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LIST OF ABBREVIATIONS

AD	Activity Data
Ag	Arable
AGB	Above Ground Biomass
ANCPI	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
AR	Afforestation/Reforestation
AR 4	Fourth 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
CN	Combined Nomenclature
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
Coll	Collaboratores
CORINAIR	Coordination of Information on the Environment, sub-project: Air
CRF	Common Reporting Format
CS	Country Specific
CSC	Carbon Stock Change
CS EF_s	Country Specific Emission Factors
CWPB	Centre Worked Pre-baked
DDLVRC	Directorate on Driving Licenses and Vehicles Registration Certificates
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
EU	European Union
EUROSTAT	Statistical Office of the European Communities
ERT	Expert Review Team
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
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 1996 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
MADR	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
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}	Available for 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
NIM	National Institute of Meteorology
NIR	National Inventory Report
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
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
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
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

ES EXECUTIVE SUMMARY

ES.1. Background information on greenhouse gas (GHG) inventories and climate change and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

ES.1.1 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. 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.

ES.1.2 Background information on greenhouse gas inventories

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), and its Kyoto Protocol, Romania is required to elaborate, regularly update and submit the National GHG Inventory. In compliance with the reporting requirements, this is the 31th version of the National Inventory Report (NIR) submitted by Romania, covering the national inventories of GHG emissions/ removals for the period 1989-2020. This inventory (comprising the current National Inventory Report and the associated CRF tables) represents the 2022 National Greenhouse Gas Inventory of Romania under the UNFCCC and the Kyoto Protocol. This report documents Romania’s National Inventory 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 NIR also comprises a full quantitative assessment of the uncertainty; the uncertainty analysis is presented both on the sub-sectorial level and in the Annex 2.

ES.1.3 Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Considering the provisions in Decision 15/CMP. 1, the report specifies the information required under Article 7.1 of the Kyoto Protocol; Romania is reporting also elements on Afforestation, Reforestation, Deforestation, Forest Management and Revegetation activities (KP Art. 3 paragraphs 3 and 4 activities), within the current NGHGI; the reporting considers the elements that are available in accordance with the current functioning status of the CRF Reporter application.

ES.2 Summary of national emission and removal-related trends and emission and removals from KP-LULUCF activities

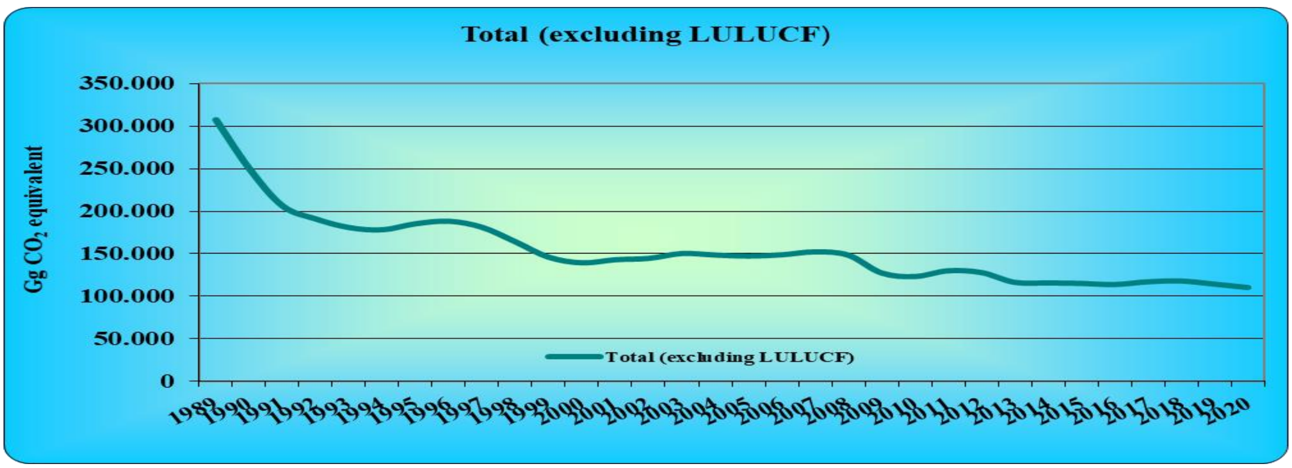
ES.2.1 GHG inventory

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 Forth Assessment Report (the GWP values are presented in the Annex 6.1 of the NIR). 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. 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 2020, and the average share of each direct GHG in total emissions for 1989-2020 period are presented in the Table ES.1. The total GHG emissions excluding LULUCF, in CO_2 equivalent, during 1989-2020 period, are presented in the Figure ES.1.

Table ES.1 Share of each direct GHG in total emissions in 1989, 2020, respectively 1989-2020 period

GHG	1989 (%)	2020 (%)	Average share for 1989-2020 period (%)
CO_2	68.71%	67.44%	68.20%
CH_4	21.33%	20.70%	21.85%
N_2O	8.51%	9.97%	8.84%
HFCs	0.00%	0.02%	0.55%
PFCs	1.45%	0.00%	0.53%
SF_6	0.00%	0.00074%	0.02%
NF_3	0.00%	0.00%	0.00%

Figure ES.1 The total GHG emissions in CO_2 equivalent during 1989-2020 period



ES.2.2 KP-LULUCF activities

The data relevant to the KP LULUCF activities are presented within the Chapter 11.

ES.3 Overview of source and sink category emissions estimates and trends, including KP-LULUCF activities

ES.3.1 GHG inventory

The present NGHGI for 1989–2020 was compiled according to the recommendations for GHG inventories set out in the Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories (FCCC/CP/2013/10/Add. 3) and in the Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol, 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 CRF Reporter software, delivered by the UNFCCC Secretariat. This version of NIR refers to figures in CRF table's generated using CRF Reporter version 6.0.8.

ES.3.2 KP LULUCF activities

The data relevant to the KP LULUCF activities are presented within the Chapter 11.

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.

PART 1 ANNUAL INVENTORY SUBMISSION

1 INTRODUCTION

1.1 Background information on GHG inventories and climate change and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

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 2020 year, the forest land area accounted for approximately 6,986 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 its Kyoto Protocol, Romania is required to produce and regularly update the national GHG inventory. According to the COP decision regarding Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories (FCCC/CP/2013/10/Add. 3), Parties shall submit a National Inventory Report (NIR) containing detailed and complete information on their inventories, in order to ensure the transparency of the inventory. This is the 30th complete submission of the National

GHG Inventory of Romania. The structure of the National Inventory Report is in line with the provisions in the Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories (FCCC/CP/2013/10/Add. 3) and in the Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol, document provided by the UNFCCC Secretariat. This inventory (comprising the current National Inventory Report and the associated CRF tables) represents the 2022 National Greenhouse Gas Inventory of Romania under the UNFCCC and the Kyoto Protocol. For this submission, Romania prepared the CRF tables and the database containing emissions/removals estimates and background data for 1989-2020 period and the National Inventory Report. 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 (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 and Article 8 of the KP as presented in Table 1.1.

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

Year	Submission	Review process
2002	CRF tables and draft NIR submitted (late submission)	No Review
2003	CRF tables and NIR submitted	In-Country Review
2004	CRF tables and NIR submitted	Desk Review
2005	CRF Reporter database, CRFs for LULUCF and NIR submitted	Centralized Review
2007	2nd version of the 2006 submission: CRF Reporter database, CRF Tables and NIR + Initial Report of Romania under the Kyoto Protocol	In-Country Review
2008	2007 and 2008 submissions: CRF Reporter database, CRF Tables and NIR	Centralized Review
2009	2009 submission: CRF Reporter database, CRF Tables and NIR	Centralized Review
2010	2010 submission: CRF Reporter database, CRF Tables and NIR	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

Year	Submission	Review process
2016	2nd version of the 2015 and 2016 submission	Centralized Review
2018	2018 submission	In-Country Review
2020	2020 submission	Centralized Review

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

1.1.3 Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

The present NIR includes supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol as follows:

- ❖ information on anthropogenic greenhouse gas emissions by sources and removals by sinks from LULUCF activities under KP's Article 3, paragraphs 3 and 4, in accordance with the provisions in Section I.D of the Annex to Decision 15-CMP. 1; the information is subject to the current functioning status of the CRF Reporter application;
- ❖ information on Kyoto units (emission reduction units (ERUs), certified emission reductions (CERs), temporary certified emission reductions (tCERs), long-term certified emission reductions (lCERs), assigned amount units (AAUs) and removal units (RMUs)), as set out in Section I.E of the Annex to Decision 15/CMP. 1;
- ❖ changes in national systems in accordance with Article 5, paragraph 1, of the Kyoto Protocol, as set out in Section I.F of the Annex to Decision 15/CMP. 1;
- ❖ changes in national registries as set out in Section I.G of the Annex to Decision 15/CMP.1;
- ❖ minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol, as set out in Section I.H of the Annex to Decision 15/CMP. 1.

1.2 A description of the national inventory arrangements and national system

1.2.1 Institutional, legal and procedural arrangements and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

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. 590/2019 for defining the obligations on the administration of the LULUCF subdomain, part of the Climate change domain, and the subsequent ministerial order 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 Greenhouse Gas Inventory (NGHGI) information, including supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol. The National Inventory Arrangements (NIA) and the National System 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 on Article 5 of the Kyoto Protocol, and complies with the provisions of the subsequent decisions of the CMPs of the Kyoto Protocol, with the provisions of 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 and of the Commission Implementing Regulation (EU) no. 749/2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) no. 525/2013 of the European Parliament and of the Council. 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), the Kyoto Protocol and the European Union legislation. Starting with 1 April 2013, the competent authority, which was responsible for administrating the National Inventory Arrangements and National System, 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 NS/NGHGI administration. Starting with 4 July 2016, the competent authority, which is responsible for administrating the National Inventory Arrangements and National System, 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. Based on the Governmental Decision no. 590/2019, beginning with August 2019, 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 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 Institute for Aerospace Research “Elie Carafoli” is 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 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 four 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. 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 system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol (NS) comprise:

- ❖ includes all institutional, legal and procedural arrangements made as a Party included in Annex I for stimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, 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 NGHGI;
- ❖ is 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 and/or COP/MOP;
- ❖ is designed and operated to ensure the quality of the NGHGI through planning, preparation and management of inventory activities;
- ❖ is designed and operated to support compliance with the Kyoto Protocol and with the European Union legislation commitments related to the estimation of anthropogenic GHG emissions by sources and removals by sink;
- ❖ is 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 COP/MOP.

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

A. *Establish and maintain the institutional, legal and procedural arrangements necessary to perform the functions for national systems, 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 NS and of preparation, for most of the sectors, 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 NGHGI 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 6.8 Table 3-rows 3 and 4;
  - in 2013, the studies mentioned in Annex 6.8 Table 2 rows 3 and 4;
  - in 2014, the study mentioned in Annex 6.8 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 6.8 Table 4-row 1;
- in 2013, of the study mentioned in Annex 6.8 Table 2-row 2;
- in 2014, of the studies mentioned in Annex 6.8 Table 1-rows 1, 2 and 3.

❖ based on the study mentioned in Annex 6.8 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 (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;

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

- ICSI 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;
- INCDS is monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;
- ICPA is monitoring and estimating/reporting the GHG emissions/removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- INCAS is monitoring the land use and land-use change in a spatial-explicit system, using aero photogrammetry and aerial surveillance technologies, at national level;
- NEPA 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;
- MEWF 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 four 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.

❖ 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:

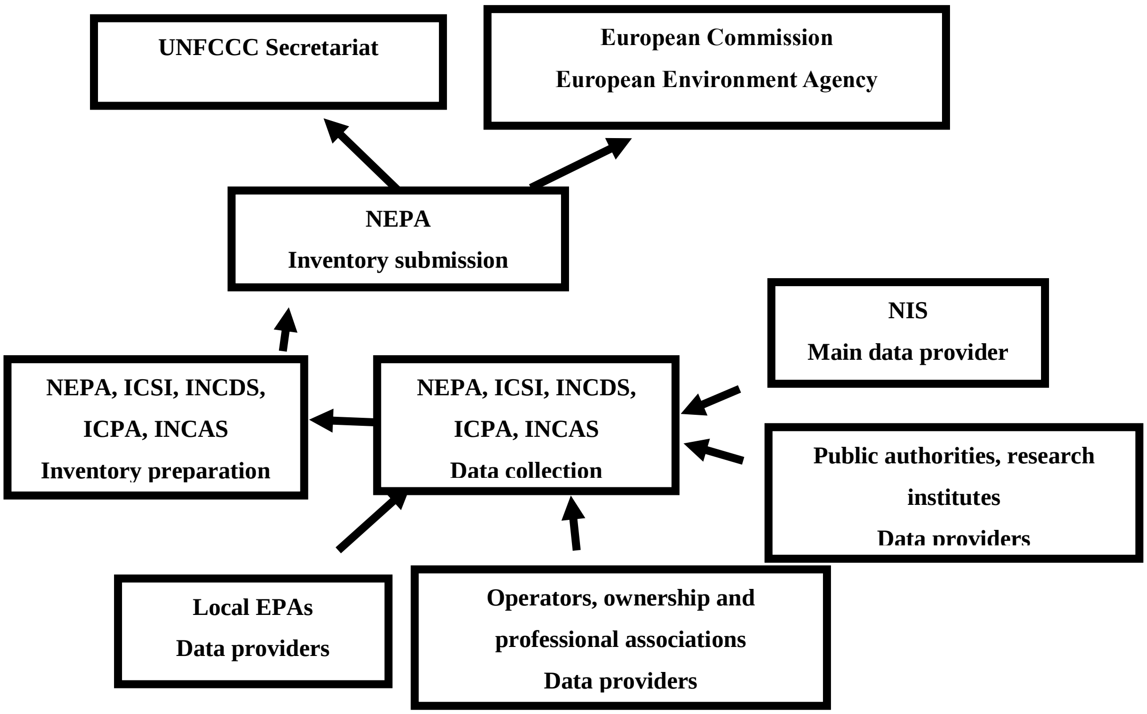
- ➢ package 1 activities – improving NS:
  - evaluation of NS and of the relevant technical assistance projects previously implemented;
  - establishing the measures necessary for improving the institutional capacity and structure for implementing the NS- the contractor identified the institutional, 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 GHGI; NEPA submits the National GHGI 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 NS include:

- ❖ GD no. 1022/2016 and 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 and the Commission Implementing Regulation (EU) no. 749/2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council;
- ❖ 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;
- ❖ 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. 590/2019 for defining the obligations on the administration 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;
- ❖ MoEO no. 872/2019 on establishing the eligible expenditures associated to the activities established through the Governmental Decision no. 590/2019 for defining the obligations on the administration of the LULUCF subdomain, part of the Climate change domain;
- ❖ 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 NS 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, 9 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 and NS/NGHGI;

- 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:
  - appropriate working space and facilities have been provided;
  - 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 (CRF Sector 4) according with the obligations under the United Nations Framework Convention on Climate Change and with the obligations under the Kyoto Protocol";

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

- ICSI 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;

- INCDS is monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category;
- ICPA is monitoring and estimating/reporting the GHG emissions/removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories;
- INCAS is monitoring the land use and land-use change in a spatial-explicit system, using aero photogrammetry and aerial surveillance technologies, at national level;
- NEPA 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;
- MEWF 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 four 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.

❖ 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 NS functions are obliged to ensure sufficient capacity for timely performance of NS 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 October 2011	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. Designate a single national entity with overall responsibility for the national inventory

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

D. Prepare national annual inventories and supplementary information in a timely manner in accordance with Article 5 and Article 7, paragraphs 1 and 2, and relevant decisions of the COP and/or COP/MOP

Specific elements comprise:

- ❖ as a Party to the UNFCCC, KP and as a Member State of the European Union, Romania annually submits the GHGI;
- ❖ 2022 submission of the NGHGI constitutes the 30th complete submission of the NGHGI of Romania;
- ❖ Romania submits the NGHGI 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 NGHGI is prepared in accordance with Article 5 and Article 7, paragraphs 1 and 2, of the KP, and with relevant decisions of the COP and/or COP/MOP. Beginning with 2010, Romania reports supplementary information required under Article 7, paragraph 1, of the KP within the NGHGI.

E. Provide information necessary to meet the reporting requirements defined in the guidelines under Article 7 in accordance with the relevant decisions of the COP and/or COP/MOP

Romania report information necessary to meet the reporting requirements defined in the guidelines under Article 7 in accordance with the relevant decisions of the COP and/or COP/MOP. Beginning with 2010, Romania reports supplementary information required under Article 7, paragraph 1, of the KP within the NGHGI:

- ❖ information on anthropogenic greenhouse gas emissions by sources and removals by sinks from LULUCF activities under KP's Article 3, paragraphs 3 and 4, in accordance with the provisions in Section I.D of the Annex to Decision 15-CMP. 1;
- ❖ information on Kyoto units (emission reduction units (ERUs), certified emission reductions (CERs), temporary certified emission reductions (tCERs), long-term certified emission reductions (lCERs), assigned amount units (AAUs) and removal units (RMUs)), as set out in Section I.E of the Annex to Decision 15/CMP. 1;
- ❖ changes in national systems in accordance with Article 5, paragraph 1, of the Kyoto Protocol, as set out in Section I.F of the Annex to Decision 15/CMP. 1;
- ❖ changes in national registries as set out in Section I.G of the Annex to Decision 15/CMP.1;
- ❖ minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol,

as set out in Section I.H of the Annex to Decision 15/CMP.

F. 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, KP and EU; their implementation is described below.

The elements on the implementation of NS 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 and NS, 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 and, respectively, in the GD no. 590/2019;
- every person part of NEPA team managing the NIA and NS/NGHGI 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 and NS/ NGHGI 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 NGHGI 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;
- ❖ NGHGI verification and evaluation is performed at ME level;
- ❖ NEPA personnel considers the observations and comments received, and as appropriate updates the NGHGI, 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, ICPA and INCAS participates as technical expert to represent Romania within the review of the LULUCF Sector of the inventory, both under UNFCCC and KP, and to provide additional elements and/or updated elements following the request of the Expert Review Team under the coordination of the UNFCCC Secretariat, together with NEPA representatives.

Elements relevant to the implementation of the NIA and NS 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 CRF Reporter application;
- ❖ results are presented in NIR, within:
  - ➢ Chapter 1, at general level;
  - ➢ Annex 1.
- ❖ in the context of CRF Reporter application use, the results of the key category analysis are presented in CRF table 7, for every year in the 1989-2020 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.

Further elements are presented in Section 1.5.

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

Specific elements comprise:

- emissions from KP Annex A 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 Annex A key categories due to:
  - NEPA's/MECC's work;
  - to the implementation of dedicated studies,
    - in 2011, the study mentioned in Annex 6.8 Table 4-row 1;
    - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1 and 2;
    - in 2014, the studies mentioned in Annex 6.8 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 and KP through the implementation of:
  - ICSI's, INCDS's, ICPA's and INCAS's work;
  - the studies:
    - in 2011, the study mentioned in Annex 6.8 Table 4-row 2;
    - in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3 and 4;
    - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 3 and 4;
    - in 2014, the study mentioned in Annex 6.8 Table 1-row 4.
  - the Protocol of collaboration no. 3029/MMP-RP/3.07.2012 between Ministry of Environment and Forests, NEPA and ICAS.
- CORINAIR methodology was applied in case of the NGHGI Solvent and Other Product Use Sector.

Further specific elements are presented in Sections 1.3 and 1.4.

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, ICPA and INCAS;
- 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 Annex A key categories, due to:
  - NEPA's/MEWF's work;
  - the implementation of dedicated studies:
    - in 2011, the study mentioned in Annex 6.8 Table 4-row 1;
    - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1 and 2;
    - in 2014, the studies mentioned in Annex 6.8 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 6.8 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, both under the UNFCCC and KP, through the implementation of:
  - o ICSI's, INCDS's, ICPA's and INCAS's work;
  - o the studies:
    - ▪ in 2011, the study mentioned in Annex 6.8 Table 4-row 2;
    - ▪ in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3 and 4;
    - ▪ in 2013, the studies mentioned in Annex 6.8 Table 2-rows 3 and 4;
    - ▪ in 2014, the study mentioned in Annex 6.8 Table 1-row 4.
  - o 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 1.4.

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 NGHGI 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 2020, both excluding and including the LULUCF;
- ❖ based on national (NIS, studies mentioned in Annex 6.8 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 NIR, in:
  - ➢ Uncertainties and time series consistency sub-sectorial sections;
  - ➢ in Annex 2.
- ❖ uncertainty analysis results are used for prioritize efforts for improving the quality of the NGHGI-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 COP/MOP

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:
  - o NEPA's/MEWF's work;
  - o on the studies implemented:
    - ▪ in 2011, the studies mentioned in Annex 6.8 Table 4-rows 1-2;
    - ▪ in 2012, the study mentioned in Annex 6.8 Table 3-row 3;
    - ▪ in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-4;
    - ▪ in 2014, the studies mentioned in Annex 6.8 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 (CRF Sector 4) according with the obligations under the United Nations Framework Convention on Climate Change and with the obligations under the Kyoto Protocol".
  - o 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 NIR in:
  - ➢ Source-specific recalculations, including changes made in response to the review process sub-sectorial sections, including the quantified impact;
  - ➢ Chapter 10 Recalculations.

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

Specific elements on the compilation of the national inventory include:

- ❖ NGHGI has been compiled based on Guidelines for the preparation of national communications by Parties included in Annex 1 to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories (FCCC/CP/2013/10/Add. 3; UNFCCC Reporting Guidelines);

- beginning with the 2010 submission, the NIR is compiled according to the recommendations for inventories set out in the Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol;
- all additional reporting elements under Article 7 paragraph 1 of the KP are reported, beginning with the 2010 submission.

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. 590/2019, ICSI and INCDS are implementing QA/QC and verification activities related to the LULUCF Sector related data and are documenting 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:
    - in 2011, the studies mentioned in Annex 6.8 Table 4-rows 1-2;
    - in 2012, the study mentioned in Annex 6.8 Table 3-row 3;
    - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-4;
    - in 2014, the studies mentioned in Annex 6.8 Table 1-rows 1-4.
  - documented within sectorial QC lists consistently used across the dedicated NIA and NS/NGHGI 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 and 2021, 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, 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 and KP;
- 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);

❖ NGHGI improvement plan is annually updated by the QA/QC coordinator based on the results of the previously mentioned checks; the NGHGI improvement plan is linked with the NGHGI preparation plan administered by the NGHGI coordinator;

❖ greater effort was applied to the implementation of sector-specific QC, QA and verification activities.

Further relevant information is presented under Section 1.2.3. Elements characterizing the implementation of the NIA and NS inventory management related functions are described below:

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

Elements specific to the archiving of NGHGI 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. 590/2019, ICSI, INCDS, ICPA and INCAS 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;

- ❖ both electronic and paper documentation, as far as needed to reconstruct and interpret inventory data and to describe the national inventory arrangements and national system and their functions, is archived;
- ❖ the archive is managed by NEPA, ICSI, INCDS, ICPA and INCAS; 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 1.3.2.

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 COP/MOP

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 COP/MOP. ICSI, INCDS, ICPA and INCAS participates as technical expert to represent Romania within the review of the LULUCF Sector of the inventory, both under UNFCCC and KP, and to provide additional elements and/or updated elements following the request of the 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, ICPA and INCAS participates as technical expert to represent Romania within the review of the LULUCF Sector of the inventory, both under UNFCCC and KP, and to provide additional elements and/or updated elements following the request of the Expert Review Team under the coordination of the UNFCCC Secretariat, together with NEPA representatives.

1.2.2 Overview of inventory planning, preparation and management including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

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 and NS, is NEPA; more detailed elements of inventory planning are included in Section 1.2.1. NEPA has also the obligation of the preparation and management of the GHGI; 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. 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 6.8 Table 2-row 2;
- in 2014, the studies mentioned in Annex 6.8 Table 1-rows 1-3.

Based on the implementation in 2013 of the study mentioned in Annex 6.8 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, beginning with August 2019, 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 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 Institute for Aerospace Research "Elie Carafoli" is 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 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 four 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.

1.2.3 Quality assurance, quality control and verification plan on GHG inventory and KP-LULUCF inventory

Romania established the QA/QC Procedure based on the UNFCCC and Kyoto Protocol's provisions related to the NGHGI, NIA and NS, 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. 590/2019, 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 NGHGI in line with the requirements of the IPCC 2006, Wetlands Supplement and KP Supplement and with the provisions of the Regulation no. 525/2013 of the European Parliament and of the Council and of the Commission Implementing Regulation (EU) no. 749/2014. 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 NGHGI 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 MECC 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 CRF Reporter 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 CRF Reporter level;
- ❖ checking the correctness and the completeness of the data transcription from the CRF Reporter level to the CRF tables level;
- ❖ checking the data used in the NIR against the CRF tables and calculation sheets;
- ❖ checking the correctness of applied methods descriptions, at the NIR's level;
- ❖ checking the references completeness at the NIR's level;
- ❖ checking the archiving of the CRF tables, NIR, CRF Reporter'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 6.8 Table 4-rows 1-2;
- in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3-4;
- in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-4;
- in 2014, the studies mentioned in Annex 6.8 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 NGHGI according to the Regulation no. 525/2013 of the European Parliament and of the Council and to the Commission Implementing Regulation (EU) no. 749/2014, 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 6.8 Table 4-row 1;
- ❖ in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-4;
- ❖ in 2014, the studies mentioned in Annex 6.8 Table 1-rows 1-4.

Additionally, in 2012, 2016, 2017, 2018, 2019 and 2020, 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, 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 and Kyoto Protocol and procedures defined in the relevant COP/MOP 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 no. 525/2013, Commission Implementing Regulation (EU) no. 749/2014 and 406/2009/EC 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 NGHGI 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;
- ❖ 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 6.8 Table 4-rows 1-2;
  - in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3-4;
  - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-4;
  - in 2014, the studies mentioned in Annex 6.8 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).

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

1.2.4 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 Chapter 13 of the NIR.

1.3 Inventory preparation, and data collection, processing and storage

1.3.1 GHG inventory and KP-LULUCF inventory

The present NIR was compiled according to the recommendations for inventories set out in the Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories (FCCC/CP/2013/10/Add. 3) and in the Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol and includes detailed information on the inventories for all years from the base year to the year 2020, 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 National System 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 and National System ensures the NGHGI quality in three phases:

- ❖ planning;
- ❖ preparation;
- ❖ management of the NGHGI preparation activities.

1.3.2 Data collection, processing and storage, including for KP-LULUCF inventory

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 Annex A key categories, due to:

- NEPA's/MEWF's work;
- the implementation of dedicated studies:
  - in 2011, the study mentioned in Annex 6.8 Table 4-row 1;
  - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-2;
  - in 2014, the studies mentioned in Annex 6.8 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, ICPA's and INCAS's work;
- the studies:
  - in 2011, the study mentioned in Annex 6.8 Table 4-row 2;
  - in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3-4;
  - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 3-4;
  - in 2014, the study mentioned in Annex 6.8 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 6.8 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, ICPA and INCAS. Also, the activities were carried out mostly at MEWF, ISPE, ICAS and Denkstat, as contractors of studies:

- in 2011, the studies mentioned in Annex 6.8 Table 4-rows 1-2;
- in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3-4;
- in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-4;
- in 2014, the studies mentioned in Annex 6.8 Table 1-rows 1-4.

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.

Data archive

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. 590/2019, ICSI, INCDS, ICPA and INCAS 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, ICPA and INCAS team manages and maintains the NGHGI database and the documentation of specific inventory information. According to the provisions in IPCC 2006, the NGHGI 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, ICPA and INCAS; 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 Kyoto Protocol 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 NGHGI data are archived as follows:

- ❖ electronically – all available documents;
- ❖ on paper – the documents used for the NGHGI 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.

1.4 Brief general description of methodologies and data sources used

1.4.1 GHG inventory

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 KP Annex A Sectors are estimated following the IPCC 2006. Emissions/removals from LULUCF Sector are estimated using IPCC 2006, Wetlands Supplement and KP Supplement. CORINAIR methodology was applied in case of the solvent use related categories in the NGHGI 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

Sector	Data sources
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)
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, ICPA’s and INCAS’s work and the implementation by ISPE, ICAS and Denkstat, of the studies:
  ➢ in 2011, the studies mentioned in Annex 6.8 Table 4-rows 1-2;
  ➢ in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3-4;
  ➢ in 2013, the studies mentioned in Annex 6.8 Table 2-rows 1-4;
  ➢ in 2014, the studies mentioned in Annex 6.8 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 6.8 Table 4-row 1;
  - in 2013, the study mentioned in Annex 6.8 Table 2-row 1;
  - in 2014, the studies mentioned in Annex 6.8 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, ICPA and INCAS work;
- the studies:
  - in 2011, the study mentioned in Annex 6.8 Table 4-row 2;
  - in 2012, the studies mentioned in Annex 6.8 Table 3-rows 3 and 4;
  - in 2013, the studies mentioned in Annex 6.8 Table 2-rows 3-4;
  - in 2014, the study mentioned in Annex 6.8 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 6.8 Table 3-row 2 and Table 4-row 4.

1.4.2 KP-LULUCF activities

The data relevant to the KP LULUCF activities are presented within the Chapter 11.

