulp, Paper and Print category* for the 2013 year for the *coke_oven_coke* was identified a transcription error in the Common Reporting Tables (CRT) of the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.

Liquid fuels

- ✓ In *1.A.1.a Public Electricity and Heat Production category* for the 2007-2022 period for the *Residual fuel oil, Transport diesel and Refinery gas* was identified a transcription error in the Common Reporting Tables (CRT) of the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.
- ✓ In *1.A.2.e Food Processing, Beverages and Tobacco category* for 2022 year for the *Residual fuel oil* was identified a transcription error in the Common Reporting Tables (CRT) of the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.
- ✓ In *1.A.2.g Other category* for 2014-2022 period for the *Refinery gas* was updated the consumption in TJ*;* in this case the CO_2, CH_4 and N_2O emissions are updated.

2. Net Calorific Value

- ✓ For categories 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction and 1.A.4 Other Sectors for liquid fuels (Refinery Gas, Gas diesel oil, Residual fuel oil, Petroleum coke, Heating and other gasoil) and Natural gas the period 1990–2022, have been updated the Net Calorific Value; this has been resulted in the update of CO_2, CH_4 and N_2O emissions.

3. CO_2 emission factors

- ✓ For categories 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction and 1.A.4 Other Sectors for liquid fuels (Refinery Gas, Residual fuel oil) and Natural gas the period 1990–2022, have been updated the CO_2 emission factors; this has been resulted in the update of CO_2, CH_4 and N_2O emissions.

- ➢ **Transport (1.A.3)**
- ➢ **Domestic aviation (1.A.3.a)**

- For CO_2, CH_4 and N_2O emissions have been performed recalculation for 2022 year due to the updated value of Jet kerosene fuel consumption, data provided by NIS.

- ➢ **Railways (1.A.3.c)**

Activity data:

- Recalculations have been made on the time series, due to the updates of fuels consumption.

Emissions:

- Recalculations have been made due to updates of the Activity Data.

➢ **Domestic navigation (1.A.3.d)**

Activity data:

- Recalculations have been made for 1989 year, due to the updates of fuels consumption.

***Emissions*:**

- Recalculations have been made due to updates of the Activity Data.

➢ **Other transportation (1.A.3.e)**

***Emissions*:**

- Recalculations of the CO_2 emissions for the 1992 – 2022 period have been made due to updates of the National Emission Factors.

➢ **<u>Fugitive emissions from fuels (1.B)</u>**

➢ **1.B.2.a. Oil**

✓ **Other (1.B.2.a.6)**

- Recalculations were made for the 1995-2007 and 2010-2012 period for CO_2 emissions following the update of the NCVs values.

➢ **1.B.2.b Natural Gas**

✓ **Transmission and storage (1.B.2.b.4)**

- Recalculations have been made for the 2022 year for CO_2 and CH_4 emissions from the 1.B.2.b.4 Transmission and storage subcategory as a result of updating the activity data regarding Closing stock level (National territory) by the National Institute of Statistics.

✓ **Other (1.B.2.b.6)**

- Recalculations have been made for the 1990-2022 period for CH_4 emissions from the 1.B.2.b.6 Other subcategory as a result of updating the activity data regarding the consumption of natural gas at industrial plants and power stations.

<u>Industrial Processes and Product Use</u>

➢ **Ammonia production (2.B.1)**

- Recalculations were made for the CO_2 emissions, for the period 1989-2022, following the update of the emission factors and NCVs values for natural gas.

- **Hydrogen production (2.B.10.a)**

- Recalculations have been made for the 1989-2002 period as a result of updating activity data on the quantity of natural gas used as fuel.

- **Solvent use (2.D.3.a)**

- Recalculations have been made for the period 1990-2022. Recalculations of CO_2 emissions have been made as a result of the recalculation of NMVOC emissions, to ensure the consistency of the data used to estimate emissions in preparation of the greenhouse gas inventories with the data used to prepare inventories of air pollutants pursuant to the Directive (EU) 2284/2016.

- **Petroleum coke (2.D.3.d)**

- Recalculations were made for the CO_2 emissions, for the period 1989-2007, following the update of the NCVs values.

- **Fire protection (2.F.3)**

- Recalculations have been made for the 1999-2022 period as a result of updating activity data on the total quantity of agent in fire protection equipments for the years 1999, 2000, 2002 and 2006.

- **Other - Oxidising agent used in atomic absorption spectrometry (2.G.3.b.ii)**

- Recalculations were made for 2017 due to an error when importing the excel table into the ETF GHG Inventory Reporting Tool application.

<u>**Agriculture**</u>

- **Enteric fermentation (3.A)-CH_4**

- The CH_4 emissions were recalculated for the 2022 year for swine due to calculation errors.

- **Manure management (3.B)-N_2O**

Direct emissions

- The N_2O emissions were recalculated for the 1989-2022 years due to N_2O emissions were estimated for rabbits.

- **Rice cultivation (3.C)-CH_4**

- The CH_4 emissions were recalculated for the 2022 year due to the area for rice has been updated.

<u>**Land use, land-use change and forestry**</u>

- **Harvested Wood Product (4.G)**

- The FAO database, used for activity data (AD), was queried for this year's submission, triggering some corrections to historical values and necessitating a recalculation of the E/R in the time series;
- On average, the differences in E/R across the time series between different submissions were 1.2%.

The highest discrepancies occurred in 2021 and 2022, due to the incorporation of new activity data (AD).

Waste

- **Solid waste disposal (5.A)**

- The CH_4 emissions associated to 5.A.1. Managed waste disposal sites have been recalculated for 2022 year taking into account the final data provided by NEPA (National Environmental Protection Agency);
- The CH_4 emissions associated to 5.A.1. Managed waste disposal sites were recalculated for 1995 year due to a transcription error.