1.5 Brief description of key categories, including KP-LULUCF key categories

1.5.1 GHG inventory

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 CRF Reporter application. KCA was conducted for every year of the characterized period. The results of the key category analysis are presented:

- in NIR within:
  - Chapter 1, at general level;
  - Annex 1.
- in the context of CRF Reporter application use, the results of the key category analysis are presented in CRF table 7, for every year in the 1989-2020 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.

1.5.2 KP-LULUCF activities

The identification of the KP LULUCF key categories followed the procedure described within the Chapter 2 of the KP Supplement. The data/information relevant to the KP LULUCF activities is presented within the NIR as part of Annex 1 and Chapter 11.

1.6 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

1.6.1 GHG inventory

The present NIR 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 2020, both excluding and including the LULUCF sector; it is based on national (NIS, studies mentioned in Annex 6.8 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 2021 NGHGI and the Tier 1 method:

- the total NGHGI uncertainty for 2019 excluding LULUCF was 22.2%, while including LULUCF was 32%;
- the uncertainty introduced into the trend in total national emissions, for 2019, was 2% when considering excluding LULUCF criteria and 2.6%, including LULUCF;
- the total NGHGI uncertainty for 1989 excluding LULUCF was 13.6%, while including LULUCF was 15.1%.

Considering the 2022 NGHGI and the Tier 1 method:

- the total NGHGI uncertainty for 2020 excluding LULUCF was 21.5%, while including LULUCF was 32.7%;
- the uncertainty introduced into the trend in total national emissions, for 2020, was 1.9% when considering excluding LULUCF criteria and 2.1%, including LULUCF
- the total NGHGI uncertainty for 1989 excluding LULUCF was 14.6%, while including LULUCF was 15.9%.

Based on data and information associated with the 2022 NGHGI, 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 NIR both at the Uncertainties and time series consistency sub-sectorial sections and in Annex 2.

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

1.6.2 KP-LULUCF inventory

The data relevant to the KP LULUCF activities are presented within the Chapter 11.

1.7 General assessment of the completeness

1.7.1 GHG inventory

The inventory covers all sectors and all gases in the period 1989-2020 and is complete in terms of geographical coverage. Emissions are presented by sector, by sub-sector and by gas. All the sources/ sinks not estimated or included elsewhere and the relevant justifications are presented in the Annex 5.

1.7.2 KP-LULUCF

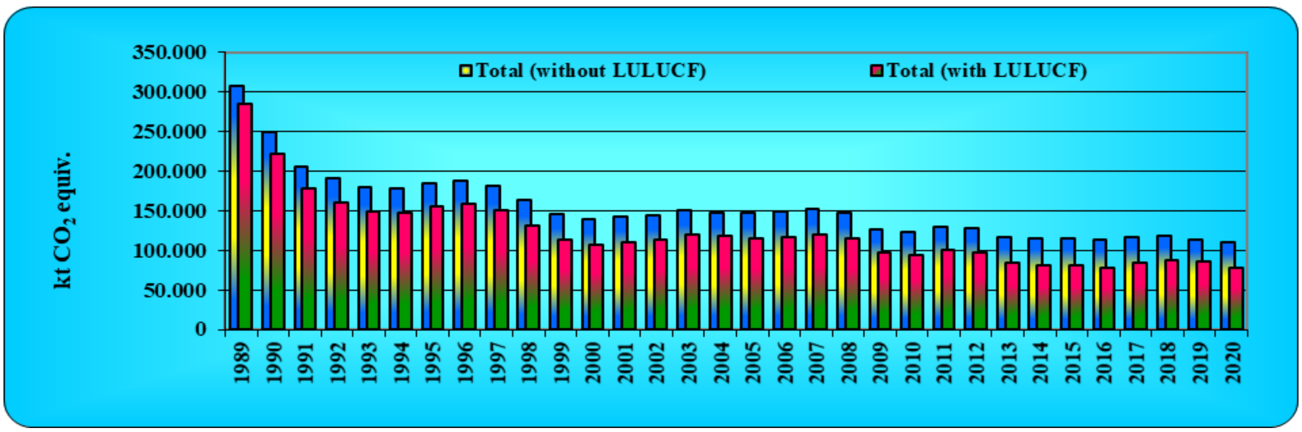
The data relevant to the KP LULUCF activities are presented within the Chapter 11.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Description and interpretation of emissions trends for aggregated GHG emissions

The total GHG emissions in 2020, excluding removals by sinks, amounted to 109,934.33 kt CO_2 equivalents. According to the provisions of the Kyoto Protocol, Romania has committed itself to reduce the GHG emissions by 8% in 2008-2012 considering the base year (1989) levels. The total GHGs emissions (without considering sinks) decreased by 64.20% in 2020 in comparison to 1989 while the net GHG emissions/ removals (taking into account the CO_2 removals) decreased by 73.02%.

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 slowly increased following the economic activities level. In 2020, excluding LULUCF, the largest contributing substance to the GHG emissions is CO_2 on average 68 per cent followed by CH_4 on average 20 per cent and N_2O on average 10 per cent. The remaining GHGs (HFCs, PFCs, SF_6, NF_3) contribute around 2 per cent.

2.1.1 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: 68.71% CO_2, 21.33% CH_4, 8.51% N_2O, 1.45% PFCs. In 2020, the shares of GHG emissions were: 67.44% CO_2, 20.70% CH_4, 9.97% N_2O, 0.0032% PFCs. The F gases started to be used as substitutes for ODS in refrigerating and air conditioning systems since 1991. In 2020, the contribution of these gases to the total GHG emissions is negligible: 1.81% HFCs and 0.07% 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	210,970.96	189,476.69	65,484.39	26,143.74	0.16	4,446.00	0.47
1990	173,463.87	145,777.19	52,034.32	21,389.26	0.18	2,808.43	0.47
1995	125,582.63	95,684.68	41,166.37	15,829.54	2.66	2,354.07	0.98
2000	92,668.30	61,238.25	31,792.48	12,763.16	72.16	1,674.72	8.68
2005	100,241.79	68,409.98	32,493.75	13,681.53	374.57	95.28	15.67
2010	84,632.65	56,374.04	26,120.06	11,037.99	1,002.11	9.13	60.69
2011	91,754.48	63,330.41	25,354.46	11,343.55	1,114.11	12.72	47.82
2012	90,239.25	59,339.00	25,507.58	10,510.42	1,221.82	7.43	50.75
2013	78,929.52	47,711.59	24,878.41	10,863.24	1,324.80	6.15	57.21
2014	78,453.48	44,364.40	24,640.17	10,740.18	1,400.94	6.34	51.78
2015	77,996.27	44,998.69	24,486.51	10,755.68	1,520.45	6.57	52.21
2016	77,011.53	42,076.43	23,927.86	10,785.07	1,676.68	5.44	49.80
2017	80,042.94	47,491.69	23,505.02	11,258.21	1,835.22	5.58	54.19
2018	80,516.21	50,773.11	23,080.16	12,039.82	1,894.33	4.97	61.98
2019	77,030.62	48,523.70	23,259.79	11,650.90	1,917.13	3.83	77.12

Year	CO_2 excluding LULUCF	CO_2 including LULUCF	CH_4 excluding LULUCF	N_2O excluding LULUCF	HFCs	PFCs	SF_6
2020	74,138.01	41,206.70	22,757.37	10,965.12	1,988.55	3.55	81.73

Carbon dioxide (CO_2) – the most significant anthropogenic greenhouse gas is the carbon dioxide. The decrease of CO_2 emissions (from 210,970.96 kt in 1989 to 74,138.01 kt in 2020) 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 2020 by 65.25% 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 2020 decreased by 58.06% in comparison with the level in the base year.

Fluorocarbons and SF_6 (HFCs, PFCs, SF_6) – Fluorocarbon emissions showed a strong decrease (99.92% in 2020 comparing with the level in 1989) for the PFCs emissions from the primary aluminium production and an increase for HFCs and SF_6 emissions.

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

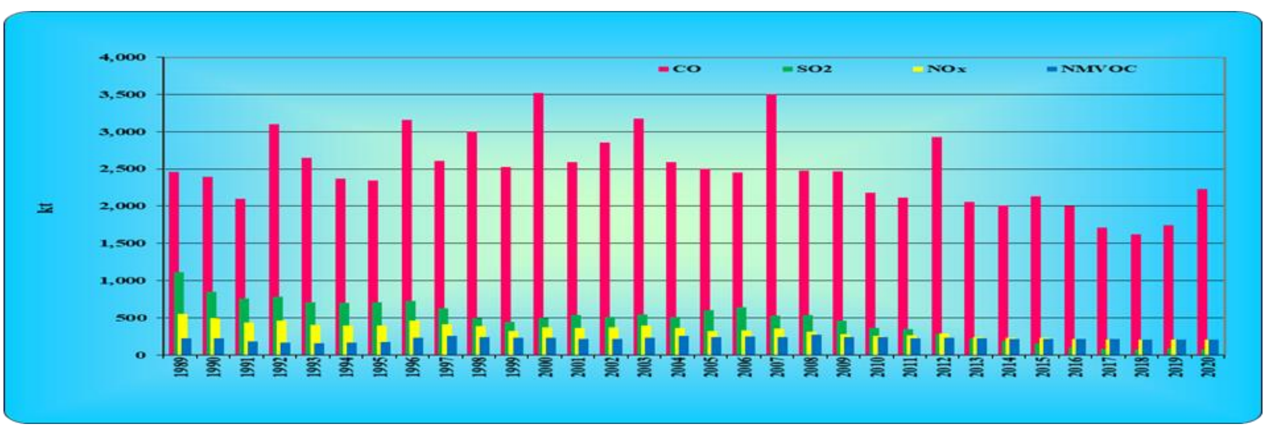
The trends of the indirect GHGs are similar with the GHGs trends (Table 2.2). The CO, NO_x, NMVOC and SO_2 emissions evolution follows the general direct GHG emissions trend. The SO_2 emissions decrease is caused by the decline of the fuels burnt for energy and the decrease of sulphur content in fuels. 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	556.66	2,457.77	225.24	1,111.08
1990	494.47	2,394.27	220.13	846.88

Year	NO_x	CO	NMVOC	SO_2
1995	395.99	2,341.79	173.02	708.67
2000	374.26	3,518.09	230.62	497.77
2005	325.12	2,501.59	241.13	602.10
2010	254.96	2,179.86	240.06	367.46
2011	261.92	2,116.12	226.21	346.91
2012	285.69	2,925.01	233.64	285.05
2013	237.95	2,055.98	221.44	221.16
2014	229.86	2,007.00	219.42	194.88
2015	229.26	2,128.00	216.08	158.49
2016	215.46	1,996.52	214.58	102.38
2017	209.54	1,709.63	215.82	85.93
2018	208.22	1,623.04	210.55	79.65
2019	206.47	1,742.21	211.25	96.22
2020	211.09	2,228.09	207.47	73.43

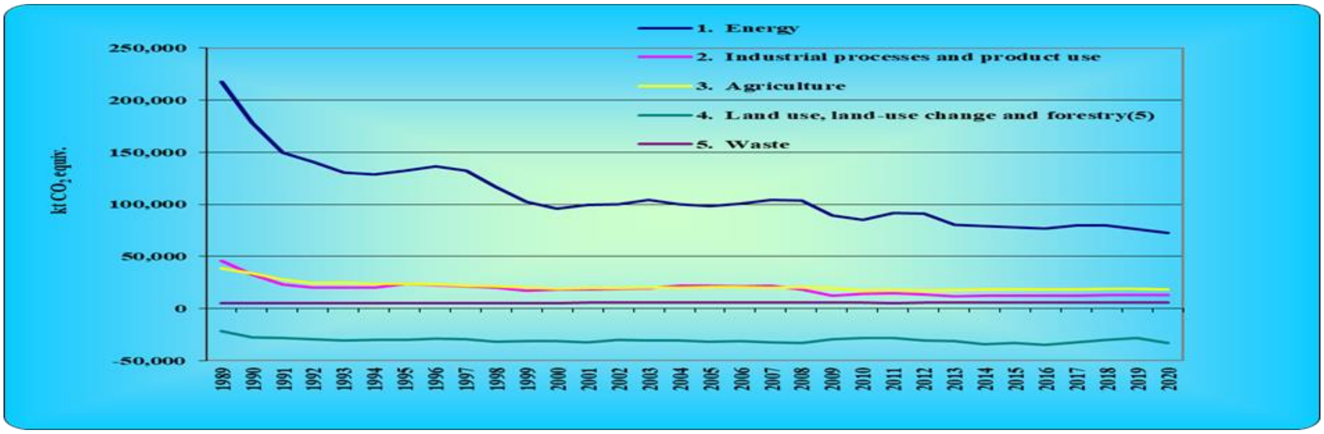
Figure 2.2 Indirect GHG emissions trends [kt]



2.2 Description and interpretation of emissions trends by sector

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 66.25% of the total national GHG emissions in 2020. The GHG emissions resulted from the Energy sector decreased by 66.50% compared with the base year.

Industrial processes and product use - contributes to total GHG emissions with 11.71% in 2020. 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 2020, mineral industry, metal industry and chemical industry have the highest share of GHG emissions of the Industrial Processes and Product Use sector, 36.67%, 29.87% and 13.13% respectively. Compared with 1989, GHG emissions from this sector in 2020 have decreased by 72.06%, mainly due to the decrease of the industrial production.

Agriculture - GHG emissions have also decreased. The GHG emissions in 2020 are 52.25% 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.

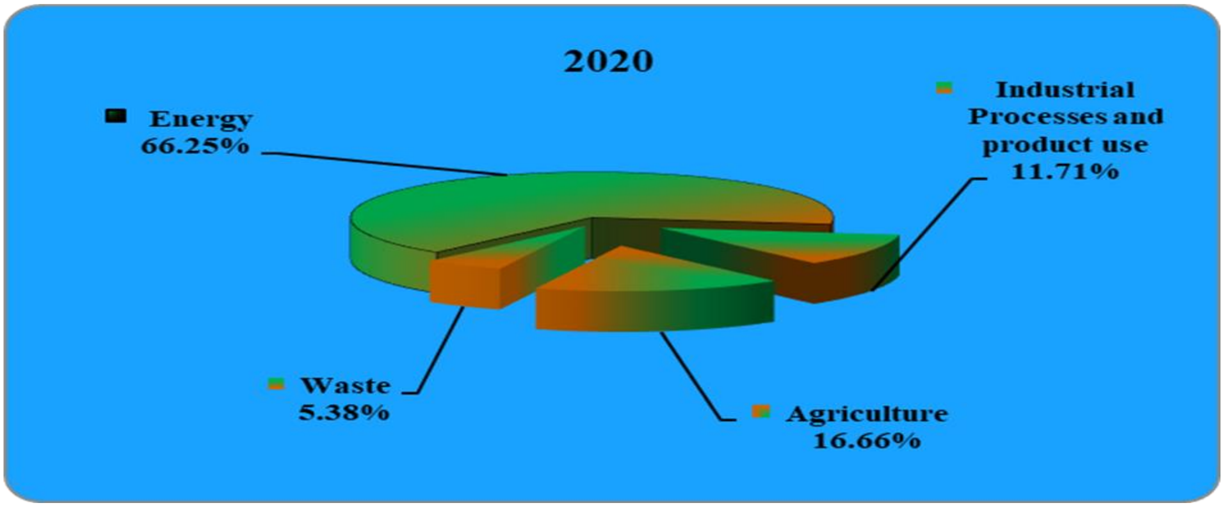
In 2020 year, 16.66% of the total GHG emissions resulted from the agriculture sector.

LULUCF - The net GHG removals/emissions level is 53.31% higher in 2020 in comparison with the level in the base year.

Waste sector **-** emissions have increased in 2020 with 13.82% in comparison with the level in 1989. The contribution of the waste sector to the total GHG emissions in 2020 is 5.38%.

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

Figure 2.4 Sectorial GHG emissions in 2020 [%]



2.2.1 Description and interpretation of emissions trends for KP-LULUCF inventory in aggregate and by activity, and by gas

The data relevant to the KP LULUCF activities are presented within the Chapter 11.

3 ENERGY (CRF Sector 1)

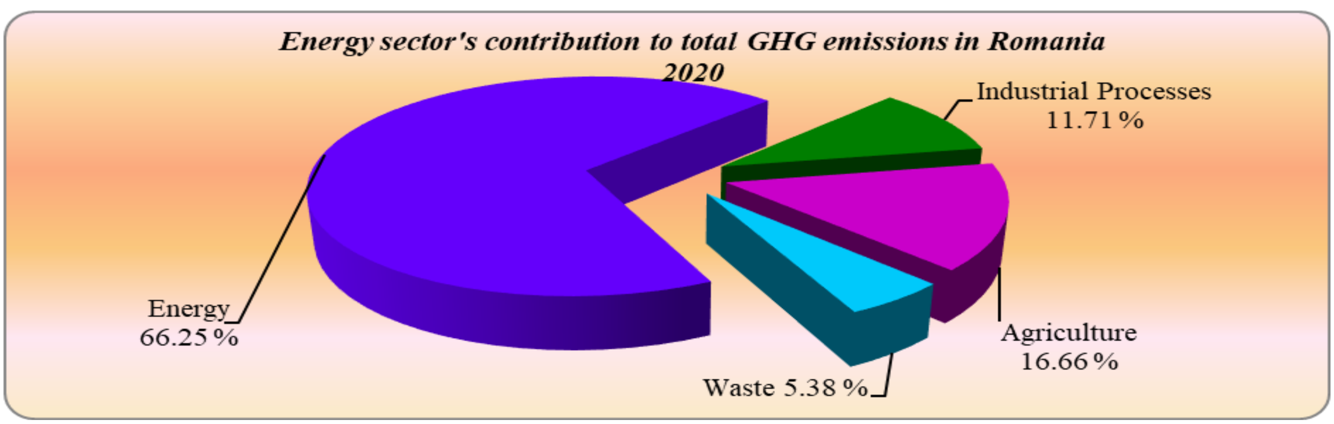
3.1 Overview of the sector

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, Agriculture, LULUCF, Waste), the Energy sector represents the largest source of anthropogenic GHG emissions in Romania. . In 2020, the Energy sector was responsible for about 66.25% of the total GHG emissions 109,934.33 kt CO_2 equivalent.

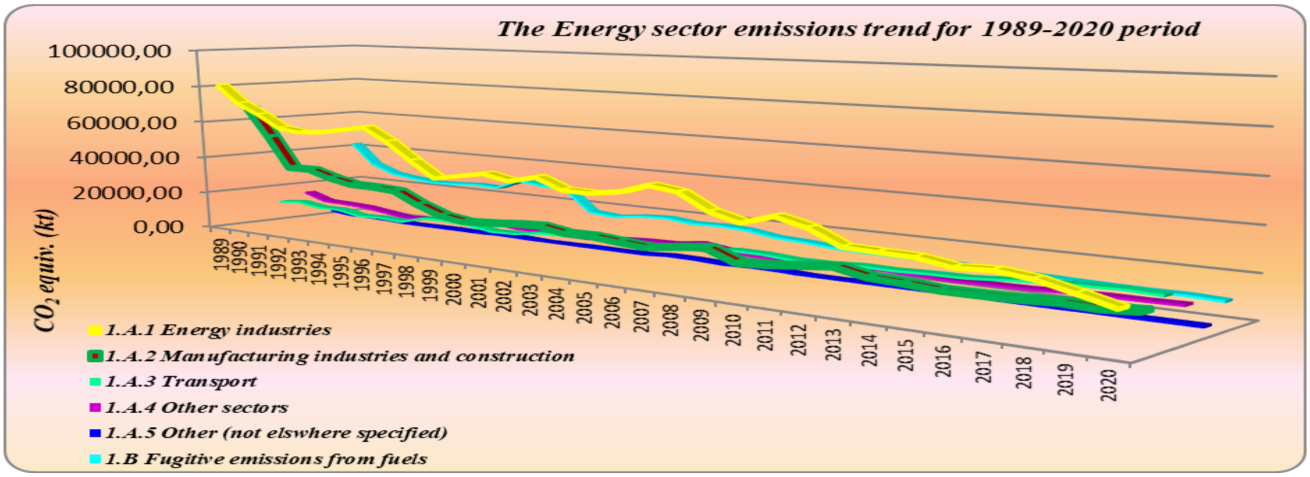
Figure 3.1 The contribution of Energy Sector to the total GHG emissions in Romania, 2020



Emission trends

In 2020, emissions from the Energy sector have decreased by 66.50% (72,834.34 kt CO_2 equivalent compared to 217,441.87 kt CO_2 equivalent in 1989, base year).

Figure 3.2 The energy sector emission trend for the period 1989-2020



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 2020, emissions from the Energy sector have decreased by 59.12% (72,834.34 kt CO_2 equivalent) compared to 1990 (178,146.01 kt CO_2 equivalent). In 2020, emissions from the Energy sector have decreased by 4.61% (72,834.34 kt CO_2 equivalent) compared to 2019 (76,350.44 kt CO_2 equivalent). According to the Energy Balance, the primary energy resources in 2020 were 22,351 thousand toe, decreased to 2,184 thousand toe in comparison with 2019, mainly due to the decrease in the production of usable natural gas (-883 thousand toe), hydroelectric energy and coal (-15 thousand toe, respectively -1,336 thousand toe). The decreased significant share in total energy resources, representing in coal production (-34.0%) and usable natural gas production (-10.7%). On types of energy carriers in 2020, the gross domestic electricity consumption increased (+453 thousand toe) and electricity energy (+95 thousand toe), but that of coal (including coke) decreased by (-1,419 thousand toe) and crude oil and petroleum products (-116 thousand toe), respectively, compared to the previous year. Final energy consumption in 2020 decreased by 362 thousand toe (- 1.5%) compared to 2019, this decreased in almost all types of economic activities, except construction (+ 10%) compared to the previous year. The energy consumption of the population increased compared to the previous year, both quantitatively (+256 thousand toe, representing 3.3%) and as a share of total final energy consumption (34.0% compared to 32.5% in 2019).

Table 3.1 Shares of GHG emission categories within the Energy sector, in 2020

Energy sector-categories	**Percentages for 2020**
Energy industries	25.18
Manufacturing Industries and Construction	20.30
Transports	25.26
Other sectors	16.58
Other	0.89
Fugitive emissions	11.79

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

Figure 3.3 The different GHG's contribution to the 2020 Energy sector

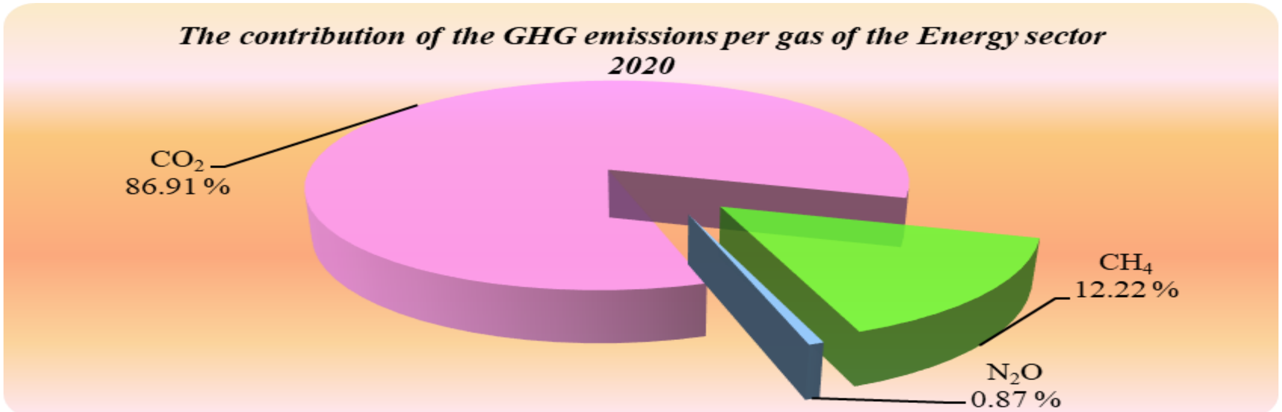


Table 3.2 Status of emissions estimation within the Energy Sector for 2020

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	✓	✓	✓
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	✓	✓	✓

IPCC category-Energy Sector	Emissions estimation status		
	CO_2	CH_4	N_2O
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
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	✓	✓

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

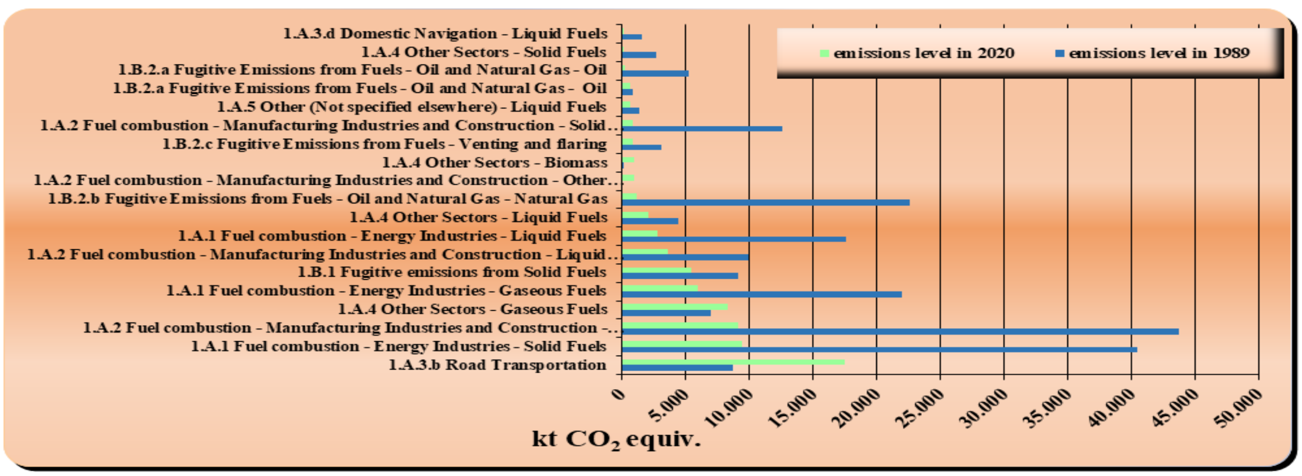
3.1.1 Key sources

Table 3.3 Key categories overview - Energy 2020

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	15.92%	T1, T2, T3
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	L, T	8.60%	T1, T2, T3
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	L, T	8.30%	T1, T2, T3
1.A.4 Other Sectors - Gaseous Fuels	CO_2	L, T	7.58%	T1, T2
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	L, T	5.44%	T1, T2, T3
1.B.1 Fugitive emissions from Solid Fuels	CH_4	L, T	4.97%	T1, T2
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	L, T	3.34%	T1, T2, T3
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	L, T	2.57%	T1, T2, T3
1.A.4 Other Sectors - Liquid Fuels	CO_2	L, T	1.93%	T1, T2
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	L, T	1.07%	T1
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	L, T	0.93%	T1, T2, T3
1.A.4 Other Sectors - Biomass	CH_4	L, T	0.90%	T1, T2
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	L	0.84%	T1
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	L, T	0.82%	T1, T2, T3
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CO_2	L	0.59%	T1, T2
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	L, T	0.58%	T1, T3

Key categories	GHG	Criteria (L and/or T)	Contribution in total GHG emissions [%]	Methodological tier used
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	T	0.21%	T1
1.A.4 Other Sectors - Solid Fuels	CO_2	T	0.20%	T1, T2
1.A.3.d Domestic Navigation - Liquid Fuels	CO_2	T	0.12%	T1, T2, T3
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CO_2	T	0.00%	T1, T2

Figure 3.4 Key categories, both by level and trend criteria, overview – Energy Sector, 2020



3.2 Fuel combustion (CRF 1.A)

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 3 and Annex 4. 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 CRF tables (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 3.5 Comparison of the sectorial approach with the reference approach

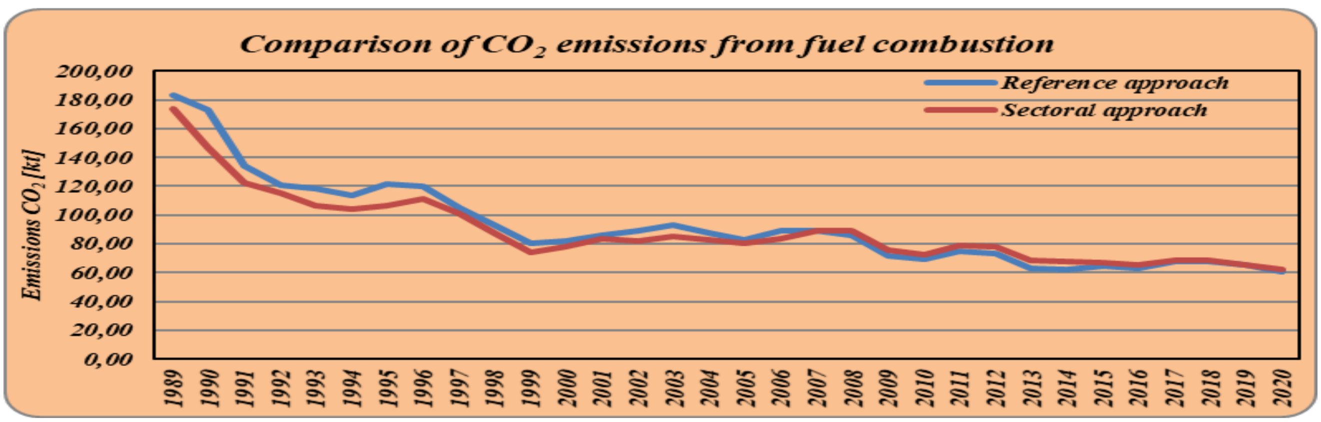


Figure 3.6 Comparison of the sectorial approach with the reference approach – liquid fuels

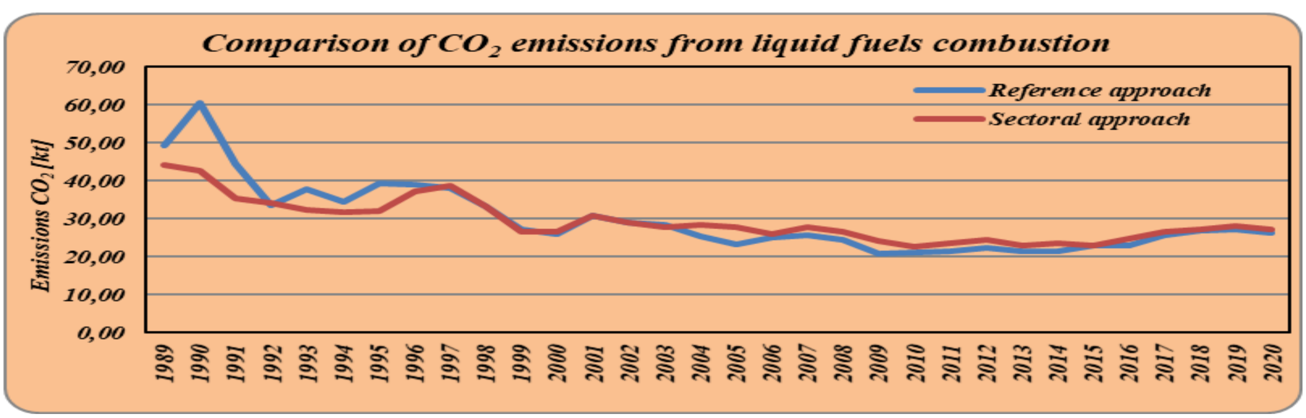


Figure 3.7 Comparison of the sectorial approach with the reference approach – solid fuels

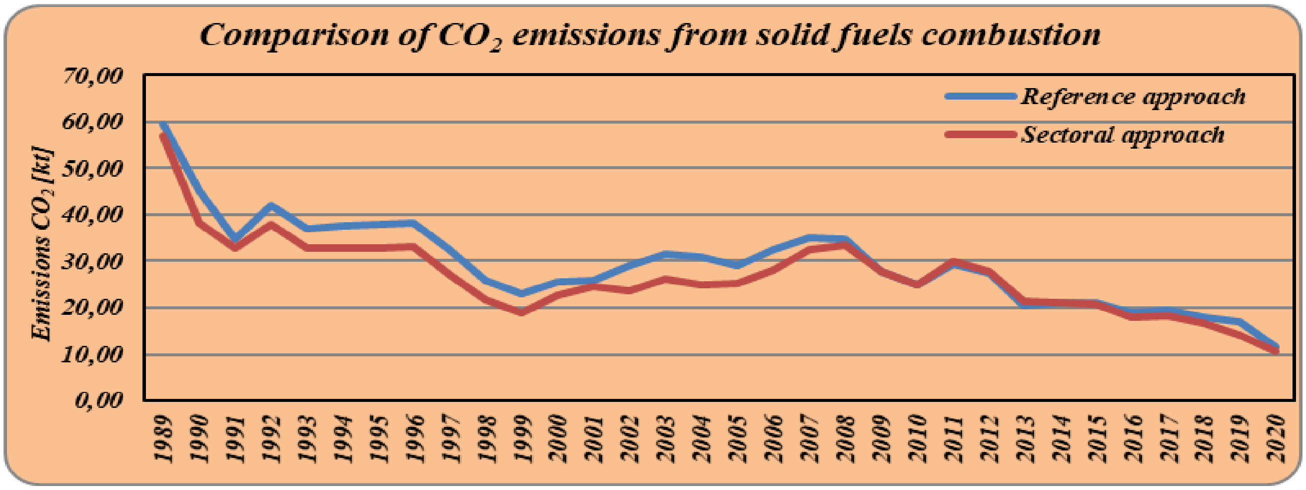


Figure 3.8 Comparison of the sectorial approach with the reference approach – gaseous fuels

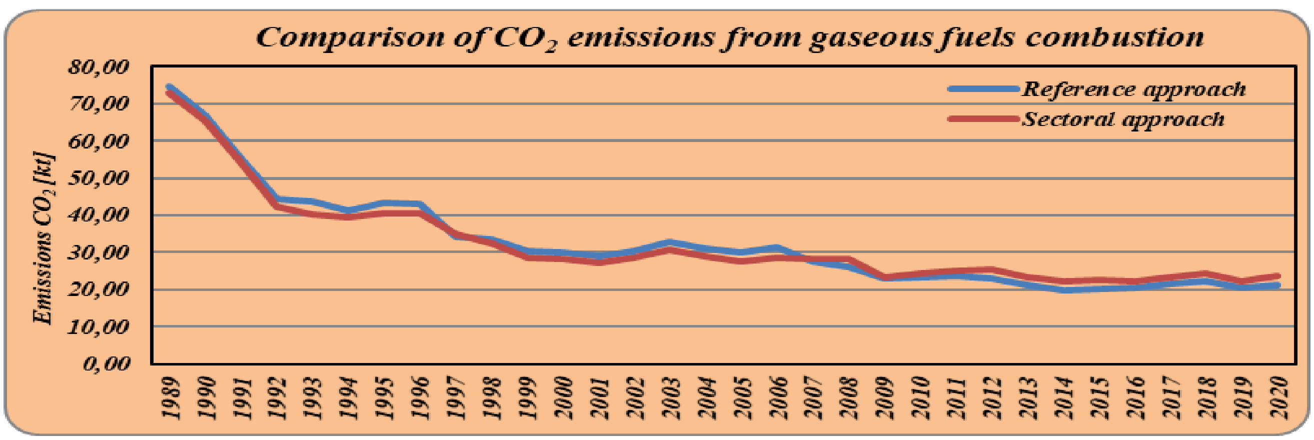
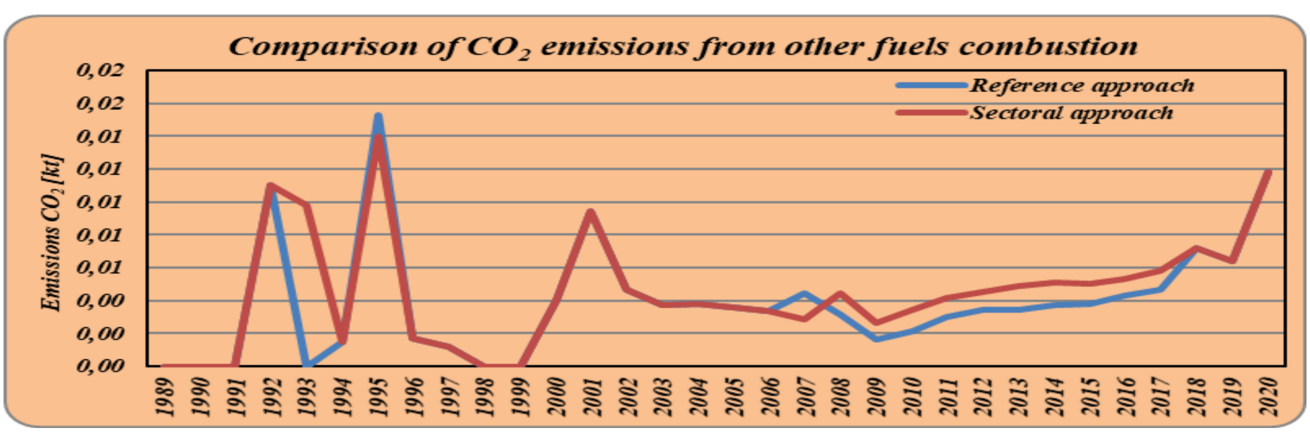


Figure 3.9 Comparison of the sectorial approach with the reference approach – other fuels



Explanation of Differences

A comparison between the RA and the SA indicates differences in both the energy consumption data and CO_2 emissions, 0.29% in terms of energy consumption and, -3.21% in terms of CO_2 emissions for 2020. 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 2007–2020 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 2007-2020 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 Bunkers fuels(CRF 1.D.1)

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 (CRF 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 3.3). In 2020 the emissions from International

Aviation category represent 0.78 % (143.39 kt CO_2 eq.) of total emissions from the Transport sector (18,401.03 kt CO_2 eq,). In 2020 the emissions from the International Aviation category have decreased by 83.36 % compared to the base year 1989 due to the fuel consumption has decreased. 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 respect, the NIS confirmed that it will continue to maintained the change regarding the methodological approach to fuel consumption in the IEA/Eurostat Questionnaire for International Aviation. In 2020, there is a significantly decrease in non-bio jet kerosene consumption compared to 2019.

Figure 3.10 GHG emissions from International Aviation category for 1989 – 2020 period

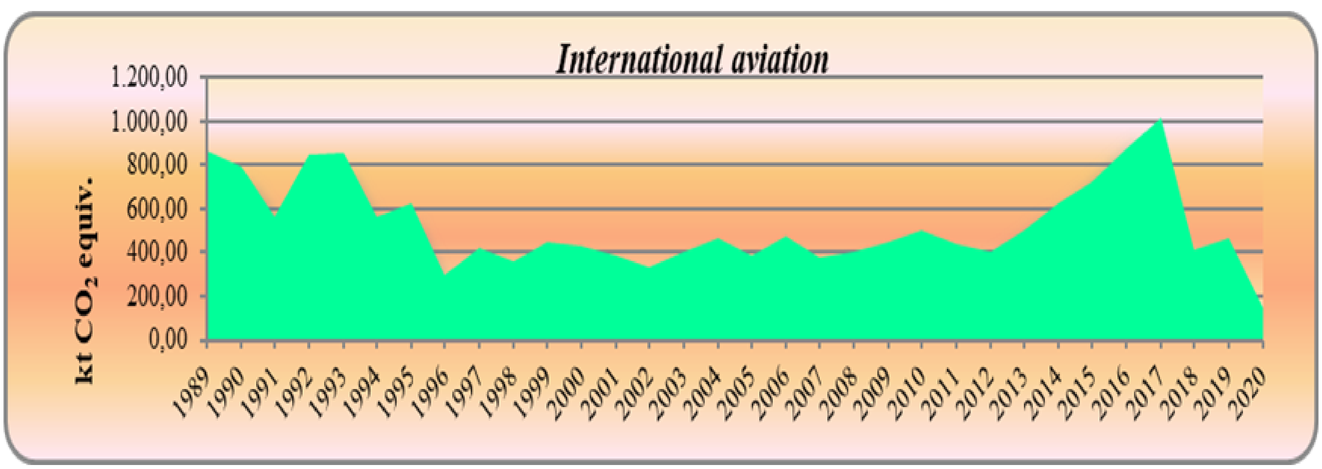
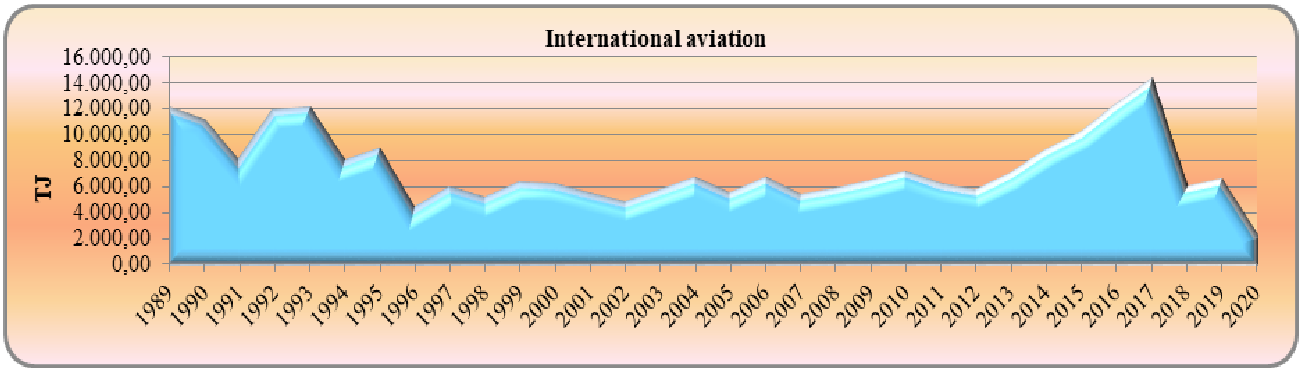


Figure 3.11 Total fuel consumption from International Aviation category for 1989 – 2020 period



3.2.2.2 International Navigation (CRF 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 2020 the emissions from International Navigation category represent 0.76 % (139.63 kt CO_2 eq.) of total emissions from the Transport sector (18,401.03 kt CO_2 eq,). 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 3.12, 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 2020 year, the fuel consumption level associated with the International Navigation category increased by 37.94 % compared with 2019. The Tier1 and Tier 2 method have been used and are presented in section 3.2.7.4.2.

Figure 3.12 Total GHG emissions from International Navigation category for 1989 – 2020 period

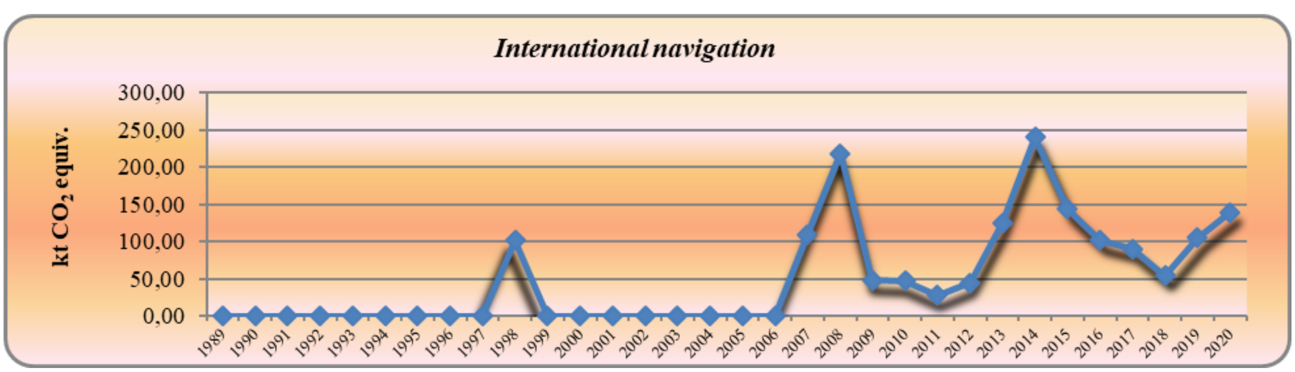
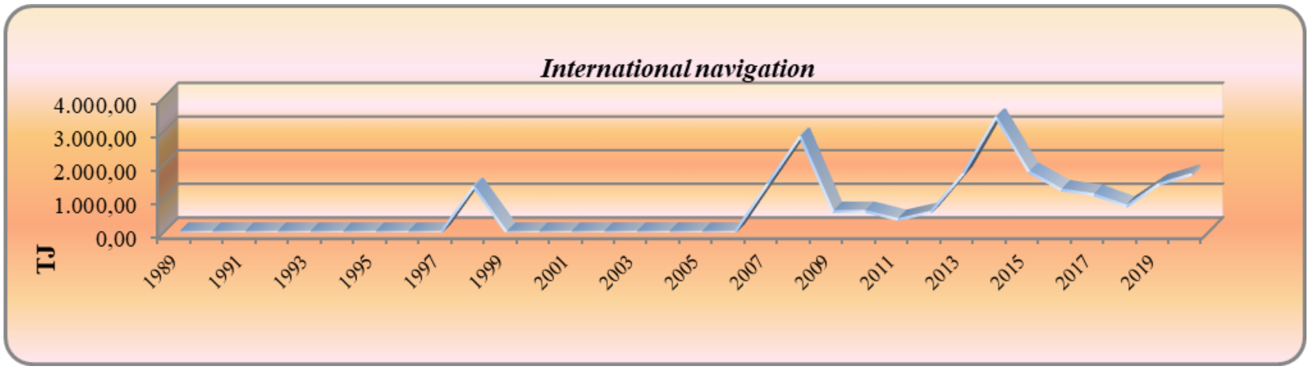


Figure 3.13 Total fuel consumption from International Navigation category for 1989- 2020 period



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 2007–2020 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 CRF 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 9.57% from the total apparent energy consumption during the period 1989–2008, and arround 7.44 % for the 2009-2020 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 2015-2019 period the share of the non-energy use of the fuels in total consumption is about 6.37% and for 2020 year is about 7.03%. 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	163,99	2567,60	6,00
1990	117,95	2213,90	5,06
1995	119,18	1600,86	6,93
2000	140,53	1237,02	10,20
2005	192,64	1286,45	13,02
2006	184,83	1316,77	12,31
2007	186,10	1369,18	11,97
2008	160,80	1390,77	10,36
2009	128,83	1223,47	9,53
2010	126,15	1198,63	9,52
2011	126,84	1268,42	9,09
2012	102,56	1275,45	7,44
2013	89,75	1135,92	7,32
2014	90,41	1115,95	7,49
2015	78,89	1135,99	6,49

Year	Non-energy use [PJ]	Apparent energy consumption incl. non-energy use [PJ]	[%]
2016	79,85	1092,31	6,81
2017	74,00	1141,31	6,09
2018	73,77	1168,10	5,94
2019	78,07	1119,73	6,52
2020	81,50	1078,49	7,03

Figure 3.14 Comparison between the energy and non-energy use of the fuels in the energy sector

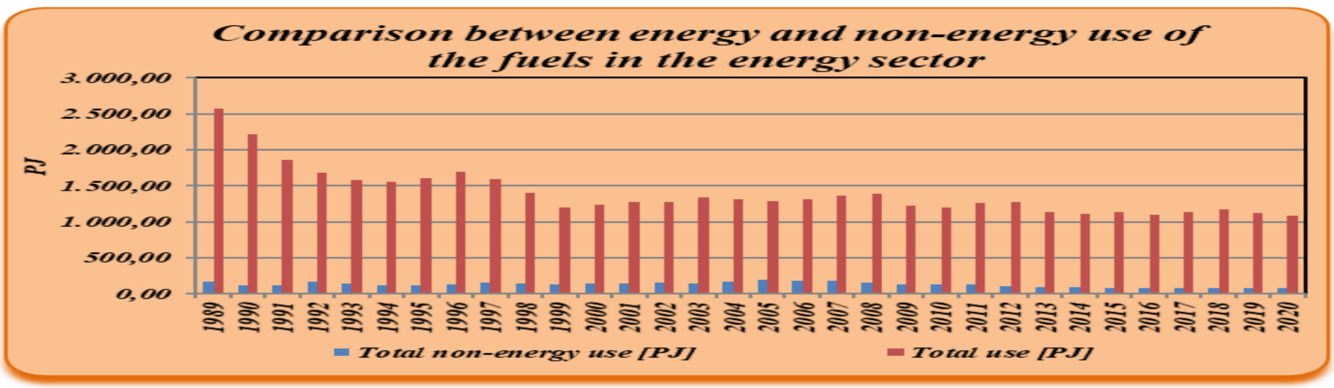
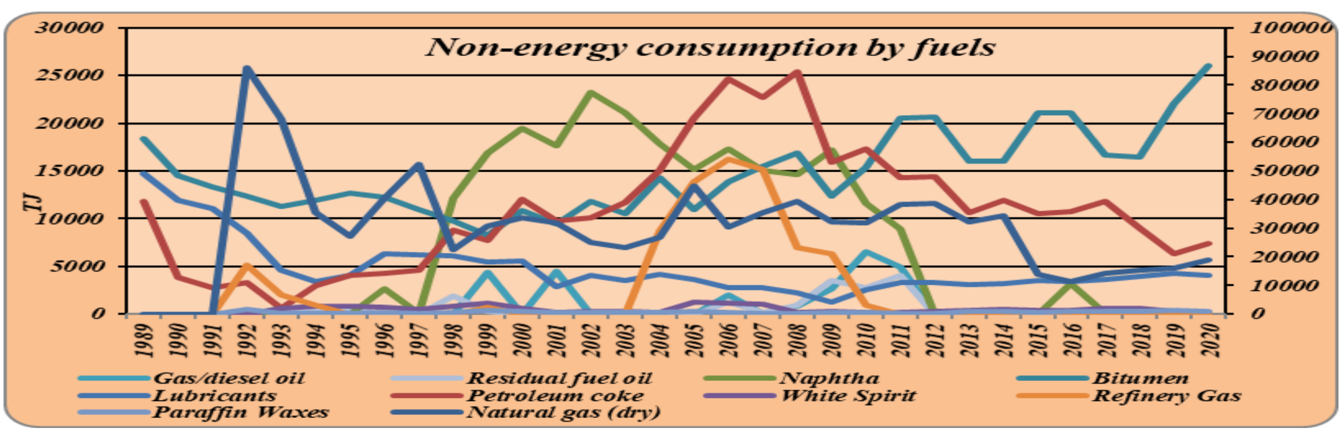


Figure 3.15 The most important non-energy consumption of the fuels



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

Liquid Fuels

- ***Activity data***
  - Recalculations were made for the following fuels:

- Gas/Diesel Oil (for 1999, 2001 and 2006 years), Residual Fuel Oil (for 1993, 1994, 1995, 1998, 1999, 2001 and 2006 years) and Refinery Gas (for 1992, 1993, 1994, 1999, 2004, 2005 and 2006 years) due to updating the activity data (the Net Calorific Values); this resulted in the updating of emissions for the 1992–2006 period.
- Petroleum Coke (for the period 2007–2019) are due to including the activity data from monitoring reports provided by the economic operators under EU-ETS trading scheme, this resulted in the updating of emissions for the 2007–2019 period.

3.2.4 Fuel combustion (CRF 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 64.249,65Gg CO_2 equivalent in 2020. Within the fuel combustion sector, 28.54 % of the CO_2 equivalent emissions correspond to 1.A.1 Energy Industries category, 23.01% of the CO_2 equivalent emissions correspond to 1.A.2 Manufacturing Industries and Construction, 28.64% of the CO_2 equivalent emissions correspond to 1.A.3 Transport, 18.80% of the CO_2 equivalent emissions correspond to 1.A.4 Other Sectors and less than 1,01% from the CO_2 equivalent emissions correspond to 1.A.5 Other (Not specified elsewhere). It is observed that the Energy Industries category are the main source of GHG emissions from fuel combustion with 18,339.29Gg CO_2 equivalent of the emissions in 2020. 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, 2012-2020, 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 2020 in comparison with 2019, in the 1.A.1 Energy Industries, with 17.13%, in the 1.A.2 Manufacturing Industries and Construction category the GHG emissions of CO_2 equiv. encountered a increased with 8.24%, in the 1.A.3 Transport category the GHG emissions of CO_2 equiv. encountered a decreased with 2.83%, in the 1.A.4 Other Sectors category the GHG emissions of CO_2 equiv. encountered a increased with 2.50% and in the 1.A.5 Other category the GHG emissions of CO_2 equiv. encountered a decreased with 3.14%. 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 decrease trend in 2020 in comparison with 2019, with than 1,27%. In the period 2006-2012 the main contribution to CO_2 emissions was from solid fuels, having a pick in 2007-2008. In 2020 the contribution of the liquid fuel was about 33.96%, solid 13.12%, gaseous 29.08%. 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 3.16 Total GHG CO_2 equivalent emissions associated with the Fuel Combustion Activities by categories

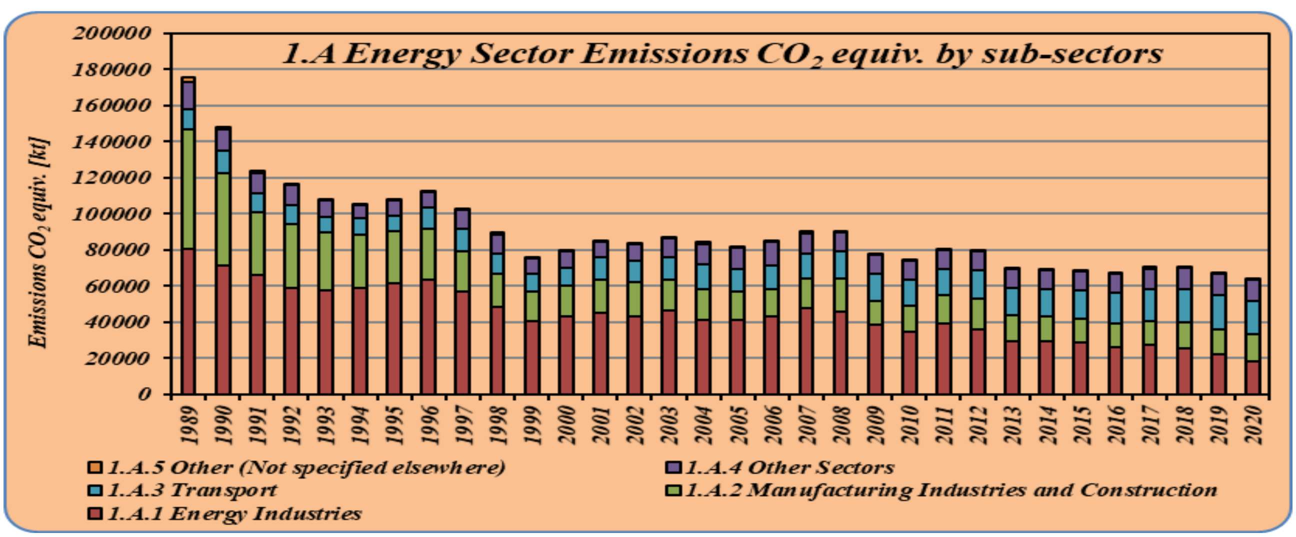


Figure 3.17 Base year and current year comparison in respect to the contribution of Fuel Combustion Activities Subsector categories emissions in total Subsector emissions

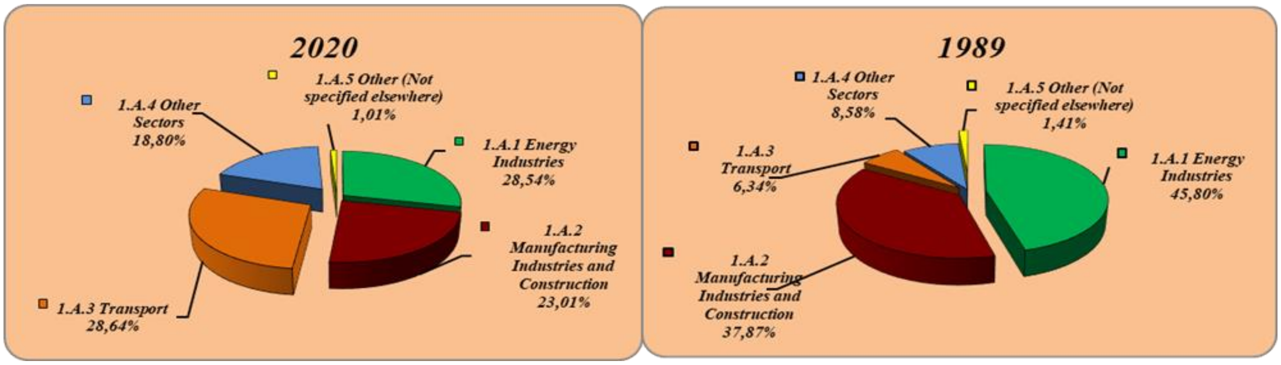
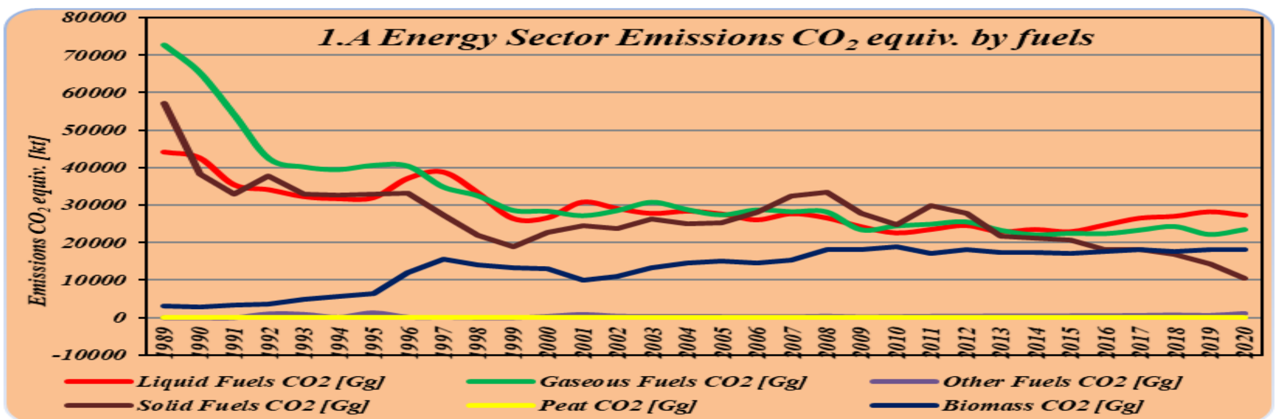


Figure 3.18 Total CO_2 emissions [kt] from Fuel combustion by fuel type



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 2007–2020 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 2007-2020 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 CRF 1.A.1, CRF 1.A.2, CRF 1.A.4 and CRF 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 CRF 1.A.1, CRF 1.A.2, CRF 1.A.4 and CRF 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 CRF 1.A.1.a, CRF 1.A.1.b, CRF 1.A.1.c, CRF 1.A.2.a, CRF 1.A.2.b, CRF 1.A.2.c, CRF 1.A.2.d, CRF 1.A.2.e, CRF 1.A.2.f and CRF 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 trading scheme 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.