- **Anaerobic digestion at biogas facilities (5.B)**

- The CH_4 and N_2O emissions associated to 5.B.1 Composting have been recalculated for 2022 year taking into account the final data provided by NEPA (National Environmental Protection Agency).

- **Incineration and open burning of waste (5.C)**

- The CH_4 and N_2O emissions were recalculated for 2021, 2022 years taking into account the final data provided by NEPA (National Environmental Protection Agency).

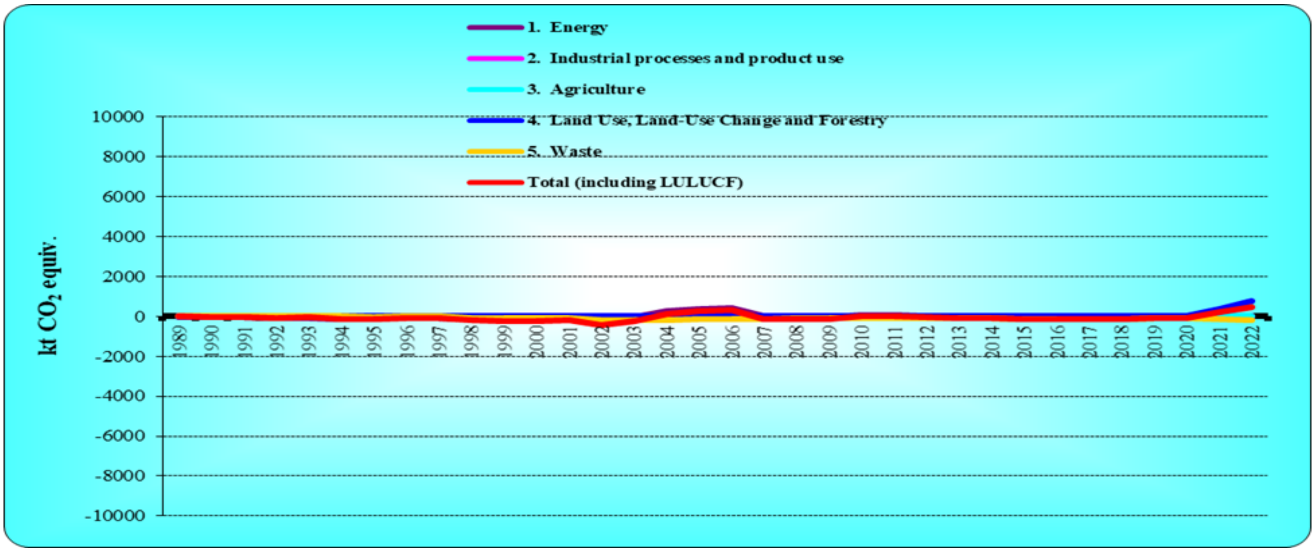
- **Wastewater Treatment and Discharge (5.D)**

- Recalculations have been performed for CH_4 and N_2O emissions from domestic and commercial wastewater, for 2022 year due to updated data regarding total population by NIS;
- Following the analysis in regard to the use of a higher tier method, recalculation have been performed for CH_4 emissions from industrial wastewater for 1998 -2022 years, since for this period more acurrate data from the operators are available.

The changes listed below have been made:

- after consulting the operators, resulted that pulp, paper and petroleum refinery uses aerobic treatment with well managed treatment plants, therefore MCF 0 was used according to 2006 IPCC Guidelines, Table 6.8;
- only beer industry was used in the industrial emissions estimation treated on site, since it uses anaerobic treatment.

Figure 10.1 Change in pollutant specific total emissions/removals, for all source/absorber categories, and for the entire time series, in comparison to the 2024 submission



Recalculations by gases

CO_2 recalculations were carried out in the following sectors:

- Fuel combustion – Sectoral Approach (CRT 1.A);
- Energy Industry sub–sector (CRT 1.A.1);
- Public Electricity and Heat Production (CRT 1.A.1.a);
- Petroleum Refining (CRT 1.A.1.b);
- Manufacture of Solid Fuels and Other Energy Industries (CRT 1.A.1.c);
- Manufacturing Industries and Construction (CRT 1.A.2);
- Iron and Steel (CRT 1.A.2.a);
- Non Ferrous Metals (CRT 1.A.2.b);
- Chemicals (CRT 1.A.2.c);
- Pulp, Paper and Print (CRT 1.A.2.d);
- Food Processing, Beverages and Tobacco (CRT 1.A.2.e);
- Non-Metallic Minerals (CRT 1.A.2.f);
- Other (CRT 1.A.2.g);
- Domestic aviation (CRT 1.A.3.a);
- Transport – Railways (CRT 1.A.3.c);
- Transport – Domestic Navigation (CRT 1.A.3.d);
- Transport – Other transportation (CRT 1.A.3.e);

- Other sectors (commercial/institutional, residential, agriculture/ forestry/ fisheries) (CRT 1.A.4);
- Other (Not specified elsewhere) (CRT 1.A.5);
- Fugitive emissions - Oil and Natural Gas – Oil - Other (CRT 1.B.2.a.6);
- Fugitive emissions - Oil and Natural Gas – Natural Gas - Transmission and storage (CRT 1.B.2.b.4);
- Ammonia production (CRT 2.B.1);
- Hydrogen production (CRT 2.B.10.a);
- Other – Solvent use (CRT 2.D.3.a);
- Other – Petroleum coke use (CRT 2.D.3.d);
- Harvested Wood Product (CRT 4.G);

CH_4/N_2O recalculations were carried out in the following sectors:

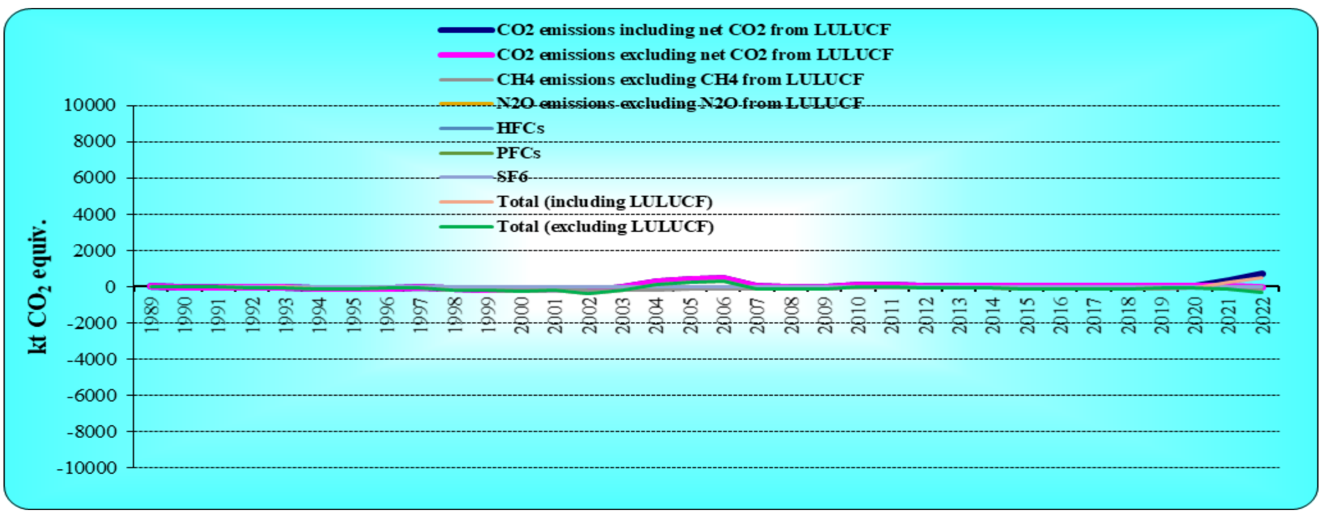
- Fuel combustion – Sectoral Approach (CRT 1.A);
- Energy Industry sub–sector (CRT 1.A.1);
- Public Electricity and Heat Production (CRT 1.A.1.a);
- Petroleum Refining (CRT 1.A.1.b);
- Manufacture of Solid Fuels and Other Energy Industries (CRT 1.A.1.c);
- Manufacturing Industries and Construction (CRT 1.A.2);
- Iron and Steel (CRT 1.A.2.a);
- Non Ferrous Metals (CRT 1.A.2.b);
- Chemicals (CRT 1.A.2.c);
- Pulp, Paper and Print (CRT 1.A.2.d);
- Food Processing, Beverages and Tobacco (CRT 1.A.2.e);
- Non–Metallic Minerals (CRT 1.A.2.f);
- Domestic aviation (CRT 1.A.3.a);
- Transport – Railways (CRT 1.A.3.c);
- Transport – Domestic Navigation (CRT 1.A.3.d);
- Other sectors (commercial/institutional, residential, agriculture/ forestry/ fisheries) (CRT 1.A.4);
- Other (Not specified elsewhere) (CRT 1.A.5);
- Fugitive emissions - Oil and Natural Gas – Natural Gas - Transmission and storage (CRT 1.B.2.b.4);
- Fugitive emissions - Oil and Natural Gas – Natural Gas - Other (CRT 1.B.2.b.6);
- Other - Oxidising agent used in atomic absorption spectrometry (CRT 2.G.3.b.ii);
- Enteric fermentation (CRT 3.A);
- Manure management (CRT 3.B);

- Rice cultivation (CRT 3.C);
- Solid waste disposal (CRT 5.A);
- Anaerobic digestion at biogas facilities (CRT 5.B);
- Incineration and open burning of waste (CRT 5.C);
- Wastewater Treatment and Discharge (CRT 5.D).

HFC/PFC/SF_6 recalculations were carried out in the following sectors:

- Fire protection (CRT 2.F.3).

Figure 10.2 Category total emissions/removals change, for all gases, and for the entire time series, in comparison to the figures in the 2024 submission

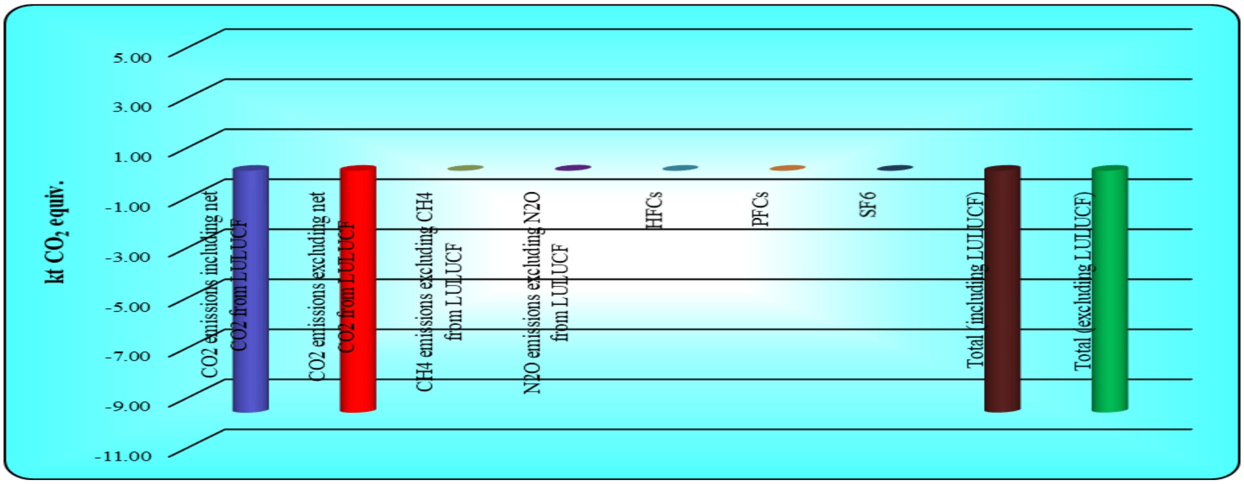


10.2 Implications for emission and removal levels

Emissions changes due to recalculations, for 1989, are as follows:

- CO_2 including LULUCF (-0.0052%), CO_2 excluding LULUCF (-0.0046%);
- CH_4 including and excluding LULUCF (-0.000001%);
- N_2O including and excluding LULUCF (0.00004%);
- HFC (0.00%);
- PFC (0.00%);
- SF_6 (0.00%);
- Total GHG including LULUCF (-0.003%);
- Total GHG excluding LULUCF (-0.003%).

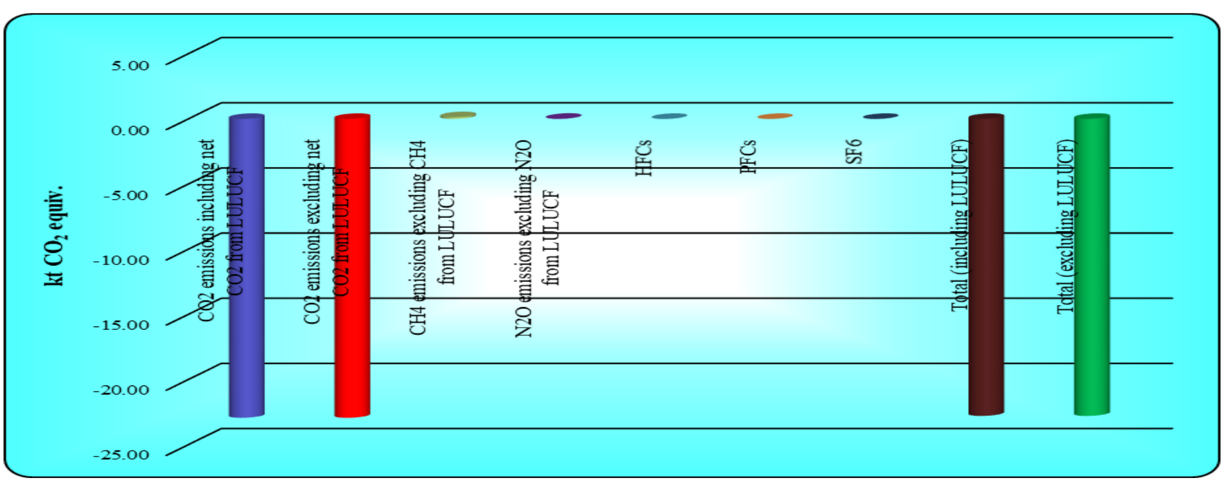
Figure 10.3 Effects of recalculations (presented in the 2025 submission) for 1989, by gas



Emissions changes due to recalculations, for 1990, are as follows:

- CO_2 including LULUCF (-0.02%), CO_2 excluding LULUCF (-0.01%);
- CH_4 including and excluding LULUCF (0.0002%);
- N_2O including and excluding LULUCF (0.0001%);
- HFC (0.00%);
- PFC (0.00%);
- SF_6 (0.00%);
- Total GHG including LULUCF (-0.01%);
- Total GHG excluding LULUCF (-0.01%).

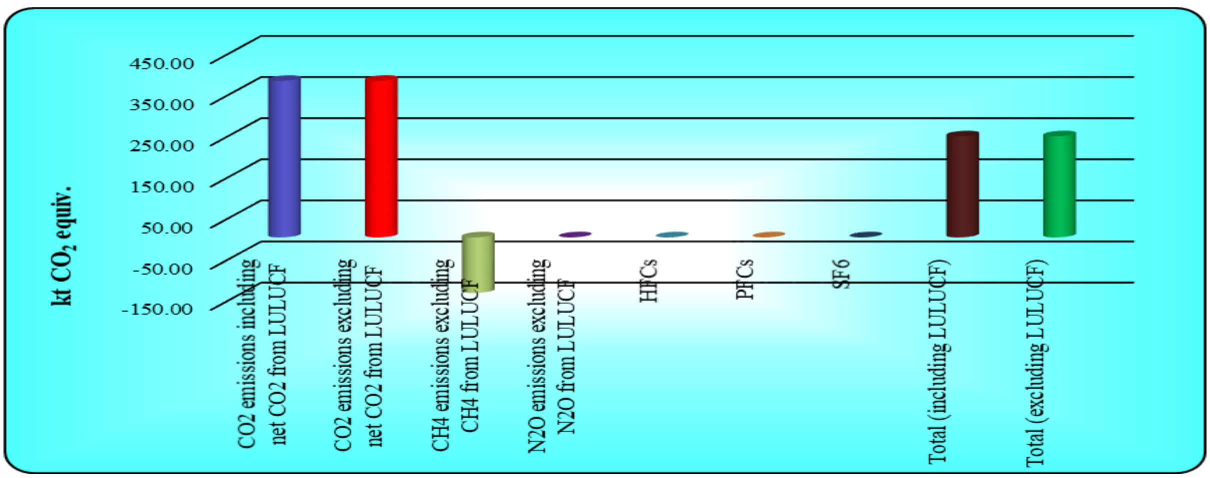
Figure 10.4 Effects of recalculations (presented in the 2025 submission) for 1990, by gas



Emissions changes due to recalculations, for 2005, are as follows:

- CO_2 including LULUCF (0.55%), CO_2 excluding LULUCF (0.38%);
- CH_4 including and excluding LULUCF (-0.367%);
- N_2O including and excluding LULUCF (0.0016%);
- HFC (0.0055%);
- PFC (0.00%);
- SF_6 (0.00%);
- Total GHG including LULUCF (0.21%);
- Total GHG excluding LULUCF (0.16%).