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 1990-2020. For the 2007-2020 period, it was also into account the activity data from monitoring reports from economic operators under the EU-ETS trading scheme. The National statistics have not prepared balances in the Eurostat format for the years before 1990, so the IEA Energy balances 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 trading scheme for the different years, as well as, the sum between the activity data (the non-ETS consumptions 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 trading scheme) and the ETS activity data (ETS consumptions), for the CRF categories presented below:

Solid fuels

For CRF 1.A.1.a category

- Other bituminous coal for the 2007-2020 period are used only the ETS consumptions;
- Sub-bituminous coal for the 2007-2020 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 2015-2020 period it was into account the non-ETS and ETS consumptions;

For CRF 1.A.1.b category

- Lignite for the 2019 and 2020 years are used only the ETS consumptions.

For CRF 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 2013-2020 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 CRF 1.A.2.f category:

- Other bituminous coal for the 2007-2020 period are used only the ETS consumptions;
- Lignite for the 2013-2020 period it was into account the non-ETS and ETS consumptions;
- Coke oven coke for the 2011-2014 and 2017-2020 periods are used only the ETS consumptions.

Liquid fuels

For CRF 1.A.1.a category

- Refinery gas for the 2007-2010 and 2014-2020 periods are used only the ETS consumptions and for the 2011-2013 period it was into account the non-ETS and ETS consumptions;

- Transport diesel for the 2007-2020 period it was into account the 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 2007-2010 period and 2013, 2018, 2019 and 2020 years 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;
- Heating and other gasoil for the 2019 year and for the 2007-2018 period and 2020 year it was into account the non-ETS and ETS consumptions.

For CRF 1.A.1.b category

- Refinery gas for the 2007-2020 period are used only the ETS consumptions;
- Transport diesel for the 2014 and 2015 years it was into account the non-ETS and ETS consumptions;
- Residual fuel oil for the 2007-2009 and 2014-2018 periods are used only the ETS consumptions for the 2010-2013 and 2019-2020 periods it was into account the non-ETS and ETS consumptions;
- Petroleum coke for the 2019 and 2020 years it was into account only the ETS consumptions;
- Heating and other gasoil for the 2020 year it was into account the non-ETS and ETS consumptions.

For CRF 1.A.1.c category

- Transport diesel for the 2007-2008 and 2011-2020 periods it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.a category

- LPG (for the 2011 year and 2013-2017 period are used only the ETS consumptions) and for the 2018 and 2019 years it was into account the non-ETS and ETS consumptions;
- Transport diesel for 2011-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.b category

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

For CRF 1.A.2.c category

- Refinery gas for 2012-2014 period it was into account the non-ETS and ETS consumptions;
- Transport diesel for 2015-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.d category:

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

For CRF 1.A.2.e category

- LPG for the 2011-2013 period it was into account the non-ETS and ETS consumptions;
- Transport diesel for 2011-2017 and 2019-2020 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 2007-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.f category

- LPG for the 2011 year and 2013-2016 period are used only the ETS consumptions and for the 2017-2020 period it was into account the non-ETS and ETS consumptions;
- Transport Diesel for the 2011-2020 periods it was into account the non-ETS and ETS consumptions;
- Residual fuel oil 2011-2015 and 2017-2020 periods are used only the ETS consumptions and for the 2008 and 2016 years it was into account the non-ETS and ETS consumptions;
- Petroleum coke for the 2008-2010 and 2017-2020 periods are used only the ETS consumptions and for the 2011-2016 period 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 year it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.g category

- Transport diesel for the 2018-2020 years it was into account the non-ETS and ETS consumptions;
- Residual fuel oil for the 2009, 2010, 2013, 2017 and 2018 years are used only the ETS consumptions and for the 2012 and 2015 years it was into account the non-ETS and ETS consumptions;
- Heating and other gasoil for the 2011-2012 and 2017-2019 periods it was into account the non-ETS and ETS consumptions.

Gaseous fuels

For CRF 1.A.1.a category

- Natural gas for the 2013-2020 period are used only the ETS consumptions and for the 2007-2012 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.1.b category

- Natural gas for the 2007-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.1.c category

- Natural gas for the 2007-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.a category

- Natural gas for the 2007-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.b category

- Natural gas for the 2007-2017 period are used only the ETS consumptions and for the 2018-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.c category

- Natural gas for the 2012, 2014, 2018, 2019 and 2020 years are used only the ETS consumptions and for the 2007-2011 period and 2013, 2015, 2016 and 2017 years it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.d category

- Natural gas for the 2011, 2012 and 2018 years are used only the ETS consumptions and for the 2007-2010 and 2013-2017 and 2019-2020 periods it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.e category

- Natural gas for the 2007-2020 periods it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.f category

- Natural gas for the 2008 year is used only the ETS consumptions and for the 2007 year and 2009-2020 period it was into account the non-ETS and ETS consumptions.

For CRF 1.A.2.g category

- Natural gas for the 2007 year and 2009-2020 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 CRF 1.A.2.g Other Fuels – Industrial Wastes, extracting from their reports the consumption associated with biomass. For the C*RF 1.A.2.f category – other fossil fuels* - Industrial waste for the 2007-2017 period are used only the ETS consumptions and for the years 2018, 2019, 2020 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 CRF categories can be reviewed in the Annex 3.1 (the sheet IEA–EUROSTAT–CRF 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 3.1, the sheet NCVs, and Annexes 4. 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 3.1 and Annexes 4.

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 2007-2020. 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 2007-2020 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 2007-2020 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 European Union Emission Trading Scheme, 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 4.3 to the NIR, 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 4.3 to the NIR, 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 2007-2020 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 European Union Emission Trading Scheme (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 2016-2020 period is 11, 10 and 8) 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 2007-2020 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 European Union Emissions Trading Scheme reporting (EU-ETS), the derived country-specific emission factors (CS EFs) for the reported liquid, solid and gaseous fuels were used. In the Annex 3.1 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 3.1 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 CO_2 emissions in the range of 50.000 tonne and 500.000 tonne-the type B and emissions over 500.000 tonne-the type C).

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 European Union Emission Trading Scheme (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

<u>For the 1989–2006 period</u>

❖ **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 2007–2020 period

- ❖ **Solid Fuels**, EFs calculated as weighted arithmetic average (WA), on each year of 2007–2020 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 2007–2020 period, ALL EU-ETS reported category activities, oxidation included, are used.
- ❖ **Gaseous fuels**, EFs calculated as weighted arithmetic average (WA) on each year of 2007–2020 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 2007–2020 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).

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 trading scheme (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 trading scheme) in TJ multiplied with the national CO_2 emission factor from monitoring reports (Tier 3 method) for the following fuels in the CRF categories presented below:

Solid fuels

For CRF 1.A.1.a category:

- Other bituminous coal for the period 2007-2020 are used only the ETS CO_2 emissions;
- Sub-bituminous coal for the period 2007-2020 are used only the ETS CO_2 emissions;
- Lignite for the years 2007, 2008, 2011, 2012, 2014 are used only the ETS CO_2 emissions and for the years 2009, 2010, 2013 and period 2015-2020 it was into account the non-ETS and ETS CO_2 emissions;

For CRF 1.A.1.b category:

- Lignite for the years 2019, 2020 are used only the ETS CO_2 emissions.

For CRF 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, 2013-2020 are used only the ETS CO_2 emissions and for the years 2007, 2012 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.f category:

- Other bituminous coal for the period 2007-2020 are used only the ETS CO_2 emissions;
- Lignite for the period 2013-2020 it was into account the non-ETS and ETS CO_2 emissions;
- Coke oven coke for the periods 2011-2014, 2017-2020 are used only the ETS CO_2 emissions.

Liquid fuels

For CRF 1.A.1.a category:

- Refinery gas for the periods 2007-2010, 2014-2020 are used only the ETS CO_2 emissions and for the period 2011-2013 it was into account the non-ETS and ETS CO_2 emissions;
- Transport diesel for the period 2007-2020 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 years 2007, 2008, 2009, 2010, 2013, 2018, 2019, 2020 it was into account the non-ETS and ETS CO_2 emissions;
- Petroleum coke for the period 2011-2016 and 2019 year are used only the ETS CO_2 emissions;
- Heating and other gasoil for the year 2019 and for the period 2007-2018 and year 2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.1.b category:

- Refinery gas for the period 2007-2020 are used only the ETS CO_2 emissions;
- Transport diesel for the years 2014, 2015 it was into account the non-ETS and ETS CO_2 emissions;
- Residual fuel oil for the periods 2007-2009, 2014-2018 are used only the ETS CO_2 emissions for the periods 2010-2013, 2019-2020 it was into account the non-ETS and ETS CO_2 emissions;
- Petroleum coke for the years 2019, 2020 it was into account only the ETS CO_2 emissions;

- Heating and other gasoil for the 2020 year it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.1.c category:

- Transport diesel for the periods 2007-2008, 2011-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 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, 2019 it was into account the non-ETS and ETS CO_2 emissions;
- Transport diesel for period 2011-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.b category:

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

For CRF 1.A.2.c category:

- Refinery gas for period 2012-2014 it was into account the non-ETS and ETS CO_2 emissions;
- Transport diesel for period 2015-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.d category:

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

For CRF 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 2011-2017, 2019-2020 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 2007-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 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 2017-2020 it was into account the non-ETS and ETS CO_2 emissions;
- Transport Diesel for the periods 2011-2020 it was into account the non-ETS and ETS CO_2 emissions;
- Residual fuel oil for the periods 2011-2015, 2017-2020 are used only the ETS CO_2 emissions and for the 2008 and 2016 years it was into account the non-ETS and ETS CO_2 emissions;
- Petroleum coke for the periods 2008-2010, 2017-2020 are used only the ETS CO_2 emissions and for the period 2011-2016 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 year 2016 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.g category:

- Transport diesel for the years 2018-2020 it was into account the non-ETS and ETS CO_2 emissions;
- Residual fuel oil for the years 2009, 2010, 2013, 2017, 2018 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;
- Heating and other gasoil for the periods 2011-2012, 2017-2019 it was into account the non-ETS and ETS CO_2 emissions.

Gaseous fuels

For CRF 1.A.1.a category:

- Natural gas for the period 2013-2020 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 CRF 1.A.1.b category:

- Natural gas for the period 2007-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.1.c category:

- Natural gas for the period 2007-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.a category:

- Natural gas for the period 2007-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.b category:

- Natural gas for the period 2007-2017 are used only the ETS CO_2 emissions and for the 2018-2020 period it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.c category:

- Natural gas for the years 2012, 2014, 2018, 2019, 2020 are used only the ETS CO_2 emissions and for the period 2007-2011 and years 2013, 2015, 2016, 2017 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.d category:

- Natural gas for the years 2011, 2012, 2018 are used only the ETS CO_2 emissions and for the periods 2007-2010, 2013-2017, 2019-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.e category:

- Natural gas for the periods 2007-2020 it was into account the non- ETS and ETS CO_2 emissions.

For CRF 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 2009-2020 it was into account the non-ETS and ETS CO_2 emissions.

For CRF 1.A.2.g category:

- Natural gas for the year 2007 and period 2009-2020 are used only the ETS CO_2 emissions and for the year 2008 it was into account the non-ETS and ETS CO_2 emissions.

Other fossil fuels

- For the CRF 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 period 2018-2020 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										
	Lignite	Natural gas	Refinery gas	Other bituminous coal	Coke_Oven _Coke	Transport diesel	Residual fuel oil	Heating and other gasoil	Petroleum Coke	Industrial Wastes	Sub-bituminous coal
	EF Ox [tCO_2/TJ]										
2007	103.45	55.29	54.32	93.24	92.92	74.00	78.58	74.46	0.00	0.00	93.75
2008	100.24	55.68	54.69	94.34	84.33	72.35	76.83	77.87	94.34	0.00	92.79
2009	98.32	55.49	58.11	95.20	92.89	74.04	77.97	74.45	91.85	0.00	93.83
2010	97.01	55.64	57.93	95.95	92.65	72.75	79.69	73.66	94.02	0.00	92.93
2007-2010 WA EFs	99.89	55.52	56.38	94.74	91.22	73.29	78.16	74.19	93.63	0.00	93.32
2011	94.75	55.52	57.42	91.80	95.16	72.92	79.49	73.31	98.50	83.50	92.70
2012	94.46	55.58	56.90	90.50	93.99	73.56	79.48	74.08	96.83	83.81	93.81
2013	95.86	55.59	57.90	92.18	95.34	70.66	78.50	76.11	92.80	89.53	94.27
2014	97.95	55.59	57.40	93.14	108.28	69.62	79.23	73.63	92.73	92.34	93.56
2015	98.10	55.54	56.23	92.61	106.24	79.28	79.52	76.03	95.38	92.46	92.15
2016	98.11	55.74	56.37	93.16	104.25	79.68	79.06	74.08	96.09	93.18	93.27
2017	98.10	55.71	55.67	94.92	96.16	80.18	79.80	73.63	95.67	90.78	92.87
2018	97.60	55.61	56.22	94.44	96.16	69.62	80.39	73.63	94.52	92.85	93.52
2019	96.83	55.60	56.40	94.37	96.38	72.46	81.08	73.63	94.29	87.76	94.43
2020	96.50	55.59	56.79	93.78	95.76	80.18	82.31	78.38	94.04	87.64	93.81

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										
	Lignite	Natural gas	Refinery gas	Other bituminous coal	Coke_Oven _Coke	Transport diesel	Residual fuel oil	Heating and other gasoil	Petroleum Coke	Industrial Wastes	Sub-bituminous coal
	EF Ox [tCO_2/TJ]										
2007	98.44	54.80	54.89	92.97	92.06	73.95	78.09	74.36	0.00	0.00	93.75
2008	94.55	55.65	56.04	93.43	84.46	73.43	76.89	78.50	94.52	0.00	92.79
2009	91.51	55.31	58.11	95.19	92.97	74.22	78.00	74.65	91.85	0.00	92.57
2010	88.66	55.48	57.71	95.87	92.65	73.29	79.71	73.67	94.02	0.00	92.05
2007-2010 WA EFs	93.47	55.30	56.77	94.31	91.11	73.74	78.04	74.30	93.73	0.00	92.86
2011	86.41	55.52	57.42	91.08	95.16	72.92	79.49	73.29	98.50	83,54	91.97
2012	86.93	55.58	56.90	90.02	93.99	73.56	79.48	74.08	96.83	83,89	93.30
2013	88.84	55.59	57.90	91.79	95.16	70.66	78.50	76.11	92.80	87,17	93.52
2014	90.70	55.59	57.40	92.78	108.28	69.62	79.23	73.63	92.34	88,38	92.54
2015	89.67	55.54	56.23	92.44	106.24	79.28	79.52	76.03	94.93	90,33	91.11
2016	89.57	55.74	56.37	92.30	104.25	79.68	79.06	74.08	95.55	92,37	92.58
2017	88.74	55.71	55.67	93.35	96.16	80.18	79.80	73.63	95.05	92,56	92.06
2018	86.03	55.61	56.22	93.62	96.16	69.62	80.39	73.63	94.06	91,33	92.02
2019	82.95	55.60	56.40	93.62	96.38	72.46	81.08	73.63	93.90	87,16	92.42
2020	81.49	55.59	56.79	93.06	95.76	80.18	82.31	78.38	93.53	87,14	92.79

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 CRF 1.A, except CRF 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										
	Lignite	Natural gas	Refinery gas	Other bituminous coal	Coke_Oven _Coke	Transport diesel	Residual fuel oil	Heating and other gasoil	Petroleum Coke	Motor Gasoline*	Sub-bituminous coal
t/TJ (including oxidation factor)											
EF CO_2	93.47	55.3	56.77	94.31	91.11	73.74	78.04	74.3	93.73	71.62	92.86
t/TJ (excluding oxidation factor)											
EF CO_2	99.89	55.52	56.38	94.74	91.22	73.29	78.16	74.19	93.63	71.62	93.32
t/TJ											
Carbon content	27.24	15.14	15.38	25.84	24.88	19.99	21.32	20.23	25.54	19.53	25.45

*** 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 Uncertainties 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 8.1. Based on the above background information, the results of the uncertainties associated to the GHG emissions estimates are as follows:

AD uncertainty

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

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

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

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

❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 7%.

❖ Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;

EFs uncertainty

CO_2 gas:

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

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

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

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

❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 20%.

❖ Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 20%;

CH_4 gas:

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

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

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

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

❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%.

- ❖ Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;

N_2O gas:

- ❖ Liquid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Solid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Gaseous fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Peat, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%.
- ❖ Biomass, CRF 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, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Solid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 5%;
- ❖ Gaseous fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Peat, CRF categories 1A1, 1A2, 1A4 and 1A5a: 5%;
- ❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 21%.
- ❖ Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 20%;

CH_4 gas:

- ❖ Liquid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50 %;
- ❖ Solid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Gaseous fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Peat, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50 %.
- ❖ Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;

N_2O gas:

- ❖ Liquid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Solid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Gaseous fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Peat, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;
- ❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50 %.
- ❖ Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 50%;

3.2.4.4 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.

Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

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 CRF 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

CRF 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
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

CRF Category	Main activity	Share of the EU-ETS reporting to the EB [%]	Reporting Plants
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 CRF 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 CRF 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 CRF tables generated by CRF 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, CRF tables.

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.

3.2.4.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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

1. Activity data

Solid fuels

1.A.1.a Public Electricity and Heat Production category

- ✓ The recalculations for the *Other bituminous coal and Sub-bituminous coal* are due to, the use of activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Lignite* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the years 2007, 2008,. 2011, 2012, 2014, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2009, 2010, 2013 and the period 2015-2020; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.b Petroleum Refining category

- ✓ The recalculations for the *Lignite* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.e Food Processing, Beverages and Tobacco category

- ✓ The recalculations for the *Other bituminous coal* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the 2012-2017 period; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Coke oven coke* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the periods 2008-2011, 2013-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2007, 2012; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.f Non-Metallic Minerals category

- ✓ The recalculations for the *Other bituminous coal* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Lignite* are due to, the use of sum between the non-ETS and ETS consumptions for the period 2013-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Coke oven coke* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 2011-2014, 2017-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

Liquid fuels

1.A.1.a Public Electricity and Heat Production category

- ✓ The recalculations for the *Refinery gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 2007-2010, 2014-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the 2011-2013 period; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual fuel oil* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2011, 2012 and period 2014-2017, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2010 and years 2013, 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Petroleum coke* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2019 and period 2011-2016; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Heating and other gasoil* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme (the ETS consumptions) for the year 2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2018; in this case the CO_2, CH_4 and N_2O emissions are updated;

1.A.1.b Petroleum Refining category

- ✓ The recalculations for the *Refinery gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2007 and period 2009-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2008; in this case the CO_2, CH_4 and N_2O emissions are updated;

- ✓ The recalculations for the *Transport diesel* are due to, the use of sum between the non-ETS and ETS consumptions for the years 2014, 2015; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual fuel oil* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 207-2009, 2014-2018, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2010-2013 and year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Petroleum coke* are are due t, the use of sum between the non-ETS and ETS consumptions for the year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.c Manufacture of Solid Fuels and Other Energy Industres category

- ✓ The recalculations for the *Transport diesel* are due to, the use of sum between the non-ETS and ETS consumptions for the periods 2007-2008, 2011-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;

1.A.2.a Iron and Steel category

- ✓ The recalculations for the *LPG* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions. for the year 2011 and period 2013-2017, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of sum between the non-ETS and ETS consumptions for the periods 2011-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.b Non Ferrous Metals category

- ✓ The recalculations for the *Residual fuel oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2007; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.c Chemicals category

- ✓ The recalculations for the *Refinery gas* are due to, the use of sum between the non-ETS and ETS consumptions for the period 2012-2014; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2015-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.d Pulp, Paper and Print category

- ✓ The recalculations for the *Residual fuel oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2008; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.e Food Processing, Beverages and Tobacco category

- ✓ The recalculations for the *LPG* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2013; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2017 and year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual Fuel Oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme. the ETS consumptions, for the years 2007, 2015, as well as, the use of the sum between the non-ETS and ETS consumptions for the periods 2008-2014, 2016-2017; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Heating and Other Gasoil* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.f Non-Metallic Minerals category

- ✓ The recalculations for the *LPG* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2011 and period 2013-2016, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2017-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual Fuel Oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 2011-2015, 2017-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2008, 2016; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Petroleum Coke* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for

the periods 2008-2010, 2017-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2016; in this case the CO_2, CH_4 and N_2O emissions are updated;

- ✓ The recalculations for the *Heating and Other Gasoil* are due to because use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2011, 2012, 2015, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2016; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.g Other category

- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the years 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual Fuel Oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2009, 2010, 2013, 2017, 2018, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2012, 2015; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Heating and Other Gasoil* are due to, the use of the sum between the non-ETS and ETS consumptions for the periods 2011-2012, 2017-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

Gaseous fuels

1.A.1.a Public Electricity and Heat Production category

- ✓ The recalculations for the *Natural gas* are due to because use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the period 2013-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2012; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.b Petroleum Refining category

- ✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.c Manufacture of Solid Fuels and Other Energy Industres category

- ✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.a Iron and Steel category

- ✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.b Non Ferrous Metals category

✓ The recalculations for the *Natural gas* are due to, the use of the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the period 2007-2017, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.c Chemicals category

✓ The recalculations for the *Natural gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2012, 2014, 2018, 2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2011 and years 2013, 2015, 2016, 2017; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.d Pulp, Paper and Print category

✓ The recalculations for the *Natural gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2011, 2012, 2018, as well as, the use of the sum between the non-ETS and ETS consumptions for the periods 2007-2010, 2013-2017, 2019-2020; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.e Food Processing, Beverages and Tobacco category

✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.f Non-Metallic Minerals category

✓ The recalculations for the Natural gas are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2008, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2007 and period 2009-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.g Other category

✓ The recalculations for the Natural gas are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2007 and period 2009-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2008; in this case the CO_2, CH_4 and N_2O emissions are updated.

Other fossil fuels

- For the CRF 1.A.2.f category – other fossil fuels - Industrial waste for the 2007-2017 period are used only the ETS consumptions and for the period 2018-2020 it was into account the non-ETS and ETS consumptions; in this case the CO_2, CH_4 and N_2O emissions are updated.

2. Net Calorific Value

- For *1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction*, *1.A.4 Other Sectors* and *1.A.5 Other (Not specified elsewhere) categories* for the 1990-2019 period, 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 *1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction*, *1.A.4 Other Sectors* and *1.A.5 Other (Not specified elsewhere) categories* for the 1990-2019 period, have been updated the CO_2 emission factors; this has been resulted in the update of CO_2, CH_4 and N_2O emissions.

4. CO_2 emissions

✓ In *1.A.2.a Iron and Steel category* for year 2019 was identified a transcription error in the CRF Reporter of the CO_2 emissions for the *other fossil fuels*.

✓ In *1.A.2.g Other category* for year 2019 was identified a transcription error in the CRF Reporter of the CO_2 emissions for the *other fossil fuels*.

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]	Other bituminuous coal		Lignite		Sub-bituminous coal		Residual Fuel Oil		Natural gas [TJ]		Transport diesel		Heating and other gas oil		Refinery gas		Petroleum coke	
	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB	ETS	EB
2007	162	0	32115	31957	2313	952	254	304	139090	178767	0	5	0	14	656	19	0	0
2008	380	0	33220	33146	3020	500	197	232	122442	157850	0	3	0	12	217	25	0	0
2009	158	0	29071	30161	2243	371	331	387	106475	123965	0	2	3	21	50	6	0	0
2010	109	0	28109	28145	1860	330	159	208	87758	117649	0	3	3	14	252	110	0	0
2011	251	0	34859	34318	2400	358	192	170	107942	123952	0	3	0	19	104	134	63	0
2012	265	0	31815	30360	2062	667	136	111	102174	107941	0	9	0	14	76	134	123	0
2013	216	0	22731	23179	2013	316	43	48	100379	86015	0	11	0	8	52	71	111	0
2014	149	0	23577	23427	1831	241	34	31	93218	79892	0	20	0	1	184	70	114	0
2015	147	0	25018	25144	1290	192	47	41	101365	75813	0	11	0	1	166	59	103	0
2016	148	0	22230	22943	997	151	70	60	99793	77239	0	11	0	1	117	67	100	100
2017	154	0	24474	25167	818	222	114	30	102504	85809	0	12	0	1	66	59	111	111
2018	142	0	23565	24183	669	231	31	59	103343	82095	0	18	0	0	137	59	108	108
2019	123	0	20988	21404	567	273	13	16	93148	77323	0	22	1	0	79	51	27	0
2020	107	0	14844	15277	599	167	19	47	93148	73336	0	21	0	1	45	44	0	0

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1990	980.766,50	984.249,02	0,36	70.723,32	70.967,23	0,34	1,53	1,53	0,28	0,61	0,61	0,31
1991	901.239,31	904.141,79	0,32	65.414,60	65.633,57	0,33	1,31	1,31	0,27	0,60	0,60	0,37
1992	787.541,03	790.144,02	0,33	58.810,66	59.022,83	0,36	1,06	1,06	0,27	0,60	0,60	0,43
1993	769.066,88	772.135,94	0,40	57.494,24	57.743,57	0,43	1,06	1,06	0,33	0,57	0,58	0,55
1994	779.390,92	783.972,42	0,59	58.325,33	58.713,84	0,67	1,08	1,09	0,46	0,58	0,58	0,91
1995	809.385,89	814.113,77	0,58	60.676,47	61.077,33	0,66	1,20	1,21	0,42	0,61	0,61	0,90
1996	841.079,95	845.991,73	0,58	62.755,31	63.176,57	0,67	1,22	1,22	0,44	0,60	0,61	0,97
1997	762.723,82	767.113,65	0,58	56.372,33	56.746,02	0,66	1,16	1,17	0,41	0,53	0,53	0,98
1998	658.908,66	662.719,95	0,58	47.878,11	48.193,92	0,66	0,93	0,93	0,44	0,42	0,42	1,00
1999	549.690,48	552.860,97	0,58	40.109,88	40.372,54	0,65	0,79	0,79	0,43	0,36	0,37	0,94
2000	570.923,27	574.267,26	0,59	42.541,28	42.815,71	0,65	0,81	0,81	0,44	0,41	0,42	0,85
2001	589.135,75	592.601,17	0,59	44.893,10	45.176,60	0,63	1,00	1,01	0,37	0,47	0,47	0,77
2002	569.228,35	572.522,24	0,58	42.504,94	42.779,88	0,65	0,80	0,80	0,44	0,42	0,42	0,87
2003	611.289,80	615.092,66	0,62	45.727,28	46.047,04	0,70	0,83	0,83	0,48	0,46	0,47	0,94
2004	548.598,51	552.291,41	0,67	40.766,10	41.074,95	0,76	0,72	0,73	0,53	0,41	0,41	1,02
2005	546.318,45	546.390,28	0,01	40.873,40	40.842,00	-0,08	0,72	0,72	0,02	0,4182	0,4167	-0,38

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2006	561.941,01	562.177,32	0,04	42.834,91	42.827,89	-0,02	0,74	0,74	0,04	0,4683	0,4673	-0,21
2007	534.861,01	597.940,16	11,79	43.311,55	47.328,25	9,27	0,63	0,73	14,44	0,48	0,50	2,74
2008	520.229,67	580.108,13	11,51	41.677,33	45.556,76	9,31	0,60	0,70	16,97	0,50	0,52	2,98
2009	442.854,70	493.878,10	11,52	34.762,33	38.275,47	10,11	0,51	0,60	16,57	0,43	0,45	5,74
2010	400.080,99	462.100,05	15,50	30.960,44	34.827,39	12,49	0,48	0,57	18,71	0,39	0,41	3,43
2011	474.345,25	521.328,73	9,90	36.281,06	39.287,79	8,29	0,57	0,64	12,47	0,48	0,49	2,21
2012	442.449,78	473.520,07	7,02	33.846,40	35.910,61	6,10	0,53	0,58	9,44	0,44	0,45	1,76
2013	368.664,72	391.275,89	6,13	27.811,70	29.406,83	5,74	0,48	0,52	8,54	0,34	0,36	3,37
2014	370.410,80	381.249,94	2,93	28.245,55	29.016,39	2,73	0,55	0,57	3,89	0,36	0,36	1,04
2015	370.680,15	396.209,25	6,89	27.989,33	28.727,80	2,64	0,54	0,57	6,37	0,36	0,31	-12,90
2016	340.186,44	355.356,99	4,46	25.163,93	26.366,39	4,78	0,51	0,53	4,78	0,31	0,32	3,58
2017	352.513,55	367.833,66	4,35	26.020,95	27.177,54	4,44	0,54	0,56	4,47	0,33	0,34	3,23
2018	337.024,88	352.697,08	4,65	24.415,34	25.594,24	4,83	0,48	0,50	5,65	0,30	0,32	3,42
2019	303.621,94	314.395,19	3,55	21.325,68	22.036,02	3,33	0,46	0,48	2,92	0,27	0,28	2,12
2020		269.478,61			18.262,98			0,46			0,22	

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1990	830.992,38	856.669,58	3,09	49.137,95	51.476,29	4,76	1,62	1,88	15,81	0,22	0,26	17,71
1991	575.712,87	592.130,19	2,85	33.278,76	34.773,10	4,49	0,97	1,13	16,92	0,13	0,16	18,74
1992	556.080,29	567.948,83	2,13	33.801,95	34.877,99	3,18	1,59	1,71	7,37	0,23	0,24	7,76
1993	506.066,40	517.329,22	2,23	30.387,75	31.409,44	3,36	1,41	1,52	7,93	0,20	0,21	8,43
1994	477.289,50	488.737,48	2,40	28.103,12	29.136,30	3,68	1,13	1,24	9,96	0,16	0,18	10,61
1995	481.244,15	491.792,06	2,19	28.030,94	28.972,90	3,36	1,36	1,46	7,42	0,18	0,20	8,14
1996	463.593,41	474.160,66	2,28	27.339,47	28.295,46	3,50	1,13	1,24	9,18	0,16	0,18	9,65
1997	369.245,80	379.772,94	2,85	21.547,92	22.494,72	4,39	0,98	1,08	10,39	0,14	0,15	10,96
1998	304.705,80	305.121,11	0,14	18.106,03	18.135,50	0,16	0,83	0,83	0,25	0,12	0,12	0,24
1999	276.171,35	276.276,54	0,04	16.414,74	16.424,06	0,06	0,78	0,78	0,13	0,11	0,11	0,13
2000	286.256,97	286.562,36	0,11	17.131,35	17.156,82	0,15	0,93	0,93	0,27	0,13	0,13	0,27
2001	300.660,19	301.125,73	0,15	18.330,65	18.364,68	0,19	0,96	0,96	0,26	0,14	0,14	0,26
2002	318.631,48	319.371,48	0,23	18.936,96	18.989,09	0,28	1,21	1,21	0,29	0,17	0,17	0,29
2003	293.538,01	294.104,69	0,19	16.879,70	16.920,69	0,24	1,22	1,22	0,24	0,17	0,17	0,25
2004	276.628,56	276.960,07	0,12	17.078,38	17.104,19	0,15	1,14	1,14	0,19	0,16	0,16	0,20

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2005	258.520,16	258.646,20	0,05	15.951,62	15.961,20	0,06	1,01	1,01	0,07	0,14	0,14	0,08
2006	249.577,01	249.658,20	0,03	15.063,46	15.070,00	0,04	1,07	1,07	0,05	0,15	0,15	0,05
2007	229.728,54	280.581,36	22,14	14.024,24	16.943,05	20,81	1,08	1,16	7,15	0,15	0,16	6,10
2008	230.568,35	294.390,92	27,68	14.394,38	18.517,82	28,65	0,95	1,12	17,40	0,13	0,16	17,34
2009	177.539,55	216.106,12	21,72	10.687,38	13.233,48	23,82	0,77	0,90	16,35	0,11	0,12	16,69
2010	178.772,50	231.429,38	29,45	10.653,02	14.021,78	31,62	0,88	1,02	15,26	0,12	0,14	15,30
2011	196.250,57	252.529,29	28,68	12.692,61	15.554,55	22,55	0,97	1,11	14,80	0,13	0,15	14,30
2012	199.674,87	279.601,47	40,03	12.871,49	17.093,82	32,80	1,04	1,22	16,47	0,15	0,17	15,36
2013	190.662,57	237.826,45	24,74	12.050,64	14.296,74	18,64	0,95	1,05	10,72	0,13	0,14	10,22
2014	195.571,31	232.146,31	18,70	11.592,31	13.721,82	18,37	0,96	1,01	4,69	0,13	0,14	4,45
2015	203.203,85	233.256,40	14,79	12.057,87	12.713,47	5,44	0,94	0,97	3,09	0,13	0,13	3,04
2016	195.764,93	220.476,57	12,62	11.468,45	12.847,94	12,03	0,96	0,96	-0,52	0,13	0,13	-0,65
2017	201.744,07	227.027,95	12,53	11.745,09	13.176,75	12,19	0,96	0,94	-2,23	0,13	0,13	-2,34
2018	215.708,18	242.980,92	12,64	12.599,83	14.019,39	11,27	1,06	0,96	-9,87	0,14	0,13	-10,17
2019	209.312,48	231.950,61	10,82	12.380,47	13.595,58	9,81	1,03	0,94	-8,64	0,14	0,13	-8,58
2020		246.369,05			14.714,29			1,04			0,14	

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 [%]**
	NGHGI 2021	**NGHGI 2022**		**NGHGI 2021**	**NGHGI 2022**		**NGHGI 2021**	**NGHGI 2022**		**NGHGI 2021**	**NGHGI 2022**	
1990	196.603,93	196.752,53	0,08	10.847,11	10.860,99	0,13	16,67	16,72	0,27	0,16	0,16	0,14
1991	198.753,97	198.871,50	0,06	10.712,72	10.723,70	0,10	11,99	12,03	0,29	0,12	0,12	0,14
1992	172.234,41	172.322,28	0,05	9.858,78	9.866,96	0,08	12,42	12,45	0,21	1,16	1,16	0,00
1993	164.293,46	164.356,97	0,04	8.390,56	8.396,51	0,07	13,29	13,31	0,15	0,96	0,96	0,00
1994	151.578,27	151.569,62	-0,01	6.848,94	6.848,32	-0,01	12,84	12,84	0,00	0,73	0,73	-0,04
1995	173.355,00	173.330,67	-0,01	7.880,46	7.878,84	-0,02	14,28	14,28	0,02	0,88	0,88	-0,11
1996	214.893,25	214.937,16	0,02	7.520,04	7.524,19	0,06	29,77	29,78	0,05	0,92	0,92	0,00
1997	272.258,42	272.252,34	0,00	9.109,97	9.110,27	0,00	39,31	39,32	0,03	1,27	1,27	-0,10
1998	271.446,78	271.404,57	-0,02	9.431,50	9.428,47	-0,03	35,24	35,24	0,00	1,16	1,16	-0,11
1999	240.694,25	240.669,88	-0,01	7.962,99	7.961,42	-0,02	33,03	33,04	0,01	0,85	0,85	-0,11
2000	241.713,77	241.661,38	-0,02	8.228,25	8.224,39	-0,05	32,18	32,18	0,00	0,88	0,88	-0,15
2001	207.577,05	207.558,71	-0,01	7.802,71	7.801,45	-0,02	22,88	22,89	0,00	0,56	0,56	-0,08
2002	208.789,01	208.744,62	-0,02	7.866,47	7.863,40	-0,04	23,44	23,44	0,01	0,50	0,50	-0,01
2003	252.047,75	252.013,96	-0,01	9.297,29	9.294,96	-0,03	28,74	28,74	0,01	0,59	0,59	-0,08
2004	281.977,13	282.102,80	0,04	9.899,60	9.907,03	0,08	34,85	34,85	0,02	0,63	0,63	-0,01
2005	289.359,11	289.362,00	0,00	10.225,15	10.225,38	0,00	35,56	35,56	0,01	0,62	0,62	-0,01

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2006	315.919,10	315.963,47	0,01	11.987,94	11.990,67	0,02	33,77	33,77	0,00	0,64	0,64	-0,02
2007	287.670,33	287.670,33	0,00	10.091,67	10.091,67	0,00	35,36	35,36	0,00	0,62	0,62	0,00
2008	296.994,96	296.994,96	0,00	8.920,31	8.920,31	0,00	44,78	44,78	0,00	0,73	0,73	0,00
2009	300.948,96	300.948,96	0,00	9.138,51	9.138,47	0,00	43,99	43,99	0,00	0,82	0,82	0,00
2010	305.962,32	305.962,32	0,00	9.095,15	9.095,07	0,00	45,54	45,54	0,00	0,84	0,84	0,00
2011	290.715,70	290.715,70	0,00	9.219,01	9.219,01	0,00	40,89	40,89	0,00	0,84	0,84	0,00
2012	305.190,28	305.190,28	0,00	9.692,24	9.692,28	0,00	42,53	42,53	0,00	0,94	0,94	0,00
2013	294.053,37	294.053,37	0,00	9.365,56	9.365,46	0,00	40,88	40,88	0,00	0,84	0,84	0,00
2014	283.596,20	283.596,20	0,00	8.902,88	8.902,31	-0,01	41,13	41,13	0,00	0,84	0,84	0,00
2015	281.221,66	281.221,66	0,00	9.289,29	9.289,29	0,00	39,15	39,15	0,00	0,82	0,82	0,00
2016	284.711,38	284.711,38	0,00	9.456,55	9.456,47	0,00	39,29	39,29	0,00	0,84	0,84	0,00
2017	297.738,00	297.738,60	0,00	9.989,59	9.989,64	0,00	40,08	40,08	0,00	0,85	0,85	0,00
2018	310.000,51	310.001,25	0,00	10.440,91	10.440,96	0,00	41,11	41,11	0,00	0,97	0,97	0,00
2019	310.677,47	310.677,60	0,00	10.485,12	10.461,81	-0,22	41,43	41,43	0,00	0,96	0,96	0,00
2020		314.439,90			10.760,06			41,57			0,93	

Table 3.12 The impact of recalculations on GHG emission estimates in the sub-sector 1.A.5 - Other

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	30.015,39	30.015,39	0,00	2.464,90	2.464,90	0,00	0,17	0,17	0,00	0,03	0,03	0,00
1990	12.799,28	12.762,20	-0,29	1.211,76	1.208,14	-0,30	0,12	0,12	-0,30	0,02	0,02	-0,30
1991	21.422,45	21.363,41	-0,28	1.279,12	1.273,45	-0,44	2,22	2,22	-0,03	0,05	0,05	-0,19
1992	11.673,00	11.617,78	-0,47	987,52	982,25	-0,53	0,37	0,37	-0,15	0,02	0,02	-0,45
1993	5.774,58	5.779,84	0,09	305,63	306,13	0,16	0,54	0,54	0,01	0,01	0,01	0,08
1994	7.464,30	7.451,09	-0,18	433,92	433,04	-0,20	0,54	0,54	0,00	0,01	0,01	-0,03
1995	8.877,38	8.871,28	-0,07	554,28	553,90	-0,07	0,84	0,84	0,00	0,01	0,01	0,00
1996	6.828,82	6.830,57	0,03	274,45	274,62	0,06	0,96	0,96	0,00	0,02	0,02	0,02
1997	13.632,36	13.615,56	-0,12	845,40	844,16	-0,15	0,70	0,70	-0,01	0,02	0,02	-0,06
1998	10.671,48	10.670,60	-0,01	697,66	697,61	-0,01	0,40	0,40	0,00	0,01	0,01	0,00
1999	3.609,43	3.609,23	-0,01	103,19	103,17	-0,01	0,67	0,67	0,00	0,01	0,01	0,00
2000	3.824,39	3.824,05	-0,01	238,11	238,08	-0,01	0,45	0,45	0,00	0,01	0,01	0,00
2001	10.580,73	10.580,18	-0,01	382,58	382,54	-0,01	1,86	1,86	0,00	0,03	0,03	0,00
2002	9.968,28	9.967,97	0,00	268,19	268,17	-0,01	1,99	1,99	0,00	0,03	0,03	0,00
2003	11.263,98	11.263,29	-0,01	377,89	377,84	-0,01	1,93	1,93	0,00	0,03	0,03	0,00
2004	22.560,26	22.557,94	-0,01	1.307,92	1.307,75	-0,01	1,64	1,64	0,00	0,03	0,03	0,00

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2005	23.228,55	23.233,96	0,02	1.163,88	1.164,31	0,04	2,40	2,40	0,00	0,04	0,04	0,01
2006	14.052,25	14.051,35	-0,01	502,65	502,59	-0,01	2,21	2,21	0,00	0,03	0,03	0,00
2007	18.896,92	18.896,92	0,00	950,81	950,81	0,00	1,85	1,85	0,00	0,03	0,03	0,00
2008	16.629,06	16.629,06	0,00	811,69	811,69	0,00	1,70	1,70	0,00	0,03	0,03	0,00
2009	8.597,59	8.597,59	0,00	270,73	270,73	0,00	1,49	1,49	0,00	0,02	0,02	0,00
2010	8.845,88	8.845,88	0,00	267,80	267,80	0,00	1,56	1,56	0,00	0,02	0,02	0,00
2011	10.314,14	10.314,14	0,00	538,48	538,48	0,00	0,82	0,82	0,00	0,02	0,02	0,00
2012	10.283,35	10.283,35	0,00	558,37	558,37	0,00	0,82	0,82	0,00	0,02	0,02	0,00
2013	8.116,28	8.116,28	0,00	406,31	406,31	0,00	0,67	0,67	0,00	0,01	0,01	0,00
2014	7.531,14	7.531,14	0,00	385,24	385,24	0,00	0,62	0,62	0,00	0,01	0,01	0,00
2015	10.151,77	10.151,77	0,00	453,62	453,62	0,00	1,33	1,33	0,00	0,02	0,02	0,00
2016	10.591,70	10.591,70	0,00	427,53	427,53	0,00	1,56	1,56	0,00	0,02	0,02	0,00
2017	12.482,12	12.482,12	0,00	645,64	645,64	0,00	1,33	1,33	0,00	0,02	0,02	0,00
2018	9.017,41	9.017,41	0,00	627,79	627,79	0,00	0,03	0,03	0,00	0,01	0,01	0,00
2019	8.667,91	8.667,91	0,00	628,11	628,11	0,00	0,03	0,03	0,00	0,01	0,01	0,00
2020		8.082,54			648,03			0,02			0,005	

3.2.4.6 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 (CRF 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.

Energy Industries, CRF - 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 CRF category 1.A.1 is a decrease in the emissions, but having a constant contribution to the total of 1A Fuel combustion emissions: 45.80% in the base year and a 28.54% in 2020. For the last years of the time-series, 2016, 2017, 2018 and 2019, the share of the Energy Industries in the total Energy sector encountered a increasing, having a share of 39.29% 2016 year, 38.74% 2017 year, of 36.40% 2018 year and 32.96% in 2019 year. The contribution of this sub-sector to the 1.A. – Fuel combustion is, for the year 2020, about 18,339.29 kt CO_2 equiv. having the main contributor the activity category 1.A.1.a – Electricity and Heat Production with 15,283.69 kt CO_2 equiv.

Figure 3.19 Total GHG emissions trend for the subsector 1.A.1 Energy industries by category

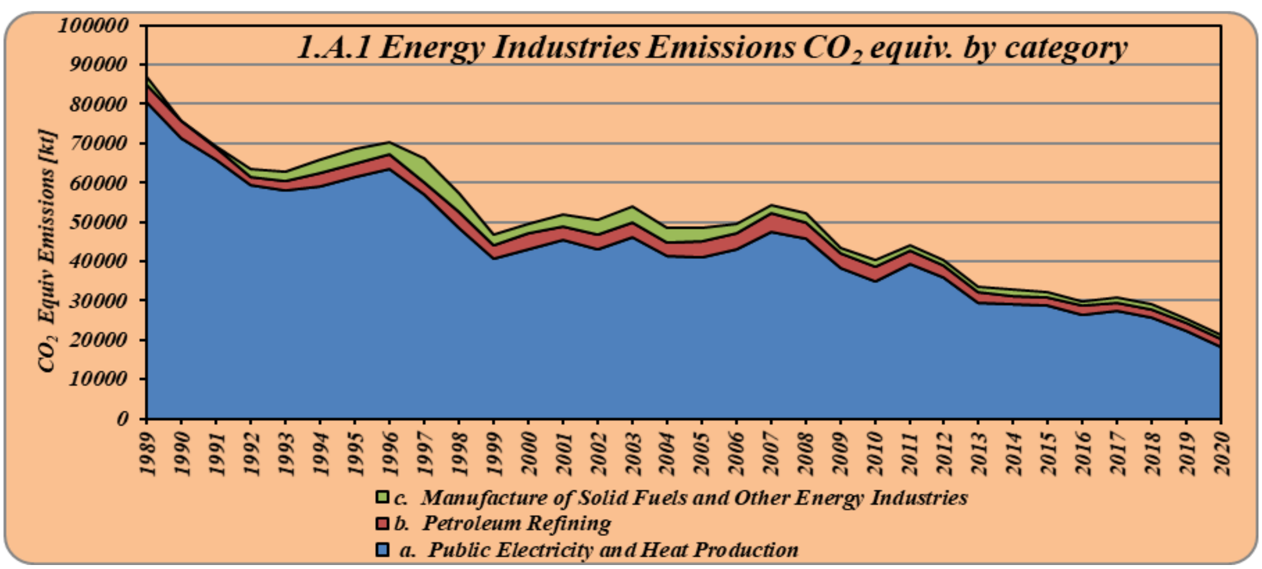
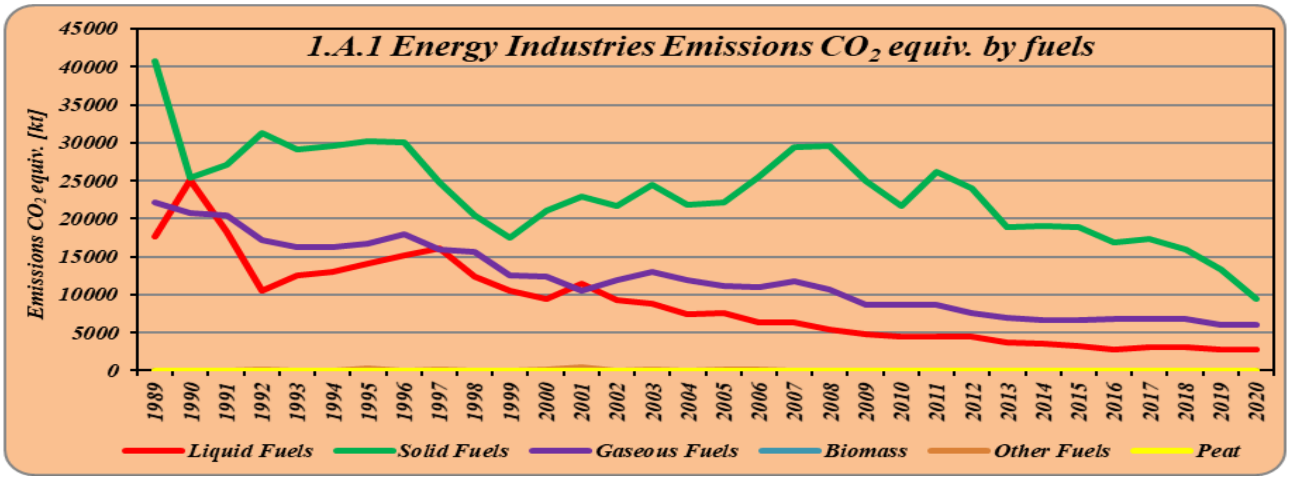


Figure 3.20 GHG emissions trend for the subsector 1.A.1 Energy industries by type of fuels



3.2.5.1 Public Electricity and Heat Production (CRF 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 (CRF sector 1.A.). The share to the total of GHG emissions 1A – Fuel Combustion, for CRF category 1.A.1.a is 42.10% in the base year and 23.79% for the year 2020 (about 15,283.69 kt CO_2 equiv.). The share of this activity category to the 1.A.1. - Energy Industry is 45.80% for the base year and 28.54% for the year 2020 (about 18,339.29 kt CO_2 equiv.). The most quantity of combusted fuel in this activity is from solid fuel (aprox. 51.85%), 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 11.10% in total fuels used. Small quantities of GHG emissions are from the combustion of biomass and other fuels (10.49 kt CO_2 equiv. for the 2020 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 2012 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 figure 3.22.

Figure 3.21 GHG emissions from 1.A.1.a Public Electricity and Heat Production

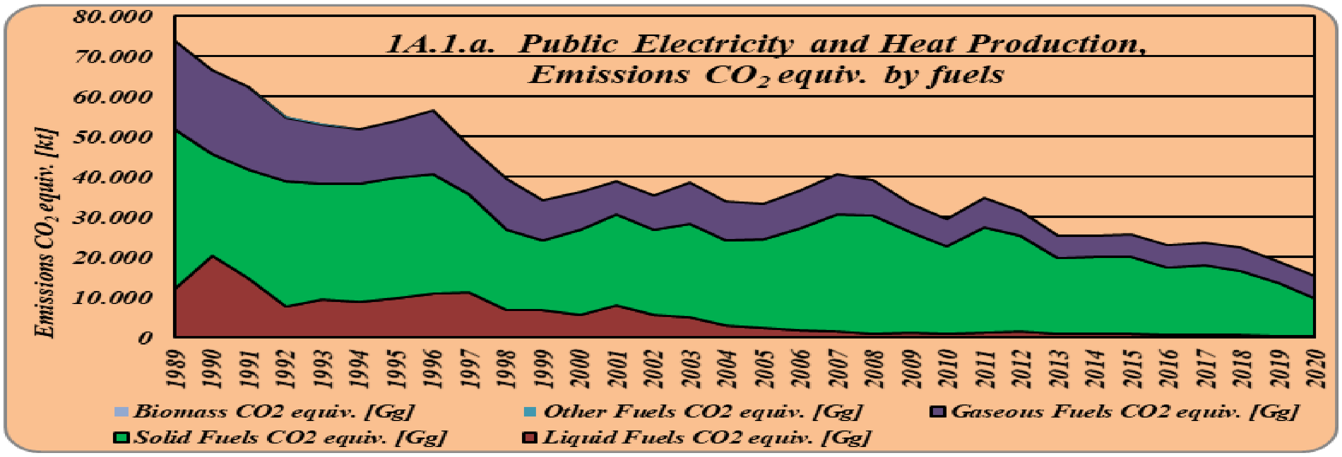
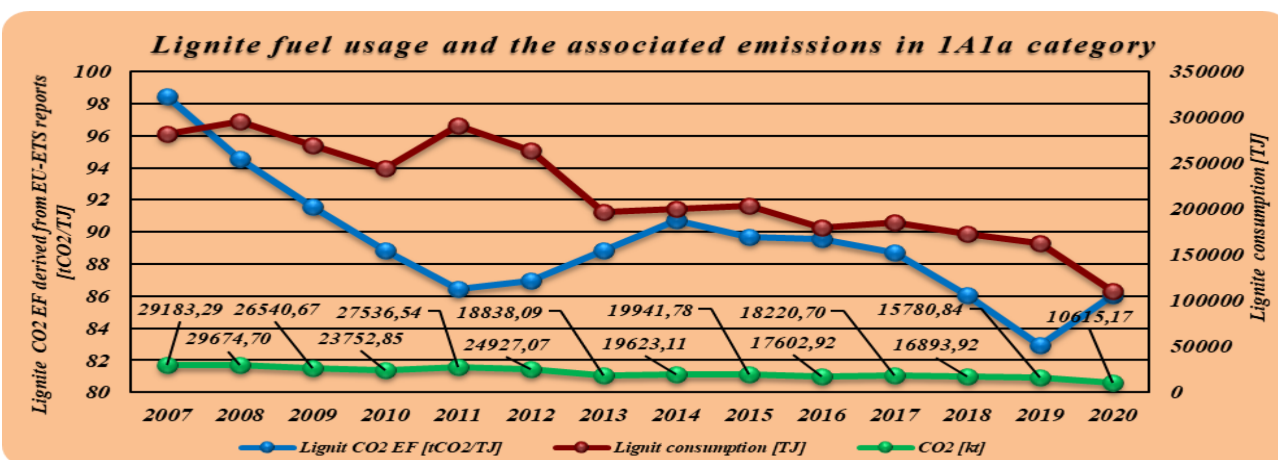


Figure 3.22 CO_2 emissions variation associated with the lignite usage in the 1.A.1.a - Public Electricity and Heat Production



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 trading scheme. See the Chapter 3.2.4.2 for more details.

3.2.5.1.3 Uncertainties 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.

3.2.5.1.4 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.

3.2.5.1.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

No improvements are planned for the next submission.

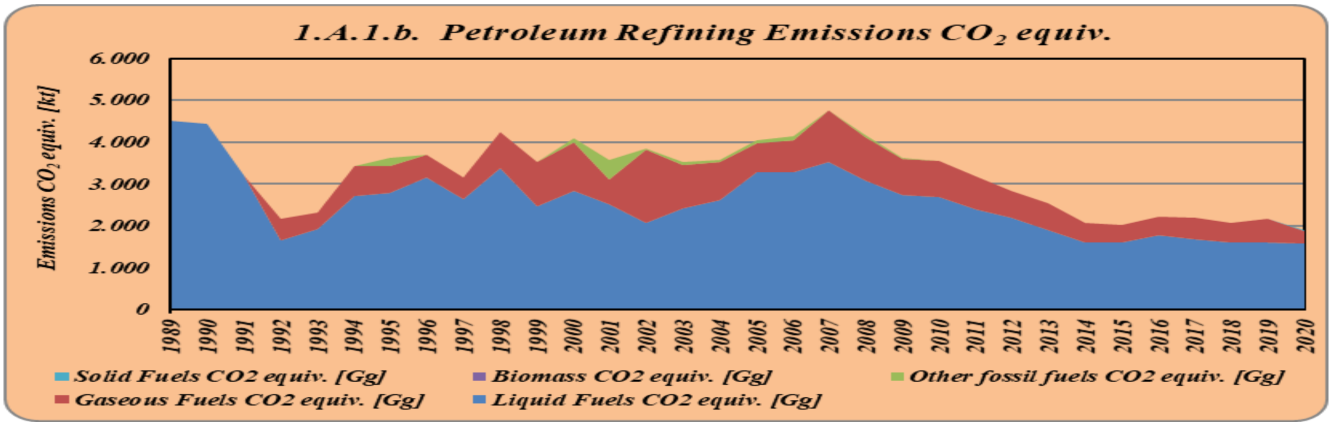
3.2.5.2 Petroleum Refining (CRF 1.A.1.b)

3.2.5.2.1 Category description

The share in total GHG emissions 1.A – fuel Combustion of this activity is 2.56% for the year 1989 and 2.94% for the year 2020. The main fuels reported are liquids which are: Refinery gas, Transport diesel and Residual fuel oil, together with natural gas having a contribution about 1,886.02 kt CO_2 equiv. in

2020. 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 (CRF Sector 1.A.).

Figure 3.23 GHG emissions from CRF 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 trading scheme. See the Chapter 3.2.4.2 for more details.

3.2.5.2.3 Uncertainties 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.

3.2.5.2.4 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.

3.2.5.2.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

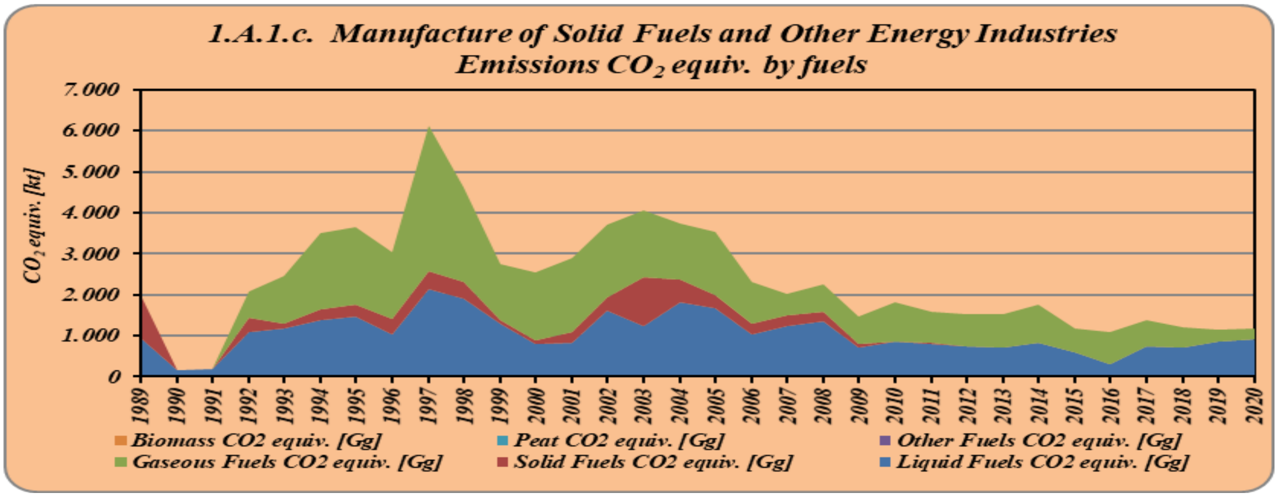
No improvements are planned for the next submission.

3.2.5.3 Manufacture of Solid Fuels and Other Energy Industries (CRF 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 (CRF sector 1.A.). The share in total GHG emissions - sector 1A, is 1.82% for the year 2020, starting to a share of 1.13% in the base year, 1989. The emissions from this activity decreased with 40.93% compared to base year. This category having a contribution about 1,169.57 kt CO_2 equiv. in 2020. 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 3.24 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 trading scheme. See the Chapter 3.2.4.2 for more details.