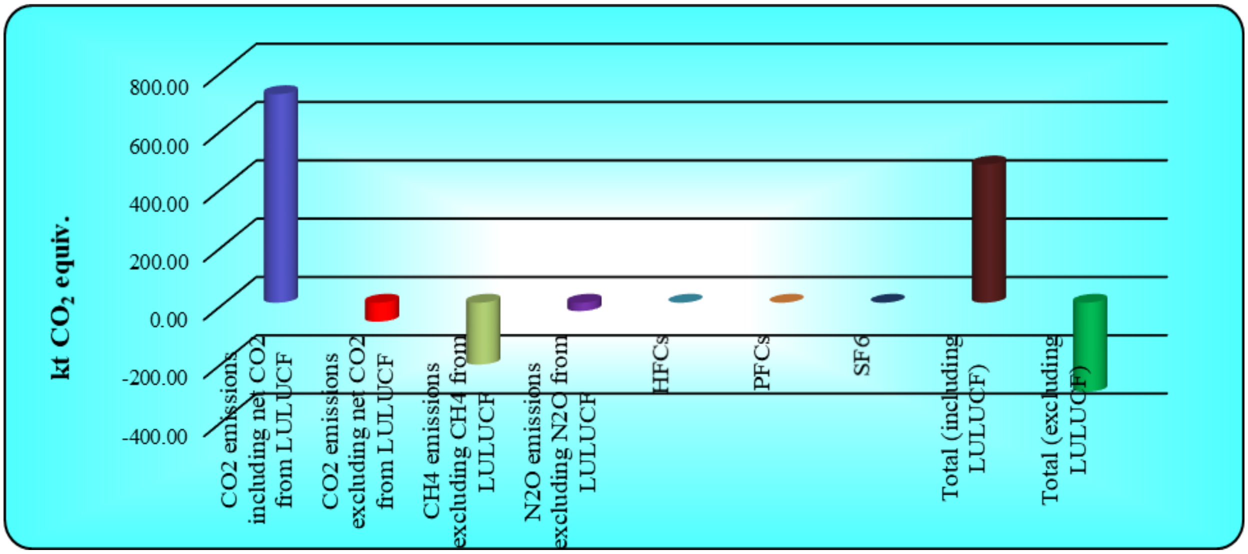
Figure 10.5 Effects of recalculations (presented in the 2025 submission) for 2005, by gas



Emissions changes due to recalculations, for 2022, are as follows:

- CO_2 including LULUCF (2.69%), CO_2 excluding LULUCF (-0.09%);
- CH_4 including and excluding LULUCF (-0.83%);
- N_2O including LULUCF (-0.308%), N_2O excluding LULUCF (-0.311%);
- HFC (0.001%);
- PFC (0.00%);
- SF_6 (0.00%);
- Total GHG including LULUCF (0.75%);
- Total GHG excluding LULUCF (-0.28%).

Figure 10.6 Effects of recalculations (presented in the 2025 submission) for 2022, by gas



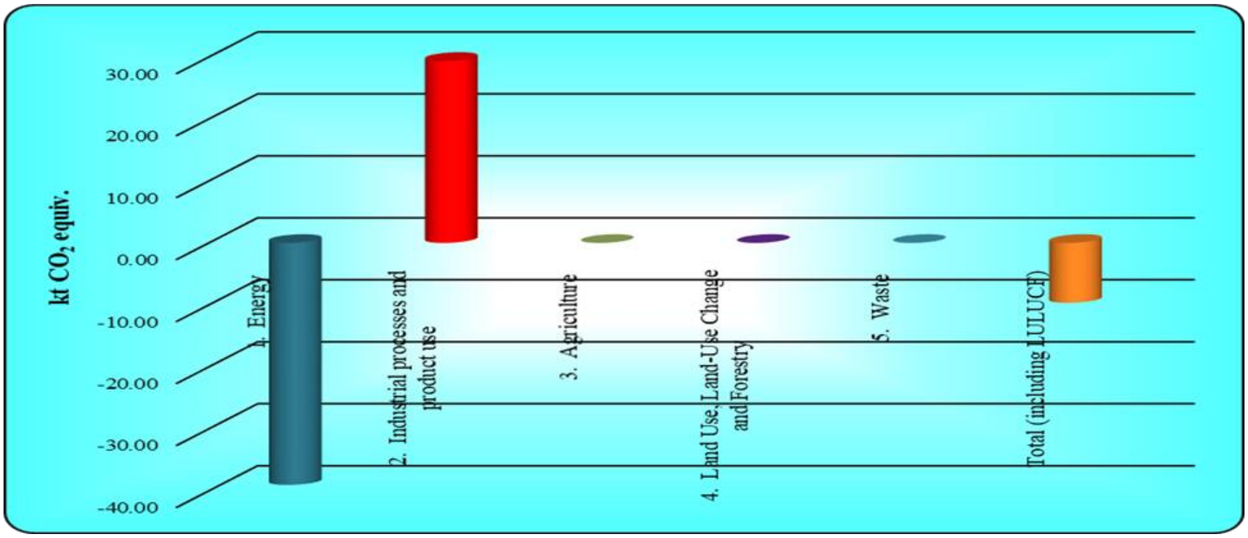
Impacts on 1989 emissions levels

Total emissions in 1989, including LULUCF have decreased by 0.003% compared to the 2024 submission.