3.2.5.3.3 Uncertainties 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.

3.2.5.3.4 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.

3.2.5.3.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

3.2.5.3.6 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 (CRF 1.A.2)

CRF 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 (CRF sector 1.A.). The share of this activity category to the 1.A.2 - Manufacturing Industries and Construction is 37.87% for the base year and 23.01% for the year 2020 (about 14,781.93 kt CO_2 equivalents).

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

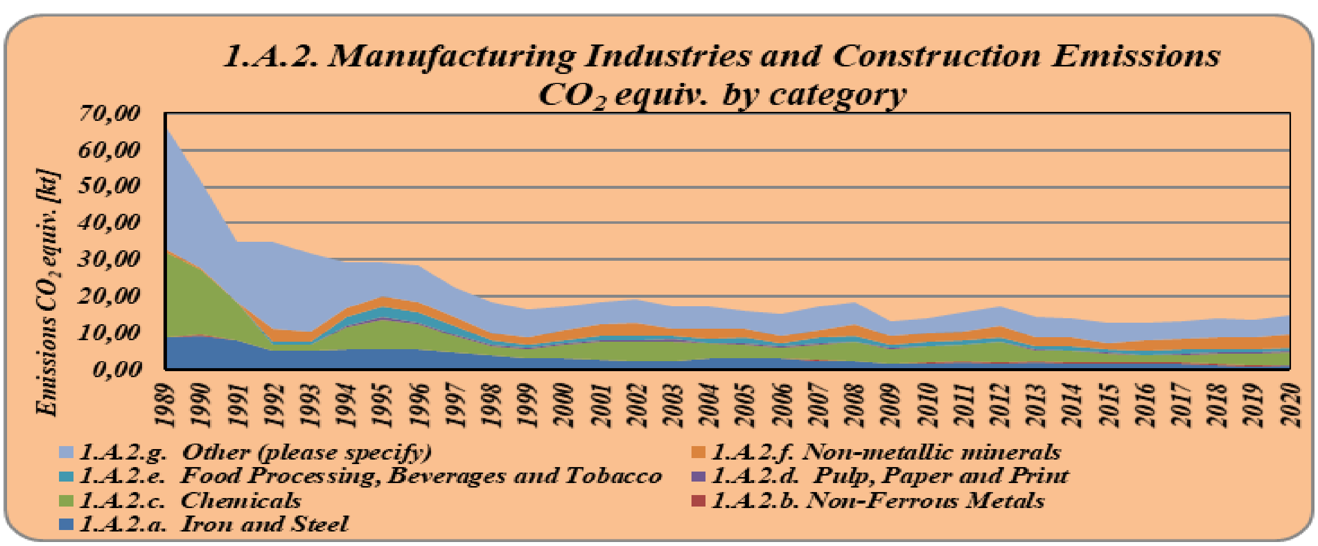
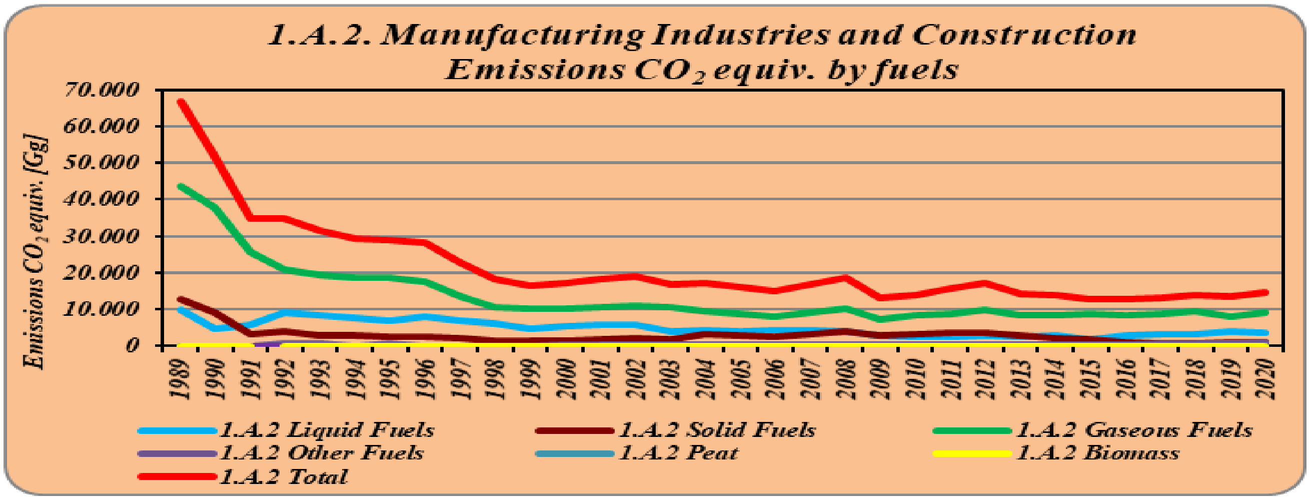


Figure 3.26 GHG emissions trend for the subsector 1.A.2 Manufacturing Industries and Constructions by fuels



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;

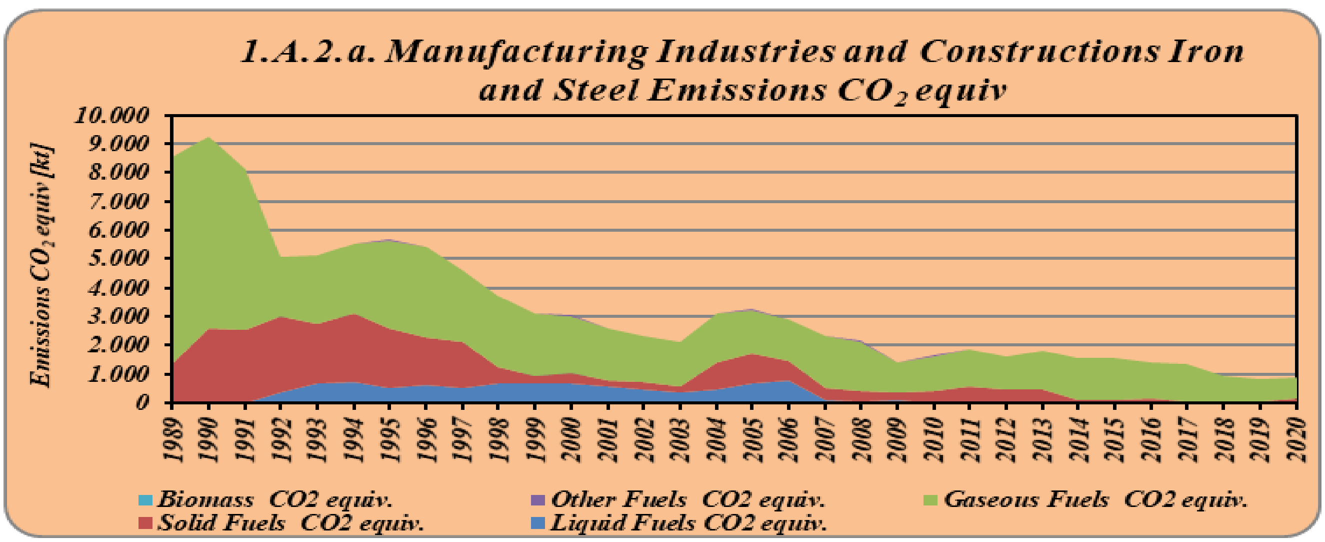
- Textiles and Leather.
- Non-specified (Industry).

3.2.6.1 Iron and Steel (CRF 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 12.83% from the base year, 1989, to 6.03% - current year, 2020. The contribution of this category is about 891.98 kt CO_2 equiv., in 2020. 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 (CRF sector 1.A.).

Figure 3.27 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 trading scheme. 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 Uncertainties 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.

3.2.6.1.4 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.

3.2.6.1.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

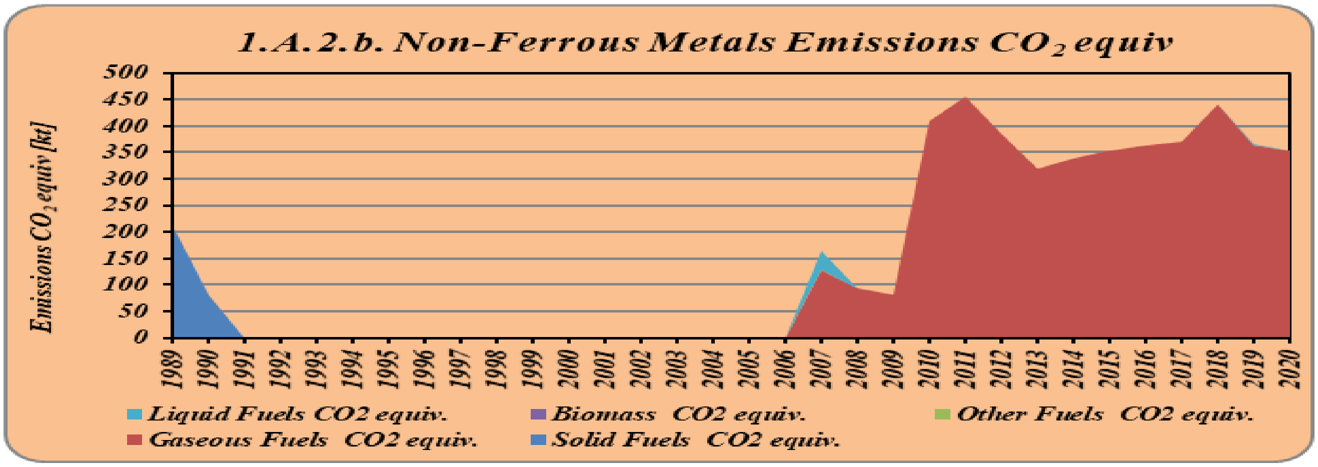
No improvements are planned for the next submission.

3.2.6.2 Fuel combustion, Manufacturing Industries and Construction, Non-Ferrous metals (CRF 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 0.32% from the base year, 1989, to 2.39% - current year, 2020. The contribution of this category is about 353.70 kt CO_2 equiv., in 2020. 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 (CRF sector 1.A.).

Figure 3.28 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 2007-2020 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 trading scheme. 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 Uncertainties 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.

3.2.6.2.4 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.

3.2.6.2.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

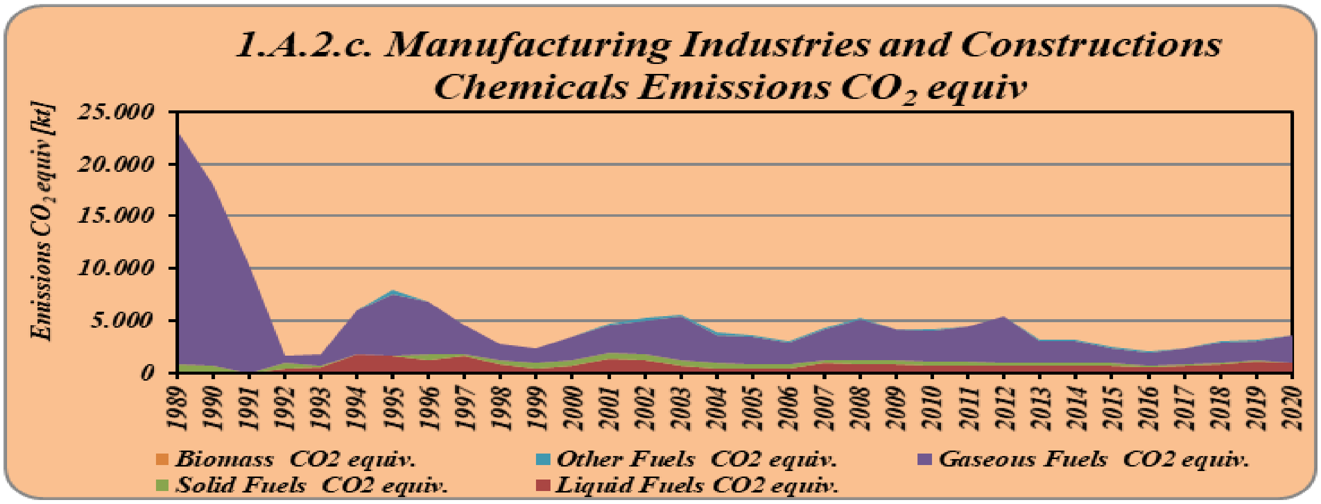
No improvements are planned for the next submission.

3.2.6.3 Category Fuel combustion, Manufacturing Industries and Construction, Chemicals (CRF 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 – 34.80% to 22.40% - current year, 2020. The contribution of this category is about 3,606.95 kt CO_2 equiv., in 2020. 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 (CRF sector 1.A.). Due to the coronavirus pandemic, the consumption and industrial activity for other fossil fuels in 2020 year cannot be compared to the previous years.

Figure 3.29 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 trading scheme. 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 Uncertainties 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.

3.2.6.3.4 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.

3.2.6.3.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

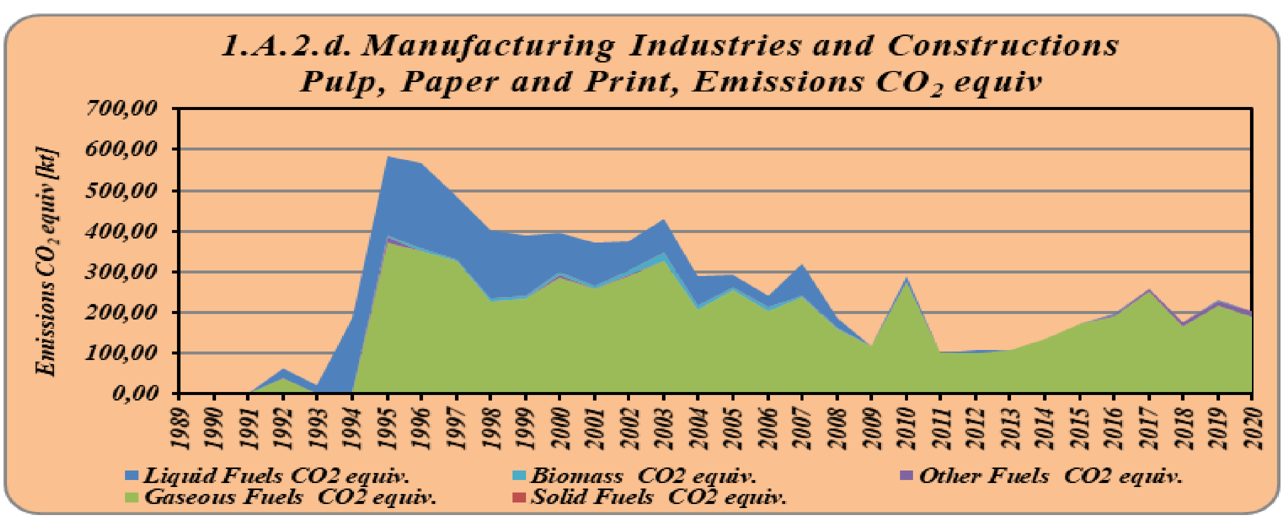
No improvements are planned for the next submission.

3.2.6.4 Fuel combustion, Manufacturing Industries and Construction, Pulp, Paper and Print (CRF 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 1.39% - in the current year, 2020. The contribution of this category is about 205.06 kt CO_2 equiv., in 2020. See more details about trends in the Chapters 3.1 – Overview of the sector and 3.2.4 Source category - Fuel combustion (CRF sector 1.A.).

Figure 3.30 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 trading scheme. 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 Uncertainties 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.

3.2.6.4.4 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.

3.2.6.4.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

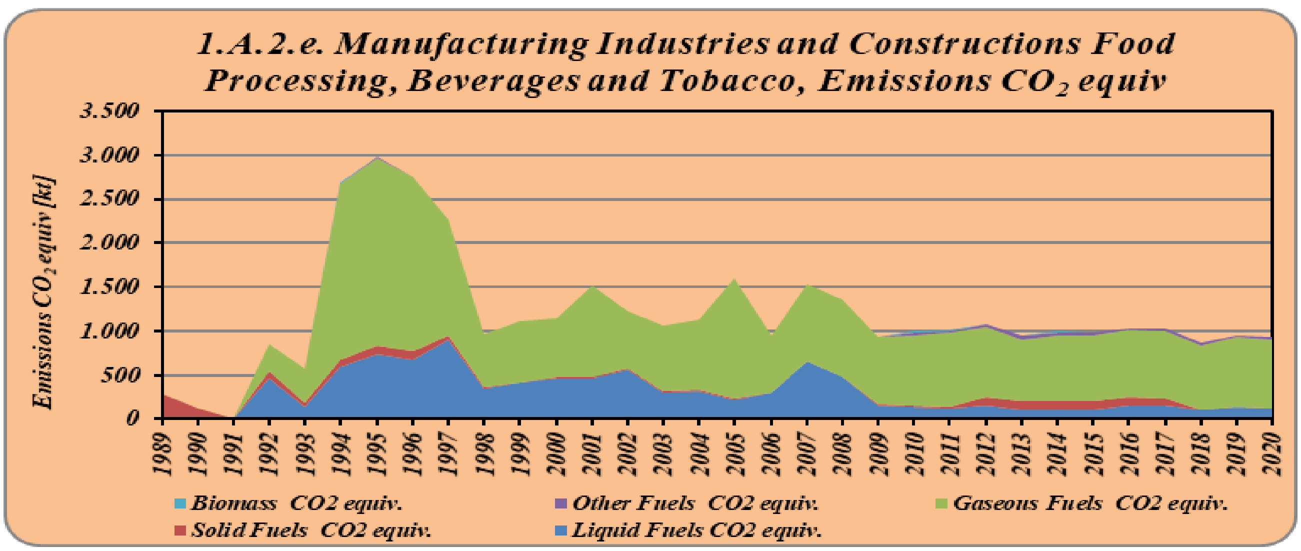
No improvements are planned for the next submission.

3.2.6.5 Fuel combustion, Manufacturing Industries and Construction, Food Processing, Beverages and Tobacco (CRF 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 0.43% - base year to the 6.31%, current year, 2020. The contribution of this category is about 933.15 kt CO_2 equiv., in 2020. 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 (CRF sector 1.A.).

Figure 3.31 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 trading scheme. 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 Uncertainties 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.

3.2.6.5.4 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.

3.2.6.5.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

No improvements are planned for the next submission.

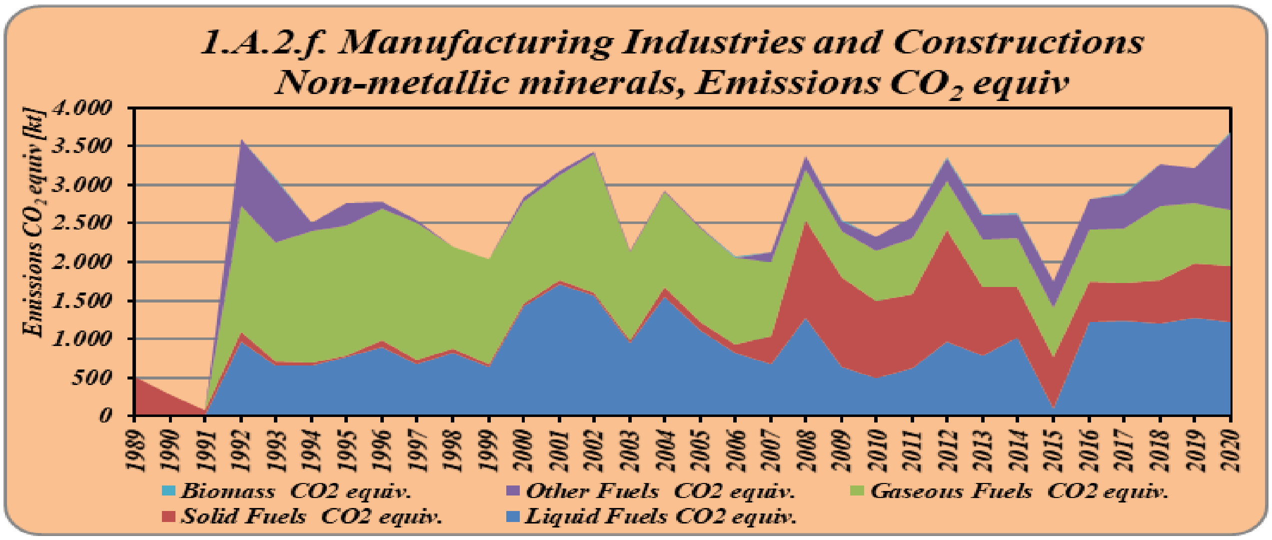
3.2.6.6 Fuel combustion, Manufacturing Industries and Construction, Other (please specify) (CRF 1.A.2.f)

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 0.78% - base year to the 24.89%, current year, 2020. The contribution of this category is about 3,679.50 kt CO_2 equiv., in 2020. 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 (CRF sector 1.A.).

Figure 3.32 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 trading scheme. 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 Uncertainties 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.

3.2.6.6.4 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.

3.2.6.6.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

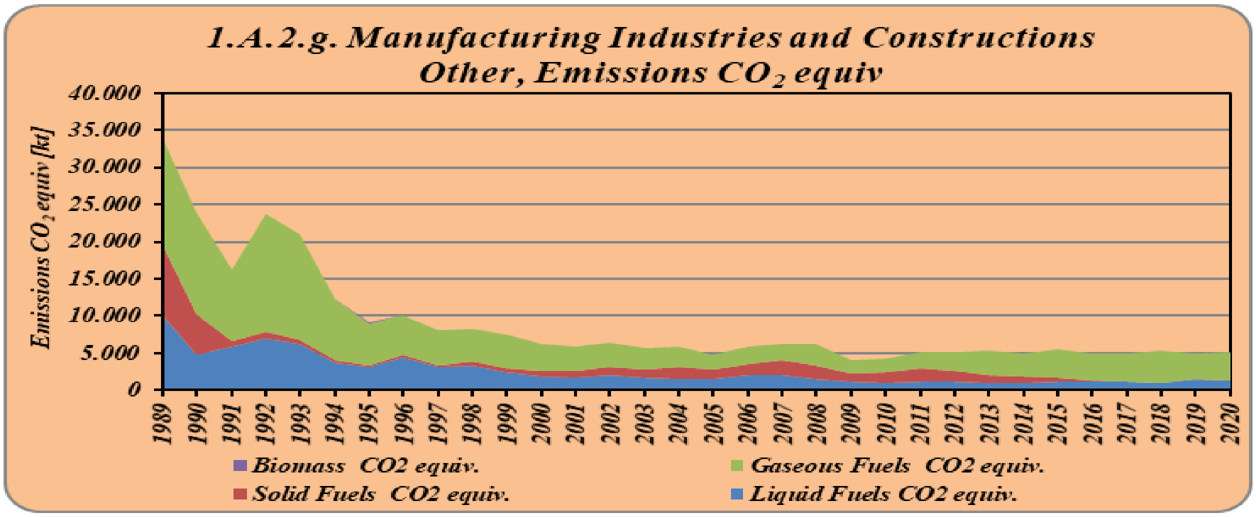
No improvements are planned for the next submission.

3.2.6.7 Fuel combustion, Manufacturing Industries and Construction, Other (please specify) (CRF 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 50.84% - base year to the 34.58, in 2020, the contribution of this category being about 5,111.58 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 (CRF sector 1.A.).

Figure 3.33 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 trading scheme. 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 Uncertainties 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.

3.2.6.7.4 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.

3.2.6.7.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

3.2.6.7.6 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 (CRF 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 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 2020 year, the emissions from transport categories accounted for 18,401.03 kt CO_2 equivalent. The GHG characterized are: CO_2, CH_4, N_2O, NO_x, NMVOC, CO and SO_2. Within the Energy Sector total emissions, 25.26 % represents transport emissions. This sector includes emissions from road transportation, domestic aviation, railways, domestic navigation and other transportation.

Figure 3.34 Contribution of each category to total fuel consumption in Transport Subsector

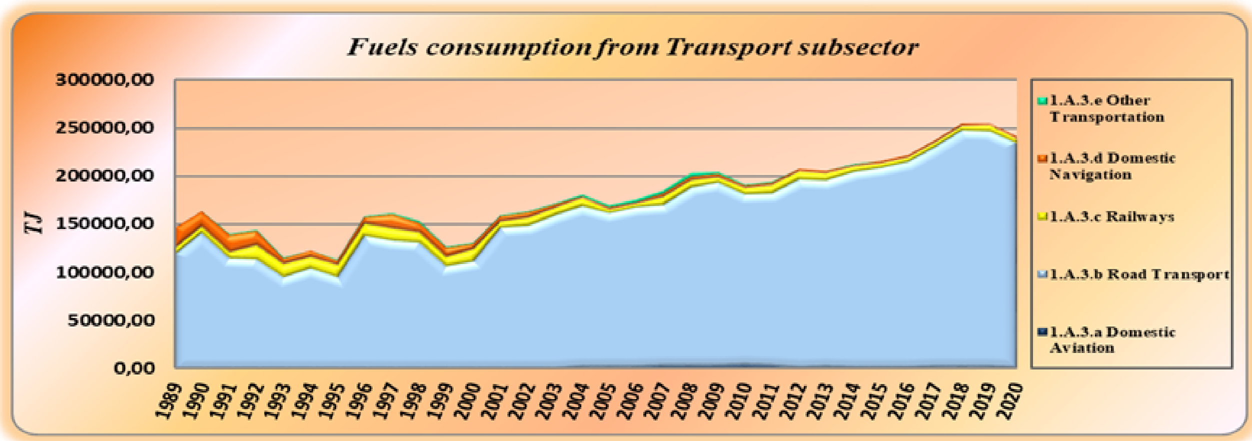
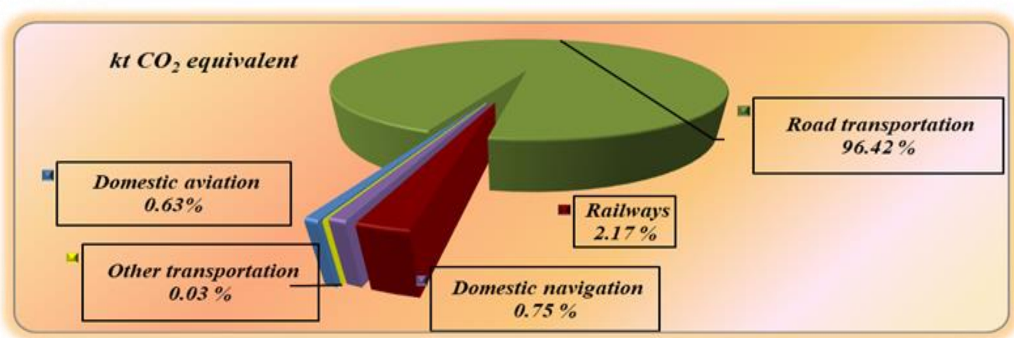


Figure 3.35 The contribution of the emissions from different categories of Transport Subsector in 2020



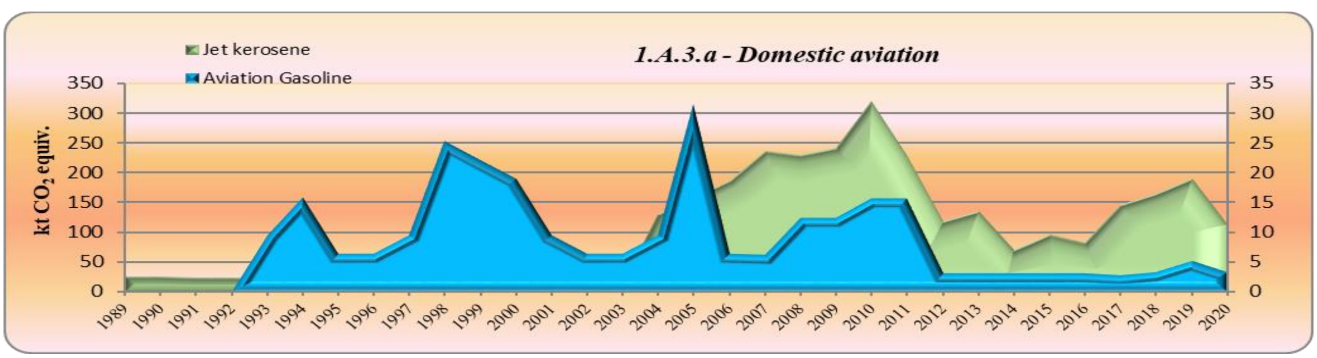
3.2.7.2 Domestic Aviation (CRF 1.A.3.a)

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 2020 year, the Domestic Aviation related emissions represents 0.63 % of total emissions from the Transport sector

(18,401.03 kt CO_2 equivalent). In the period 1989-2003 emissions remains broadly constant, the fuel consumption being constant. Starting with 2004 in the Domestic Aviation category due to the economic country development and intern and international tourism, more flights took place, and therefore fuel consumption and, implicitly, emissions, have been increased. Between 2007 - 2019 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 CRF 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 3.36 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 - 2020, 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.