Table 10.1 Recalculation of total emissions/removals, by sector, for all gases, for 1989

Differences for 1989 estimates	**Differences**		**2025**	**2024**
	kt CO_2 eq.	**%**	**kt CO_2 eq.**	**kt CO_2 eq.**
1. Energy	-39.04	-0.02	220,493.44	220,532.48
2. Industrial Processes and Product Use	29.37	0.07	45,024.30	44,994.93
3. Agriculture	0.01	0.00	38,316.17	38,316.16
4. Land Use, Land–Use Change and Forestry	0.00	0.00	-21,123.83	-21,123.83
5. Waste	0.00	0.00	5,730.05	5,730.05
Total (including LULUCF)	-9.66	-0.003	288,440.13	288,449.79

Figure 10.7 Changes of 1989 emissions/removals, in respect to the 2025 figures



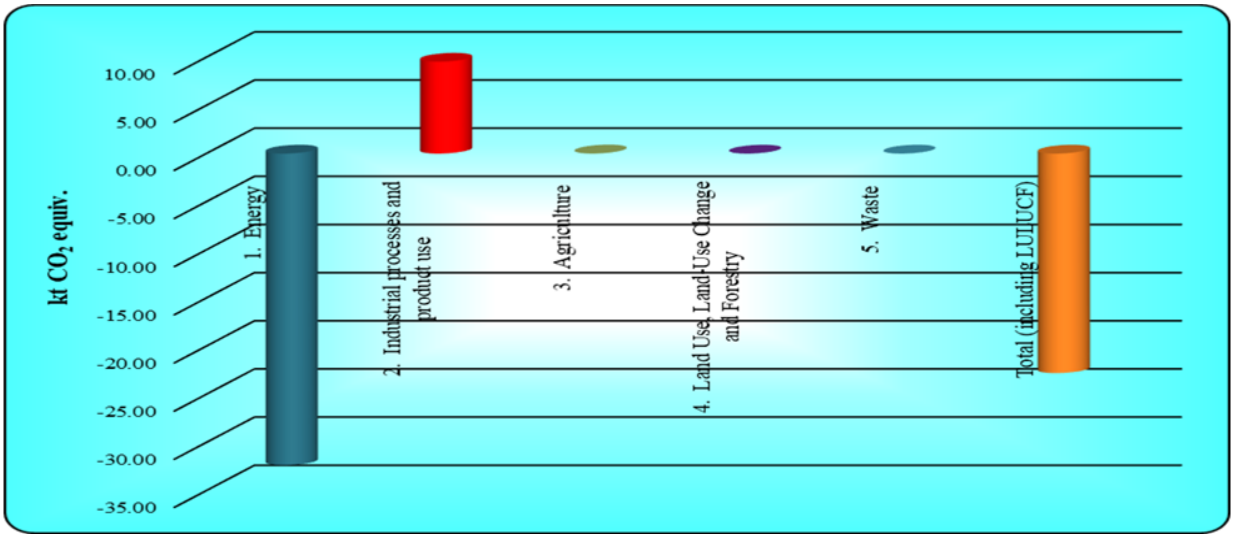
Impacts on 1990 emissions levels

Total emissions in 1990, including LULUCF have decreased by 0.01% compared to the 2024 submission.

Table 10.2 Recalculation of total emissions/removals, by sector, for all gases, for 1990

Differences for 1990 estimates	Differences		2025	2024
	kt CO_2 eq.	%	kt CO_2 eq.	kt CO_2 eq.
1. Energy	-32.34	-0.02	184,958.87	184,991.22
2. Industrial Processes and Product Use	9.54	0.03	31,917.52	31,907.98
3. Agriculture	0.01	0.00	34,124.55	34,124.54
4. Land Use, Land-Use Change and Forestry	0.00	0.00	-26,239.38	-26,239.38
5. Waste	0.00	0.00	5,635.91	5,635.91
Total (including LULUCF)	-22.79	-0.01	230,397.48	230,420.27

Figure 10.8 Changes of 1990 emissions/removals, in respect to the 2025 figures



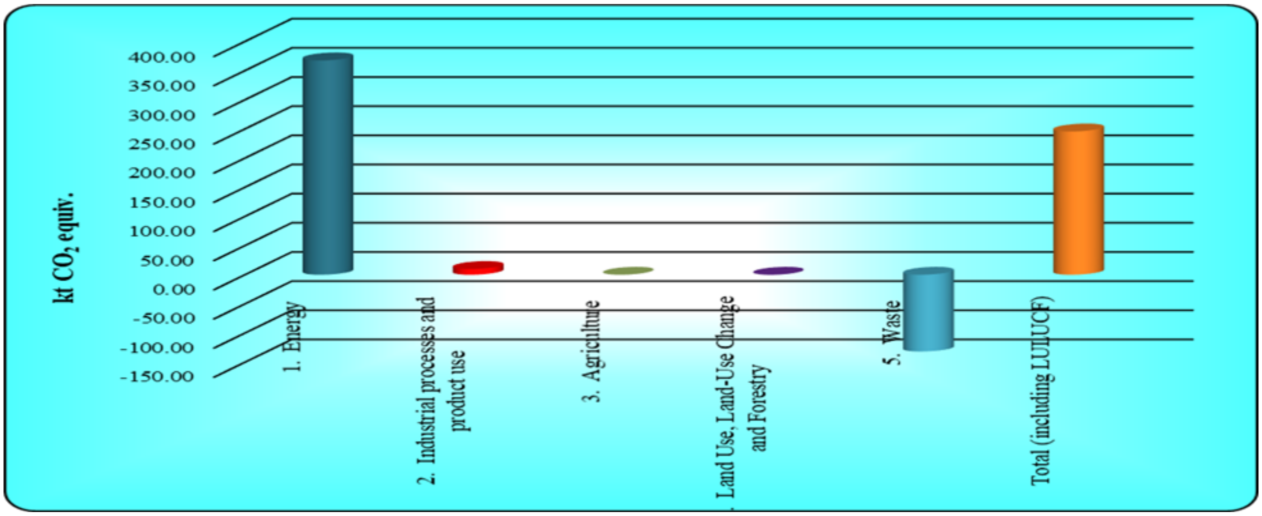
Impacts on 2005 emissions levels

Total emissions in 2005, including LULUCF have increased with 0.21% compared to the 2024 submission.

Table 10.3 Recalculation of total emissions/removals, by sector, for all gases, for 2005

Differences for 2005 estimates	Differences		2025	2024
	kt CO_2 eq.	%	kt CO_2 eq.	kt CO_2 eq.
1. Energy	367.54	0.36	101,413.61	101,046.07
2. Industrial Processes and Product Use	9.86	0.05	21,629.12	21,619.25
3. Agriculture	0.01	0.00	20,799.00	20,798.99
4. Land Use, Land-Use Change and Forestry	-0.13	0.00	-30,958.09	-30,957.96
5. Waste	-131.61	-1.97	6,534.10	6,665.71
Total (including LULUCF)	245.67	0.21	119,417.74	119,172.06

Figure 10.9 Changes of 2005 emissions/removals, in respect to the 2025 figures



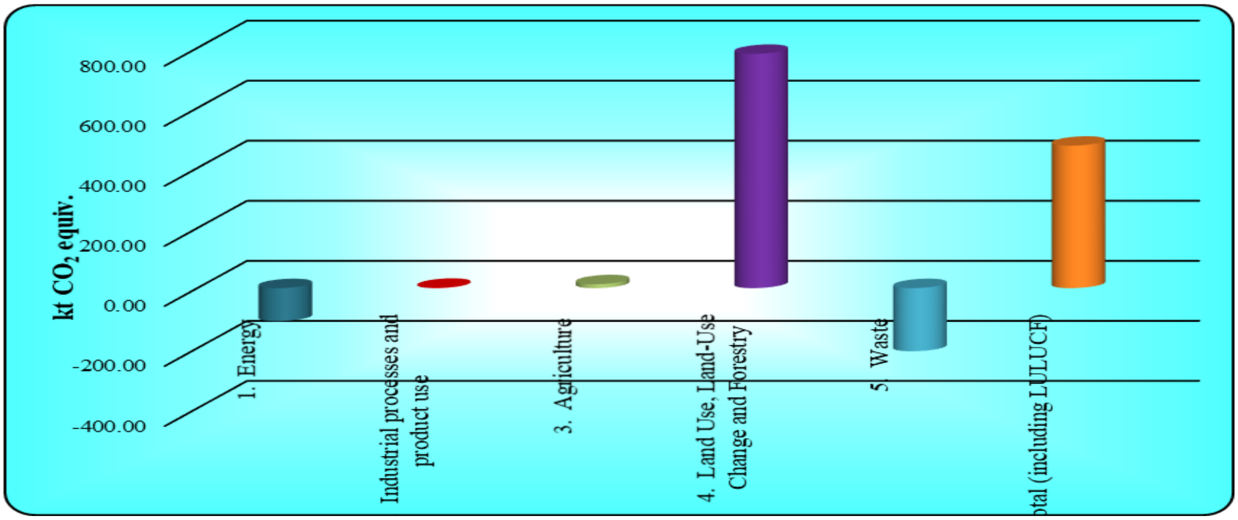
Impacts on 2022 emissions levels

Total emissions in 2022, including LULUCF have increased with 0.75% compared to the 2024 submission.

Table 10.4 Recalculation of total emissions/removals, by sector, for all gases, for 2022

Differences for 2022 estimates	Differences		2025	2024
	kt CO_2 eq.	%	kt CO_2 eq.	kt CO_2 eq.
1. Energy	-109.87	-0.15	74,945.33	75,055.20
2. Industrial Processes and Product Use	1.10	0.01	10,380.75	10,379.65
3. Agriculture	13.09	0.07	18,000.82	17,987.73
4.Land Use, Land-Use Change and Forestry	780.28	-1.68	-45,686.12	-46,466.40
5. Waste	-210.22	-3.21	6,340.35	6,550.57
Total (including LULUCF)	474.38	0.75	63,981.14	63,506.76

Figure 10.10 Changes of 2022 emissions/removals, in respect to the 2025 figures



10.3 Implications for emission and removal trends, including time-series consistency

The time-series consistency has been improved as a result of recalculations.

10.4 Areas of improvement and/or capacity-building in response to the review process

The elements on the areas of improvement as identified by Romania and, respectively, by the ERT, in the most recent review, are presented in the table below, in Annex V.17 and in the specific subsectoral sections in the NID.