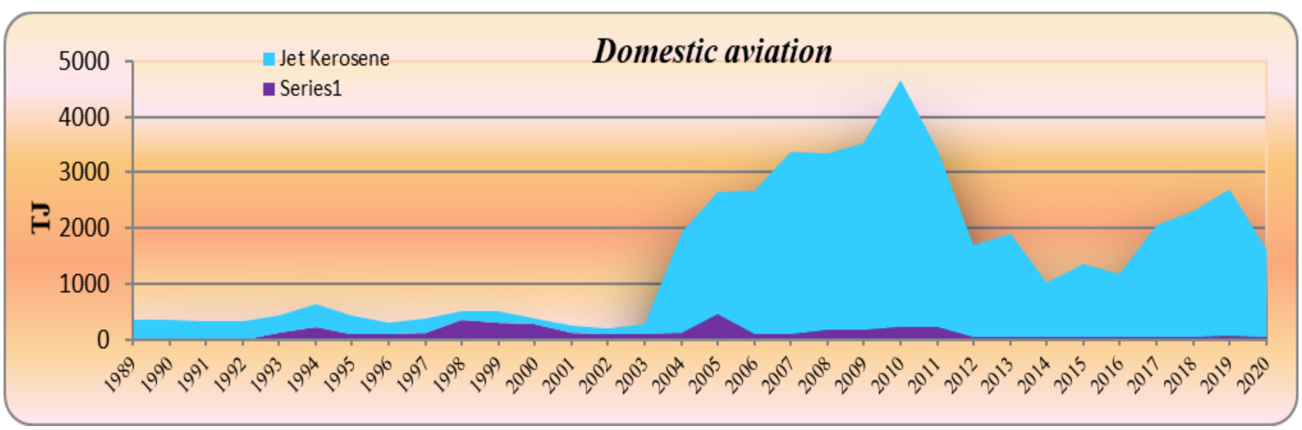
Default emission factor (kg/TJ) for all fuels	
CH_4	**N_2O**
0.5	2

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 ~~.~~3.3). 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 3.3). 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 1989-2020 period IEA/Eurostat Questionnaire data have been used. For the 2004-2006 period, fuel consumption data were not available, they being collected through extrapolations based on 2007 year fuel consumption data and LTO data on 2004 - 2007 period; for 2007 - 2020 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 3.3).

Figure 3.37 Contribution of fuels consumption from Domestic Aviation category



3.2.7.2.3 Uncertainties 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 6.3.

3.2.7.2.4 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 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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

In 2012 year, 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.

The unconformities noted were solved of the 2012 NGHGI; they are described in the Chapter 3.2.7.2.5 – 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 their solving are described at the Chapter 3.2.7.2.5 – Source-specific recalculations, including changes made in response to the review process.

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 6.3.

3.2.7.2.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

No recalculations were performed due to the activity data changes.

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

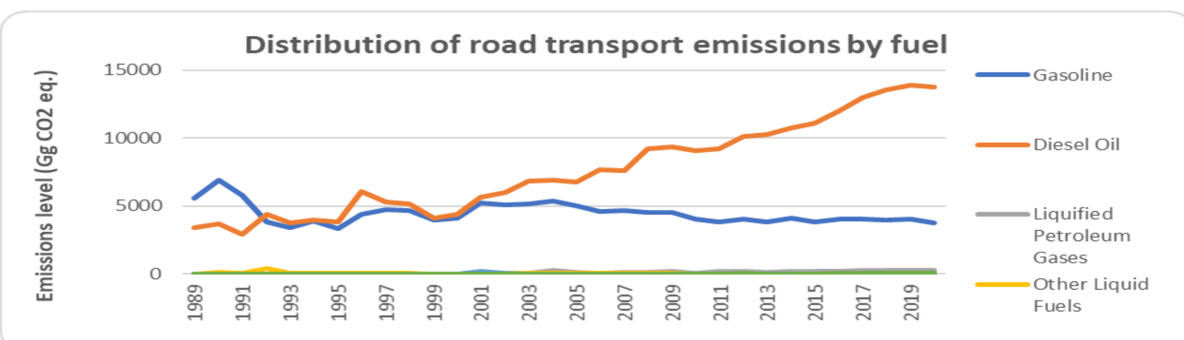
Implementation requirements and future recommendations consistent with the 2006 IPCC.

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

3.2.7.3.1 Category description

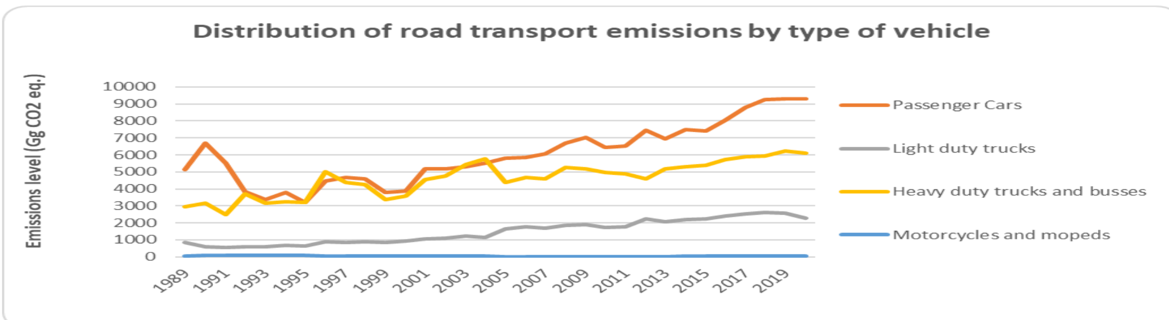
Road Transport category, is a key category, by level, trend, including LULUCF and excluding LULUCF criteria. Road Transport category includes emissions from all types of vehicles, light-duty vehicles such as automobiles and light trucks, and heavy-duty vehicles such as tractor trailers and buses; on-road 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 3.38 Distribution of Road transportation emissions by fuel (Gg CO_2 eq.)



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.

Figure 3.39 Distribution of Road transportation emissions by type of vehicle (Gg CO_2 eq.)



Overall, the GHG emissions from road transport increased by 97.16% compared to base year levels being 8998,90 kt CO_2equiv in 1989 and reached levels of 17,742.4 kt CO_2 equiv. in 2020. 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 2020, emissions from passenger cars contributed to 52.32% in total Road transportation emissions and heavy duty trucks and buses with 34.48%.

Figure 3.40 Distribution of Road transportation emissions by type of vehicle (%)

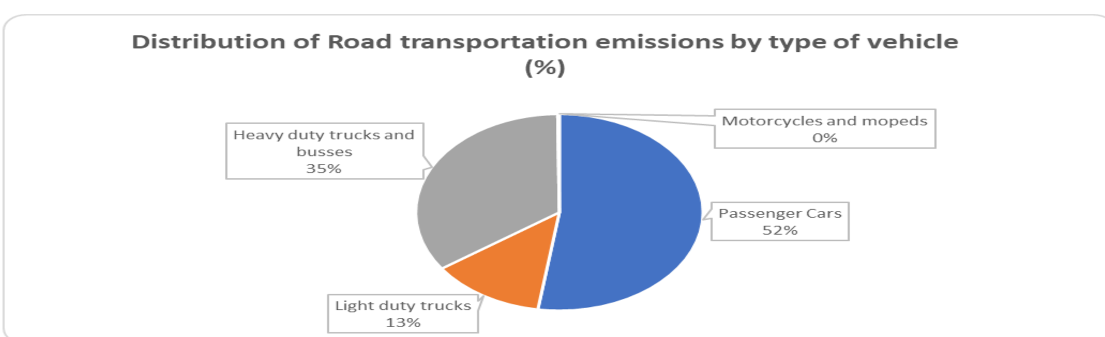
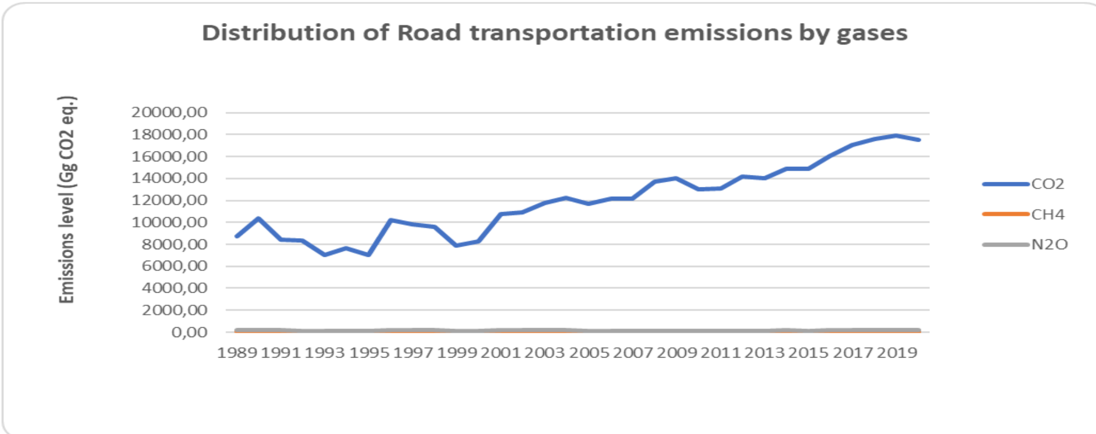


Figure 3.41 Distribution of Road transportation emissions by gases (Gg CO_2 equivalent)



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, N_2O and CH_4 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 98.66% of the total greenhouse gas emissions of the sector, in 2020. 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 2020, N_2O emissions contributed with 1.16% to the total emissions of the this sector. The changes in N_2O emissions may mainly be explained by changes in the emission of road transportation due to 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).

For the 1989–2004 period

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, 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) used, so as to be applicable to countries with older vehicle fleets. The emission factors are given 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 of the provided by the site EMEP/EEA Air Pollutant Emission Inventory Guidebook 2013 and in 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 1990-2019 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.

<u>For the 2005-2020 period</u>

Methodology

Model Copert 4, Tier 3 was used for the period 2005-2020, detailed statistics necessary to use higher level methods have allowed. For the period 2005-2020 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 2005-2020 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), Directorate for Driving Licenses and Registration Certificates (DDLRCV), 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 3.2). 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 2005-2020 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 3.13 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 (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). 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 Directorate on Driving Licenses and Vehicles Registration Certificates (DDLVRC) data compiled and processed by registered fleet RAR (see Annex 3.2).

3.2.7.3.3 Uncertainties and time- series consistency

The uncertainty associated to the GHG emissions estimates are:

Table 3.14 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.

3.2.7.3.4 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.

Following these activities there were no unconformities recorded.

In 2012, 2016, 2017, 2018, 2019, 2020 and 2021, 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, 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.

To the Road Transport, for the calculation of the emissions from CRF 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.

3.2.7.3.5 Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend

No recalculations were performed.

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

The planned improvemnets comprise:

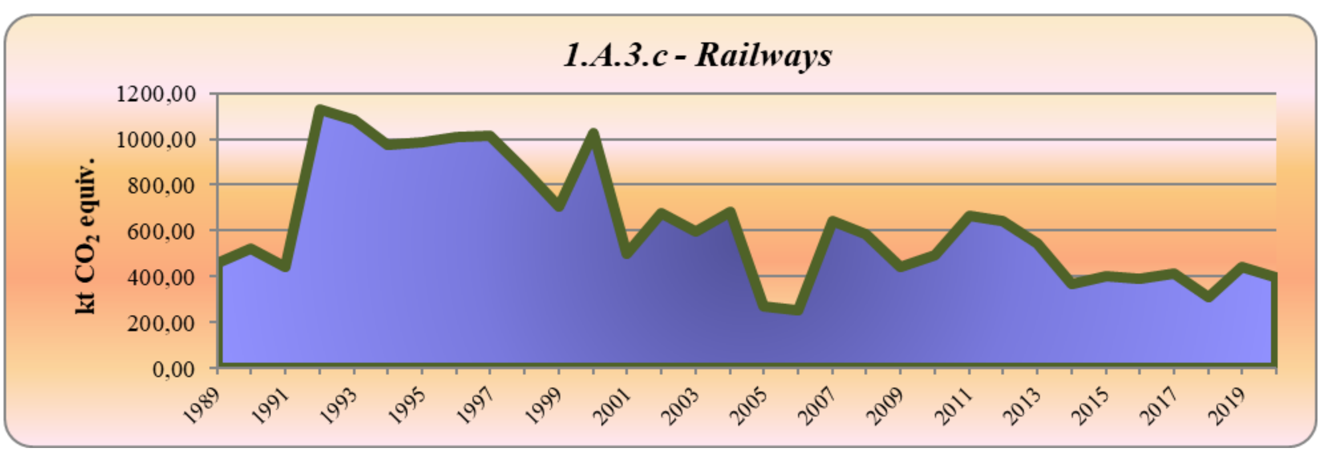
- further analyzing the issue of estimating CO_2 emissions from fossil carbon in biofuels separately, with the aim to update the approach used, as needed, as part of the next inventory submissions;
- further analyzing the approach used to characterize the emissions from lubricants combusted in two-stroke engines in road vehicles, aiming to report them under the Road transportation Subsector.

3.2.7.4 Railways (CRF 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 2020 year the emissions from Railways category represents 2.17% of total emissions from the Transport sector (18,401.03 kt 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 1989 - 2004 and 2006 - 2008 periods 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 the 2009 until 2011 the emissions have been increased due to the fuel consumption growth; for the 2012 - 2016 period, the trend of fuel consumption was decreasing. For 2018 a decrease compared to 2017 has been observed, due to the fuel consumption and domestic trips number decreased. In 2020, fuel consumption decreased by 9.47% compared to 2019.

Figure 3.42 GHG emissions Trend from Railways category for 1989 - 2020 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).

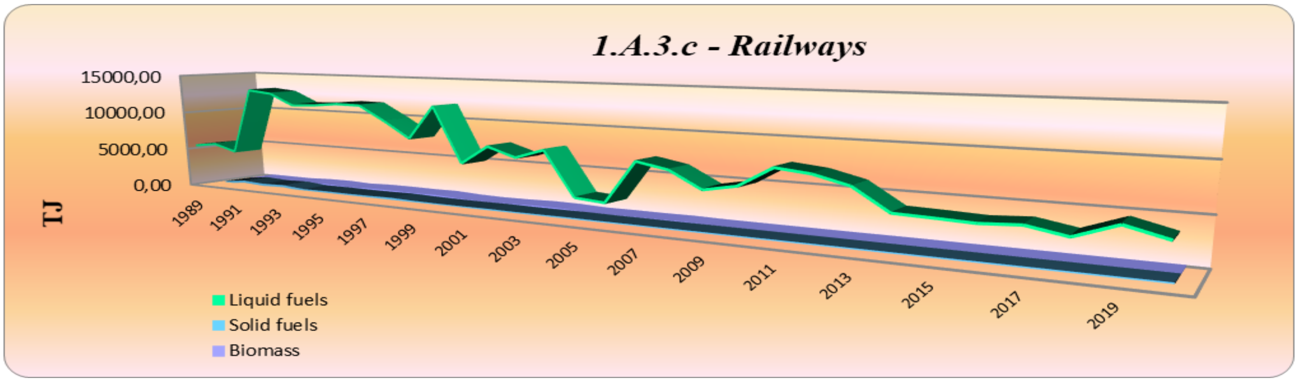
Emission factors

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, it was 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 period of 2007-2010. For the period 2007-2020 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 2007-2020 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 3.43 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 Uncertainties and time-series consistency

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

CO_2

❖ ***activity data:***

- Liquid: 5 %
- Solid: 3 %

❖ ***emision factors:***

- Liquid: 3 %
- Solid: 2 %
- 5.83 % liquid and 3.61 % solid 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 %
- Biomass: 3 %

❖ ***emision factors:***

- Liquid: 50 %

- Solid: 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 %
- Biomass: 3 %

❖ ***emision factors:***

- Liquid: 50 %
- Solid: 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 6.3.

3.2.7.4.4 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 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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

In 2012 year, 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. The unconformities noted were solved of the 2012 NGHGI; they are described in the Chapter 3.2.7.4.5 – 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 their solving are described at the Chapter 3.2.7.4.5 – Source-specific recalculations, including changes made in response to the review process.

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 6.3.

3.2.7.4.5 Category-specific recalculations, if applicable, 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:

- ***activity data***: recalculations of the activity data values for 1989 - 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;
- ***emissions factors***: recalculations of the emissions factors values for 1989 - 2019 period have been made because the country specific emissions factors have been updated;
- ***emissions***: recalculations of the CO_2 emissions, CH_4 emissions and N_2O emissions for the 1989 - 2019 period have been made due to updates of the Activity Data, Net Calorific Values and National Emission Factors.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.15 The impact of recalculations on GHG emission estimates in the Railways category (CRF 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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	5,290.37	5,575.06	5.38	390.03	411.02	5.38	0.0219	0.0231	5.39	0.1505	0.1587	5.41
1990	6,032.78	6,324.98	4.84	451.90	473.29	4.73	0.0239	0.0251	5.10	0.1623	0.1707	5.18
1995	12,137.68	12,134.26	-0.03	881.33	881.05	-0.03	0.0553	0.0553	0.00	0.3393	0.3392	-0.02
2000	12,264.65	12,477.73	1.74	903.83	919.56	1.74	0.0509	0.0518	1.73	0.3422	0.3483	1.76
2005	3,122.74	3,334.93	6.79	228.47	244.10	6.84	0.0134	0.0143	6.57	0.0815	0.0875	7.30
2007	7,686.18	7,831.78	1.89	564.03	574.79	1.91	0.0334	0.0340	1.81	0.2175	0.2216	1.91
2008	7,188.80	7,153.43	-0.49	527.54	524.78	-0.52	0.0299	0.0298	-0.52	0.2038	0.2028	-0.54
2009	5,309.92	5,362.27	0.99	393.84	397.74	0.99	0.0221	0.0223	0.98	0.1514	0.1529	0.98
2010	6,059.00	6,033.77	-0.42	444.02	442.19	-0.41	0.0251	0.0250	-0.43	0.1726	0.1718	-0.46
2015	4,788.80	4,584.03	-4.28	333.36	362.92	8.86	0.0199	0.0190	-4.23	0.1354	0.1298	-4.17
2016	4,441.58	4,453.82	0.28	353.06	353.93	0.25	0.0185	0.0186	0.20	0.125609	0.125592	-0.01
2017	4,626.85	4,676.85	1.08	370.55	374.11	0.96	0.0193	0.0195	0.78	0.132196	0.132205	0.01
2018	4,027.59	4,003.85	-0.59	280.33	278.63	-0.61	0.0167	0.0167	-0.43	0.114481	0.114460	-0.02
2019	5,435.70	5,439.26	0.07	393.77	394.03	0.06	0.0226	0.0226	0.05	0.1548	0.1548	0.00
2020		4.498.93			360.38			0.0187			0.1279	

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

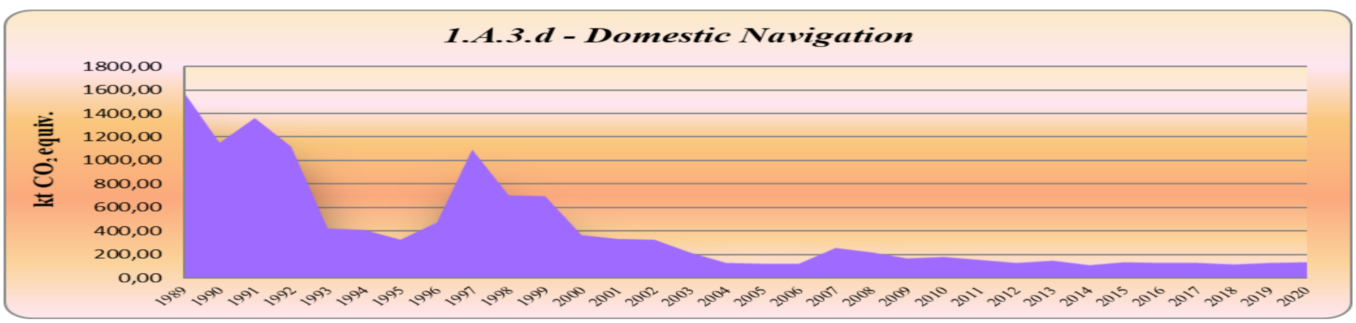
No source-specific planned improvements are envisaged.

3.2.7.5 Domestic Navigation(CRF 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). In the 2020 year the emissions from Domestic Navigation category represents 0.75 % of total emissions from the Transport sector (18,401.03 kt CO_2 equiv.). In the Domestic Navigation category, the decline of economic and industrial activities and number of maritime races have led to a reduction in fuel consumption and GHG emissions.

Figure 3.44 GHG emissions trend from Domestic Navigation category for 1989 – 2020 period



3.2.7.5.2 Methodological issues

The GHG emissions from Domestic Navigation category are calculated according to the 2006 IPCC and the 2000 IPCC GPG. The activity data are provided by IEA/Eurostat Questionnaire 2020 and values for emissions factors used are provided by the 2006 IPCC Guidelines. The Tier1 and Tier 2 methods were used and are presented in section 3.2.7.4.2.

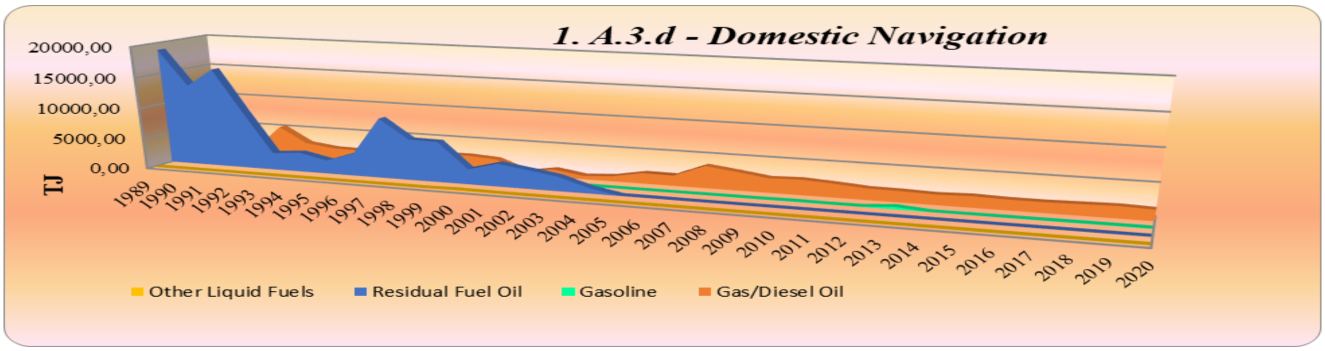
Emission Factors

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.

Activity Data

The activity data for Domestic Navigation category are provided by IEA/Eurostat Questionnaire.

Figure 3.45 Contribution of fuels consumption from Domestic Navigation category for 1989-2020 period



3.2.7.5.3 Uncertainties 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 6.3.

3.2.7.5.4 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 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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

In 2012 year, 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. The unconformities noted were solved of the 2012 NGHGI; they are described in the Chapter 3.2.7.5.5 – 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 their solving are described at the Chapter 3.2.7.5.5 – Source-specific recalculations, including changes made in response to the review process.

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 6.3.

3.2.7.5.5 Category-specific recalculations, if applicable, 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:

- ***activity data***: recalculations of the activity data values for 1989 - 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;
- ***emissions factors***: recalculations of the emissions factors values for 1989 - 2019 period have been made because the country specific emissions factors have been updated;
- ***emissions***: recalculations of the CO_2 emissions, CH_4 emissions and N_2O emissions for the 1989 - 2019 period have been made due to updates of the Activity Data, Net Calorific Values and National Emission Factors.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.16 The impact of recalculations on GHG emission estimates in the Domestic Navigation category (CRF 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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	20,435.55	20,269.21	-0.81	1,587.61	1,575.56	-0.76	0.143049	0.141884	-0.81	0.040871	0.040538	-0.81
1990	14,850.70	14,688.75	-1.09	1,151.34	1,139.63	-1.02	0.103955	0.102821	-1.09	0.029701	0.029377	-1.09
1995	4,291.56	4,294.54	0.07	325.74	326.00	0.08	0.030041	0.030062	0.07	0.008583	0.008589	0.07
2000	4,715.60	4,803.16	1.86	358.00	364.72	1.88	0.032680	0.033294	1.88	0.009316	0.009491	1.89
2005	1,738.87	1,738.70	-0.01	128.38	128.37	-0.01	0.012172	0.012171	-0.01	0.003478	0.003477	-0.01
2007	3,585.35	3,537.21	-1.34	264.59	261.55	-1.15	0.024775	0.024760	-0.06	0.007079	0.007074	-0.07
2008	3,263.50	2,974.64	-8.85	236.62	218.39	-7.70	0.020909	0.020822	-0.41	0.005978	0.005949	-0.48
2009	2,306.08	2,306.17	0.00	171.12	171.13	0.01	0.016143	0.016143	0.00	0.004612	0.004612	0.00
2010	2,493.39	2,499.92	0.26	182.64	183.12	0.26	0.017454	0.017499	0.26	0.004987	0.005000	0.26
2015	1,763.71	1,764.20	0.03	139.78	139.81	0.03	0.012346	0.012349	0.03	0.003527	0.003528	0.03
2016	1,641.49	1,643.03	0.09	130.67	130.77	0.08	0.011490	0.011501	0.09	0.003283	0.003286	0.09
2017	1,641.43	1,644.09	0.16	131.40	131.59	0.14	0.011490	0.011509	0.16	0.003283	0.003288	0.16
2018	1,757.21	1,761.25	0.23	122.41	122.70	0.24	0.012300	0.012329	0.23	0.003514	0.003522	0.23
2019	1,863.84	1,868.51	0.25	135.03	135.36	0.25	0.013047	0.013080	0.25	0.003728	0.003737	0.25
2020		1,714.93			137.16			0.012005			0.003430	

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

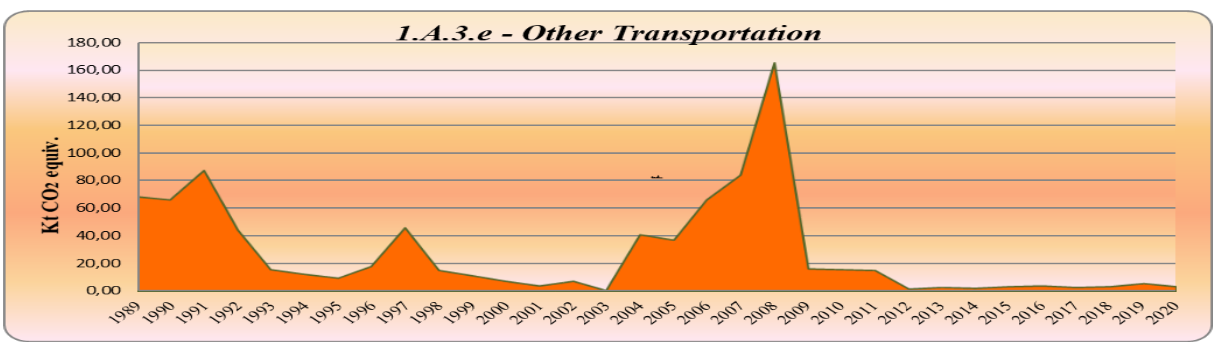
No source-specific planned improvements are envisaged.

3.2.7.6 Other transportation- (CRF 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 2020 year the emissions from Other Transportation category represents 0.02 % of total emissions from the Transport sector (18,401.03 kt CO_2 equivalent).

Figure 3.46 The GHG emissions from Other Transportation category for 1989 – 2020 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 Tier1 and Tier 2 methods were used and are presented in the section 3.2.7.4.2.

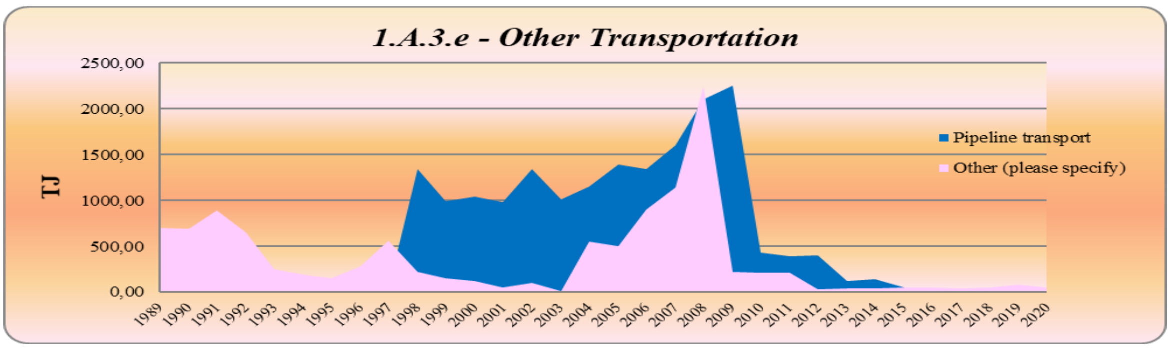
Emission Factors

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 3.47 Contribution of fuel consumption from Other Transportation category for 1989 -2020 period



3.2.7.6.3 Uncertainties 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 6.3.

3.2.7.6.4 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 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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission. In 2012 year, 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. The unconformities noted were solved of the 2012 NGHGI; they are described in the Chapter 3.2.7.6.5 – 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 their solving are described at the Chapter 3.2.7.6.5 – Source-specific recalculations, including changes made in response to the review process. 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 6.3.