Table 10.5 Summary of planned improvements GHG Inventory activities

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
Energy				
1.	Fuel combustion (CRT 1.A)	***Activity Data:*** The co-operation with Romanian authorities administrating the EU-ETS and National Institute for	Addressing	2027 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		Statistics will be maintained in order to have a fully correspondence concerning the definitions (fuel's calorific power) and quantities of the fuels, between the declarations of the operators under EU-ETS and, respectively, to NIS. A further analysis, in co-operation with the National Institute for Statistics, on the EU-ETS reporting will be conducted in order to take into consideration these emissions data, in the context of Tier 3 approach, on the activity category where these operators have to report. Annualy analysis on the EU-ETS reporting in comparison with Large Combustion Plants reporting, in order to check the concistency of the reported data, will be performed. For the current submission no necessary resources were available for these activities. ***Emission Factors:*** Following the same procedure used until now, based on EU-ETS operators reporting, the country-specific CO_2 emission factors will be calculated and included in the next inventory submission. In response of ERT recommendation, "Romania further investigate and elaborate on the non-energy use of fuels reported in the energy balance, which is not reported in the energy sector, and assess whether the country specific carbon storage factors are appropriate", Romania analysed the non-energy use of the fuels as activity data provided through the energy balances and used national values for net calorific power and country specific emission factors for the fuels reported under the EU-ETS.		

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
2.	Road transportation (CRT 1.A.3.b)	Further analyzing the issue of estimating CO_2 emissions from fossil carbon in biofuels separately, with the aim to update the approach used, as needed, as part of the next inventory submissions	Addressing	2028 inventory
3.	Road transportation (CRT 1.A.3.b)	Further analyzing the approach used to characterize the emissions from lubricants combusted in two-stroke engines in road vehicles, aiming to report them under the Road transportation Subsector	Addressing	2028 inventory
Industrial processes and product use				
1.	Non-energy products from fuels and solvent use (CRT 2.D)	Improve in the estimation of CO_2 emissions from lubricant use under 2.D.1 category by excluding the quantity of lubricants used in two-stroke engines from the total quantity of lubricants and reporting it in the energy sector. Improve in the estimation of CO_2 emissions from urea use in SCR systems under 2.D.3.	Addressing	2028 inventory
Agriculture				
1.	Source category Enteric Fermentation (CRT source category 3.A)	Aiming to their incorporation into next inventory submissions, the development of national values for the methane conversion rate (Y_m), for significant categories, is envisaged. The revision of digestible energy (DE%) values is foreseen.	Addressing	2027 inventory 2027 inventory
2.	Source category Manure Management (CRT source category 3.B)	Aiming to their incorporation into next inventory submissions, the development of national values for the following parameters, parameters relevant to significant species, are envisaged: - ash content of the manure (ASH);	Addressing	2027 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		- maximum CH_4 producing capacity for manure produced by an animal within defined population (B0); - CH_4 conversion factors for each manure management system by climate region (MCF); - percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NOx in the manure management system S, % (FracGasMS).		
3.	Source category Rice Cultivation (CRT source category 3.C)	In respect to the IPCC 2006 provisions, more detailed data on rice cultivation techniques used are proposed to be obtained.	Addressing	2027 inventory
4.	Source category Agricultural soils (CRT source category 3.D)	Aiming to their incorporation into next inventory submissions, the development of national values for the following parameters, parameters relevant to significant species, are envisaged: - national emission factors; - fraction that volatilizes as NH_3 and NO_x, specific to synthetic fertilizers nitrogen adjusted for volatilization ($Frac_{GASF}$); - fraction that volatilizes as NH_3 and NO_x, specific to animal manure nitrogen used as fertilizer, adjusted for volatilization ($Frac_{GASM}$); - national values for activity data in totality; - fraction of N input that is last through leaching and runoff ($Frac_{LEACH}$).	Addressing	2027 inventory
5.	Source category Field Burning of Agricultural Residues (CRT	Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality, for to significant species, is envisaged.	Addressing	2027 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
	source category 3.F)			
6.	Source category Liming (CRT source category 3.G)	Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality.	Addressing	2027 inventory
7.	Source category Urea application (CRT source category 3.H)	Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality.	Addressing	2027 inventory
Waste				
1.	Source category Waste water treatment and discharge (CRT sector 5.D)	Romania continued its analysis in regard to the use of a higher tier method in respect to CH_4 emissions from 5.D.2 Industrial wastewater by analising the questionaires provided by the operators. The results of the survey will need further consideration due to the data reported by the operators in relation with the amount of COD in wastewater; a part of the operators reported the activity data in terms of influent while others in terms of effluent. After further consultations the operators, they requested additional time to gather the data. If the effluent data are not available at the operators level, the plan is to assume a COD-removal factor (from the 2019-refinement) to estimate influent concentrations.	Addressing	2025 inventory
LULUCF				
1.	Forest Land (CRT sector 4.A)	Developing coherent and harmonized land identification across all land use and land-use change	Addressing	2027 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		categories, incorporating spatial information throughout the entire time series; Harmonizing national statistical data reported annually with National Forest Inventory (NFI) estimates throughout the entire time series.		
2.	Cropland (CRT sector 4.B)	- Estimation of the country specific emission factors for the soil carbon pool in organic soils; - Estimation of carbon stock in living biomass for CLperennial (orchards and vineyards); - Reestimation of SOC.	Addressing	2027 inventory
3.	Grassland (CRT sector 4.C)	- Estimation of the country specific emission factors for the soil carbon pool in organic soils; - Estimation of carbon stock in living biomass for GLgrassy; - Reestimation of SOC.	Addressing	2027 inventory
4.	Harvested Wood Products (HWP) (CRT sector 4.G)	Improve the AD data, more specific identify and improve data submitted by national authorities on FAO.	Addressing	2027 inventory

10.5 Areas of improvement and/or capacity-building related to the flexibility provisions applied with self-determined estimated time frames for improvements

Information on areas of improvement and/or capacity-building related to the flexibility provisions applied is not relevant, as flexibilities under the MPG's do not apply for Romania.

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