3.2.7.6.5 Category-specific recalculations, if applicable, 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:

- ***activity data***: recalculations of the activity data values for 1989 - 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;
- ***emissions factors***: recalculations of the emissions factors values for 1989 - 2019 period have been made because the country specific emissions factors have been updated;

- ***emissions***: recalculations of the CO_2 emissions, CH_4 emissions and N_2O emissions for the 1989 - 2019 period have been made due to updates of the Activity Data, Net Calorific Values and National Emission Factors.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.17 The impact of recalculations on GHG emission estimates in the Other Transportation category (CRF 1.A.3.e)

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	710.37	710.38	0.00	67.51	67.51	0.00	0.0216	0.0216	0.00	0.002736	0.002736	0.00
1990	700.39	700.39	0.00	65.69	65.69	0.00	0.0213	0.0213	0.00	0.002671	0.002671	0.00
1995	195.13	195.13	0.00	13.0897	13.0925	0.02	0.0015	0.0015	0.00	0.000237	0.000237	-0.01
2000	1,167.09	1,167.09	0.00	65.26	65.30	0.06	0.0026	0.0026	0.00	0.000257	0.000257	0.00
2005	1,898.19	1,898.18	0.00	113.25	113.25	0.00	0.0168	0.0168	0.00	0.001785	0.001785	0.00
2007	2,746.99	2,747.80	0.03	169.79	169.97	0.10	0.038188	0.038191	0.01	0.003856	0.003860	0.08
2008	4,353.77	4,353.54	-0.01	278.28	278.27	0.00	0.0751	0.0751	0.00	0.007436	0.007435	-0.01
2009	2,470.93	2,471.91	0.04	140.35	140.42	0.05	0.0082	0.0083	0.39	0.000956	0.000959	0.33
2010	626.44	648.20	3.47	37.83	39.41	4.18	0.0068	0.0075	10.62	0.000657	0.000727	10.60
2015	94.16	97.67	3.73	5.95	6.20	4.18	0.0015	0.0016	7.61	0.000148	0.000159	7.60
2016	89.37	94.42	5.64	5.79	6.15	6.24	0.0017	0.0019	9.73	0.000166	0.000182	9.72
2017	46.87	51.05	8.91	3.21	3.51	9.33	0.0012	0.0014	11.05	0.000121	0.000134	11.05
2018	56.64	61.95	9.37	3.91	4.29	9.72	0.0015	0.0017	11.09	0.000149	0.000166	11.09
2019	75.21	83.85	11.49	5.33	5.95	11.60	0.0024	0.0027	12.02	0.000230	0.000258	12.02
2020		64.10			4.41			0.0017			0.000169	

3.2.7.6.6 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 (CRF 1.A.4)

3.2.8.1 Category description

CRF 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 and including 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 CRF category 1.A.4 Other is 8.58% in the base year and 18.80% for the year 2020 (about 12,077.33 kt CO_2 equiv.).

Figure 3.48 GHG emissions from 1.A.4 – Other, by category

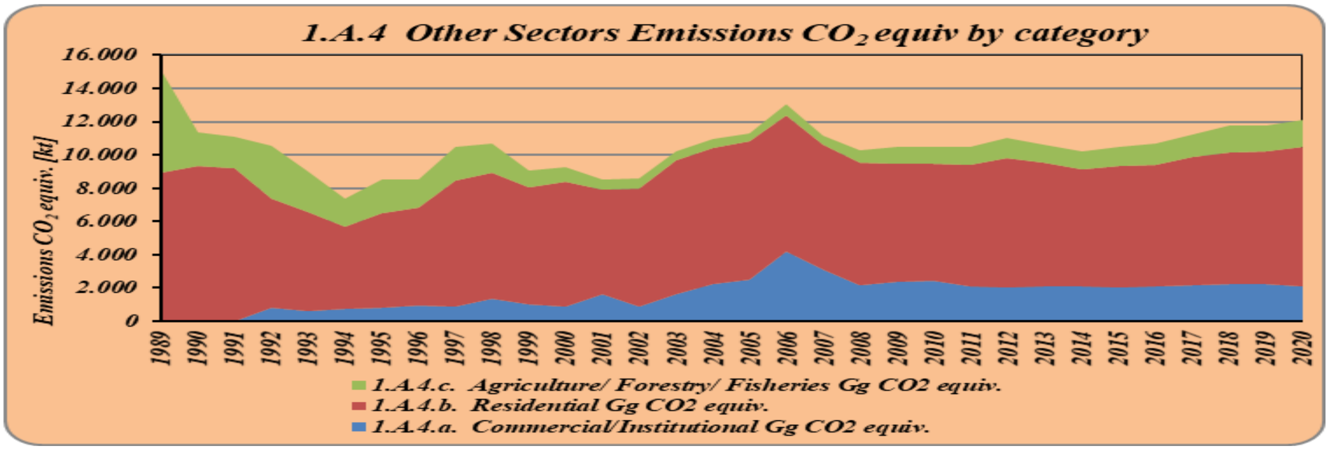
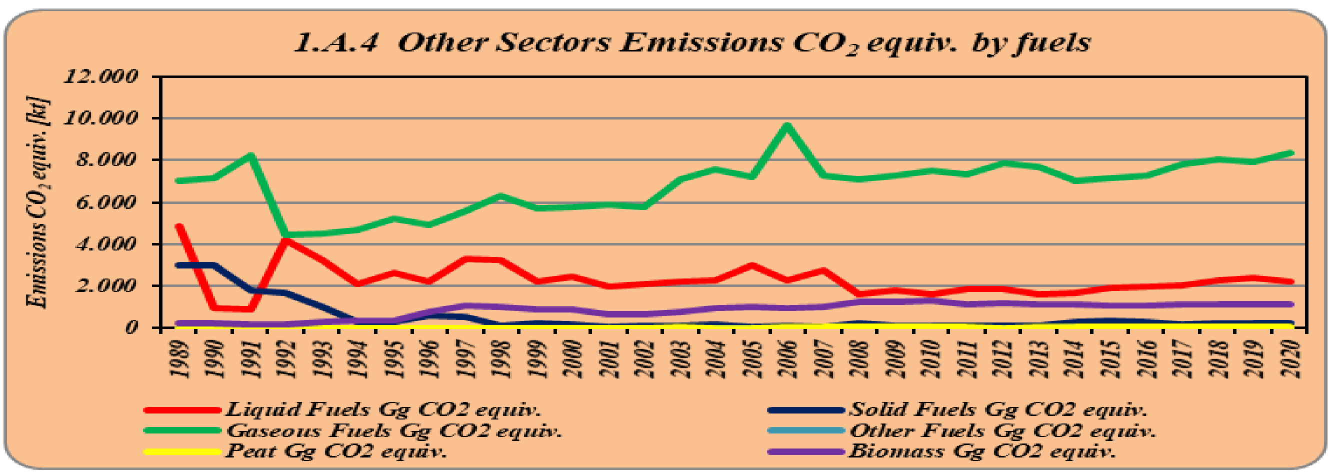


Figure 3.49 GHG emissions from 1.A.4 – Other, by fuels

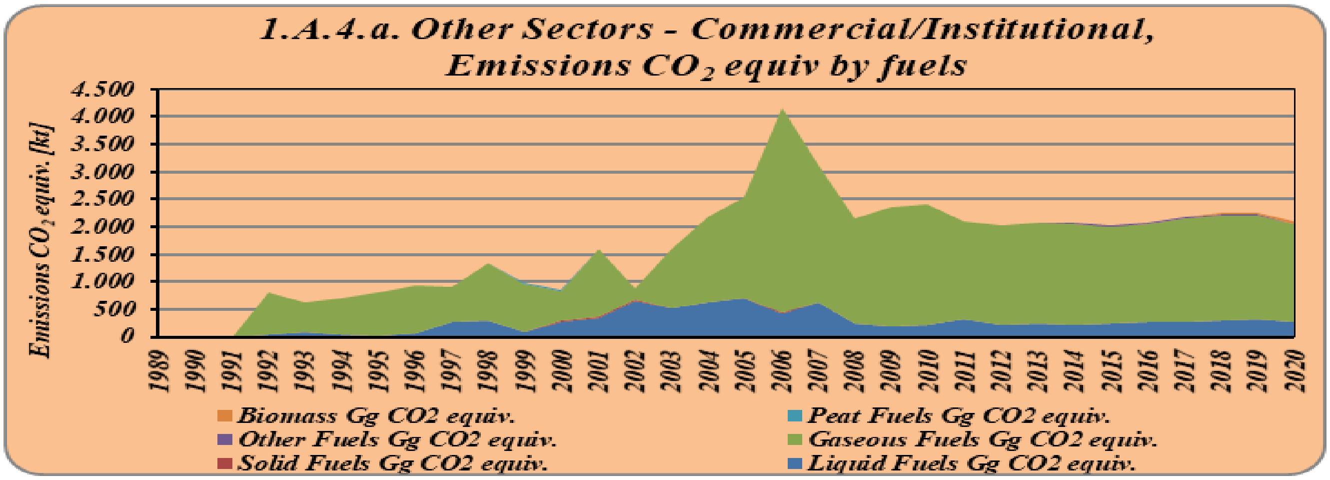


3.2.8.2 Fuel combustion, Other Sectors – Commercial/Institutional (CRF 1.A.4.a)

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 17.31%, current year, 2020. The contribution of this category is about 2,090.24 kt CO_2 equiv., in 2020. It is observed a main contribution of the natural gas usage as fuel in this activity category, mostly on the period 2003-2020. 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 (CRF sector 1.A.).

Figure 3.50 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 Uncertainties 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.

3.2.8.2.4 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.

3.2.8.2.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

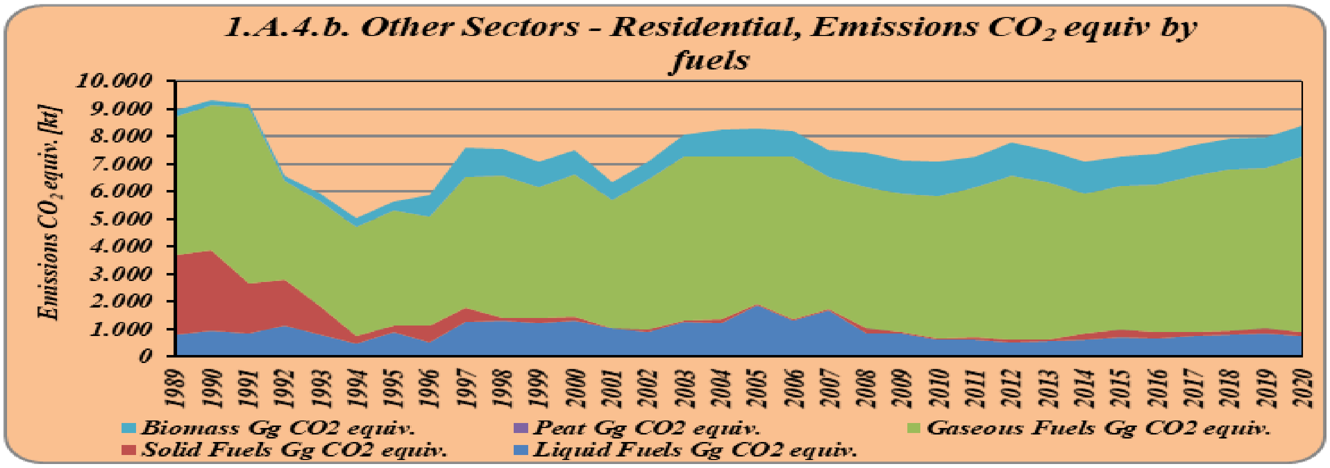
We have done an analysis and we have not identified other ways to improve the quality of the estimates of emissions. In accordance with the 2006 IPCC methodology, we are using the Tier 2 approach in estimation of CO_2 emissions.

3.2.8.3 Fuel combustion, Other Sectors – Residential (CRF 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 59.34% - base year to the 69.27%, current year, 2020. The contribution of this category is about 8,366.10 kt CO_2 equiv., in 2020. 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 (CRF sector 1.A.).

Figure 3.51 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 Uncertainties 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.

3.2.8.3.4 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.

3.2.8.3.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

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

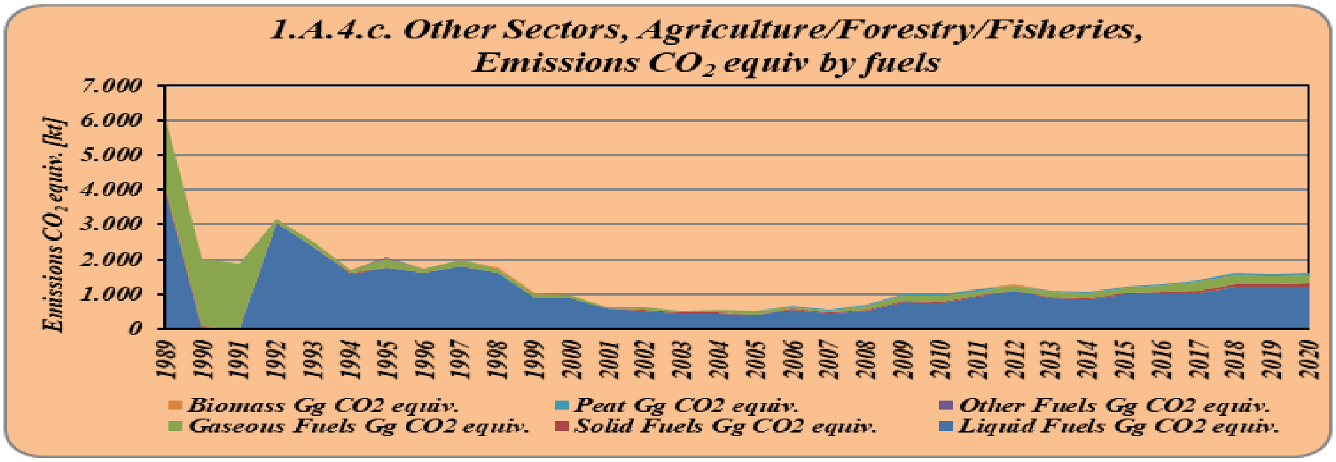
We have done an analysis and we have not identified other ways to improve the quality of the estimates of emissions. In accordance with the 2006 IPCC methodology, we are using the Tier 2 approach in estimation of CO_2 emissions.

3.2.8.4 Fuel combustion, Other Sectors – Agriculture/ Forestry/ Fisheries (CRF 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 (CRF 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 40.66% - base year to the 13.42%, current year, 2020. The contribution of this category is about 1,620.99 kt CO_2 equiv., in 2020. It is observed a main contribution of the liquid fuel combustion in this activity category, on the entire time-series.

Figure 3.52 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 Uncertainties 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.

3.2.8.4.4 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.

3.2.8.4.5 Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend

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.

3.2.8.4.6 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) - (CRF 1.A.5)

CRF category 1.A.5. Other sectors (Not specified elsewhere), as result of T1 approach is a CO_2 key category by liquid – level, excluding and including LULUCF and CO_2 key category by solid fuel - trend, excluding and including LULUCF. The fuel consumption in the following subcategories is included in this category:

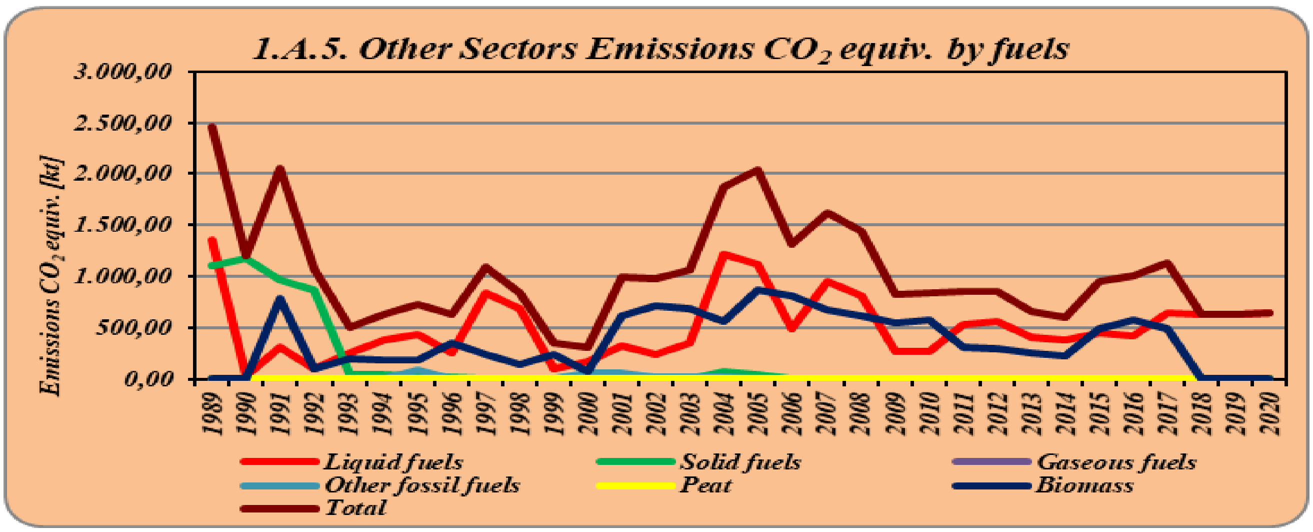
- ❖ Stationary;
- ❖ Mobile.

3.2.9.1 Other Sectors (Not specified elsewhere) - Stationary (CRF 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 (CRF 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 1.01%, current year, 2020. The contribution of this category is about 650.08 kt CO_2 equiv., in 2020. It is observed a main contribution of the liquid usage as fuel in this activity category.

Figure 3.53 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 Uncertainties 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.

3.2.9.1.4 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.

3.2.9.1.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

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.

3.2.9.1.6 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 (CRF 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 (CRF 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 2020 GHG emissions from the Fugitive Emissions from Fuels Subsector accounted for 8,584.68 kt CO_2 equivalent, which represent 7.81% 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 41,667.11 kt CO_2 equivalent, which represent 13.57 % of the total national GHG emissions in this year (see in the table below).

Table 3.18 The contribution of Fugitive Emissions from Fuels Subsector emissions to the total GHG in Romania, for 1989–2020 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	307,045.72	41,667.11	13.57
1990	249,696.53	30,364.96	12.16
1995	184,936.24	24,395.37	13.19
2000	138,979.50	16,130.53	11.61
2005	146,902.60	16,373.43	11.15
2007	151,887.14	13,683.29	9.01
2008	147,982.51	13,055.14	8.82
2009	127,058.67	11,873.06	9.34
2010	122,862.63	11,382.89	9.26
2011	129,627.15	11,345.47	8.75
2012	127,537.24	11,113.11	8.71

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	116,059.32	10,515.06	9.06
2014	115,292.89	9,827.99	8.52
2015	114,817.69	9,852.05	8.58
2016	113,456.38	9,424.56	8.31
2017	116,701.16	9,208.85	7.89
2018	117,597.48	9,041.54	7.69
2019	113,939.38	9,212.56	8.09
2020	109,934.33	8,584.68	7.81

The GHG emissions from Oil and Natural Gas category, are responsible for 36.38 % of total GHG emissions from Fugitive Emissions subsector, the Solid Fuels category contributes with 63.62 %. The GHG emissions from 1.B.2. - Oil and Natural Gas and 1.B.1. - Solid Fuels are key category sources (excluding and including LULUCF), by Level and Trend for CH_4 emissions from 1.B.1 Solid Fuels source category, by Trend for CH_4 emissions from *1.B.2.a. - Oil and Natural Gas - Oil* source category, and by Level and Trend for CH_4 emissions from *1.B.2.b. - Natural Gas* source category. The GHG emissions from *1.B.2.c - Fugitive Emissions from Fuels - Venting and Flaring* source category are key category sources (excluding and including LULUCF) by Level for CH_4 emissions.

Figure 3.54 Total GHG emissions from Fugitive Emissions from Fuels Subsector for 1989–2020 period

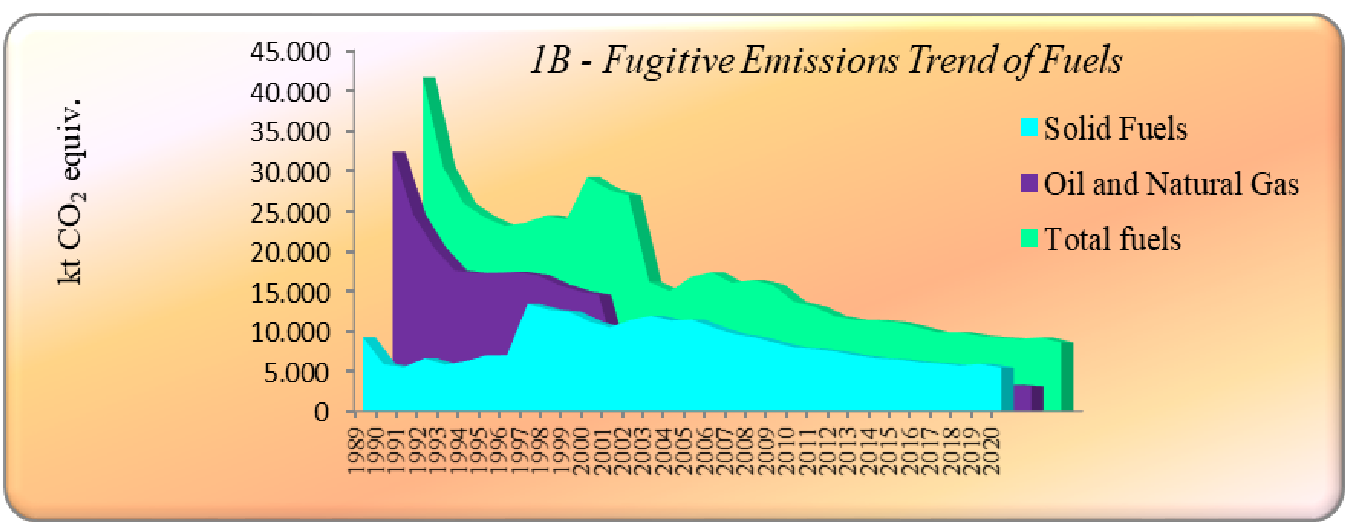
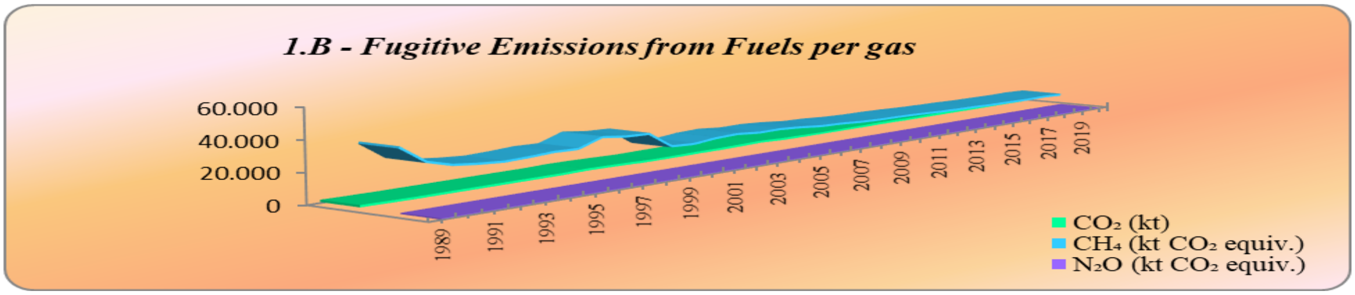


Table 3.19 The contribution, per gas, in total GHG emissions from Fugitive Emissions from Fuels Subsector, for the 1989 – 2020 period

Year	Total emissions from Fugitive Emissions from Fuels Subsector [kt CO_2 equiv.]	CH_4 emissions		CO_2 emissions		N_2O emissions	
		kt CO_2 equiv.	%	kt CO_2	%	kt CO_2 equiv.	%
1989	41,667.11	40,295.00	98.67	1,367.99	1.32	4.12	0.010
1990	30,364.96	29,193.10	98.46	1,168.36	1.53	3.49	0.012
1995	24,395.37	23,316.74	98.17	1,075.53	1.81	3.09	0.013
2000	16,130.53	15,181.68	94.11	947.43	5.87	1.42	0.009
2005	16,373.43	15,229.42	93.01	1,142.69	6.98	1.33	0.008
2007	13,683.29	12,838.45	93.82	843.70	6.17	1.14	0.008
2008	13,055.14	12,372.26	94.77	681.80	5.22	1.07	0.008
2009	11,873.06	11,405.13	96.05	466.92	3.93	1.02	0.009
2010	11,382.89	10,839.16	95.22	542.76	4.77	0.97	0.009
2011	11,345.47	10,699.79	94.30	644.72	5.68	0.96	0.008
2012	11,113.11	10,267.53	92.39	844.68	7.60	0.91	0.008
2013	10,515.06	9,673.94	92.00	840.19	7.99	0.93	0.009
2014	9,827.99	9,279.37	94.41	547.70	5.57	0.92	0.009
2015	9,852.05	9,066.76	92.02	784.39	7.96	0.91	0.009
2016	9,424.56	8,588.94	91.13	834.75	8.86	0.86	0.009
2017	9,208.85	8,432.34	91.56	775.68	8.42	0.83	0.009
2018	9,041.54	8,180.20	90.47	860.52	9.52	0.82	0.009
2019	9,212.56	8,350.10	90.63	861.64	9.35	0.82	0.009
2020	8,584.68	7,790.01	90.74	793.88	9.25	0.79	0.009

The inventory preparation, including identification of key categories, preparation of uncertainty estimates and implementation of QA/ QC procedures, have been performed according to IPCC GPG 2000.

Figure 3.55 GHG emissions from Fugitive Emissions from Fuels Subsector, per gas



3.3.2 Solid Fuels (CRF 1.B.1)

3.3.2.1 Category description

The source category "Solid Fuels" consists of three sub-source categories:

❖ "Coal Mining and Handling" *(CRF 1.B.1.a*),

❖ "Solid Fuel Transformation" (*CRF 1.B.1.b*), and

❖ "Other" (*CRF 1.B.1.c*).

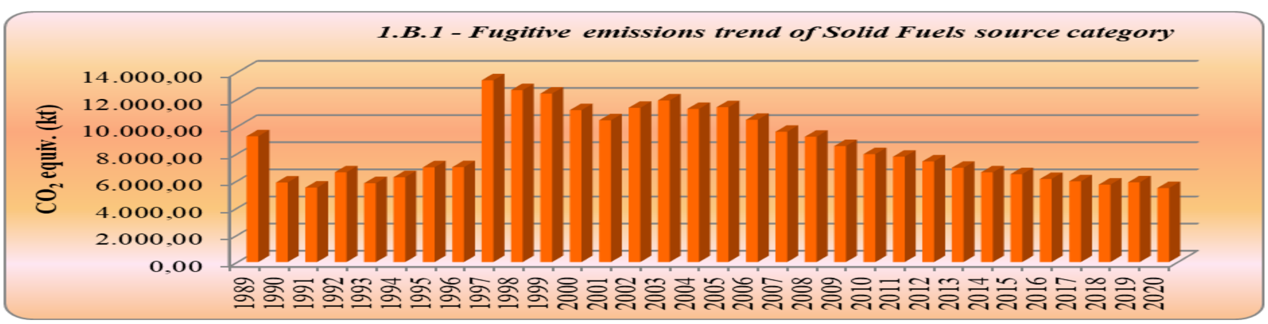
3.3.2.1.1 Coal mining and handling (CRF 1.B.1.a)

❖ 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. 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 - 2020 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 - 2020 years. 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, a process of conservation and closing of unprofitable mines and quarries started. Closing inefficient mines, led to a situation where only about 30% of the total geological reserves of coal is subject to the activity. Emissions have started to increase starting with 2000, 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). From 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 2018, coal (including coke) decreased in comparison with 2017. 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% (Source – Romanian National Institute for Statistics). The trend of the CH_4 emissions from Solid Fuels category is shown in the figure below:

Figure 3.56 Fugitive Emissions of CH_4 from Solid Fuels



3.3.2.2 Methodological issues

3.3.2.2.1 Coal mining and handling (CRF 1.B.1.a)

❖ Emission: CH_4;

❖ Key source: Yes.

Underground mines *(CRF 1.B.1.a.1.)*

❖ *Mining activities (CRF 1.B.1.a.1.i);*

❖ *Post mining activities (CRF 1.B.1.a.1.ii.)*

❖ *Abandoned Underground Mines (CRF 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 – 2020 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 anyhow. For the 1989-1999 period: *Lignite Underground Coal Production (Mt):* IEA/Eurostat Questionnaire 2020 - Indigenous Production (Lignite/Brown Coal - 24 %). For the 2000 – 2020 period: *Lignite Undergound Coal Production (Mt):* IEA/Eurostat Questionnaire 2020 - Indigenous Production (Lignite/Brown Coal - 100 %). The activity data include:

1989_BAL_Romania have been used for 1989, and IEA/ Eurostat Questionnaire 2020 - for entire 1990 - 2020 time series have been used.

❖ *Underground Coal Production (Mt):* IEA/Eurostat Questionnaire 2020 - Indigenous Production (Anthracite – 100 %, Coking Coal – 100 %, Other Bituminous Coal - 100 %, Sub-bituminous Coal - 100 %, Peat - 100 %, Lignite/Brown Coal - 24 % for 1989-1999 time series and Lignite/Brown Coal - 100 % for 2000 - 2020 time series).

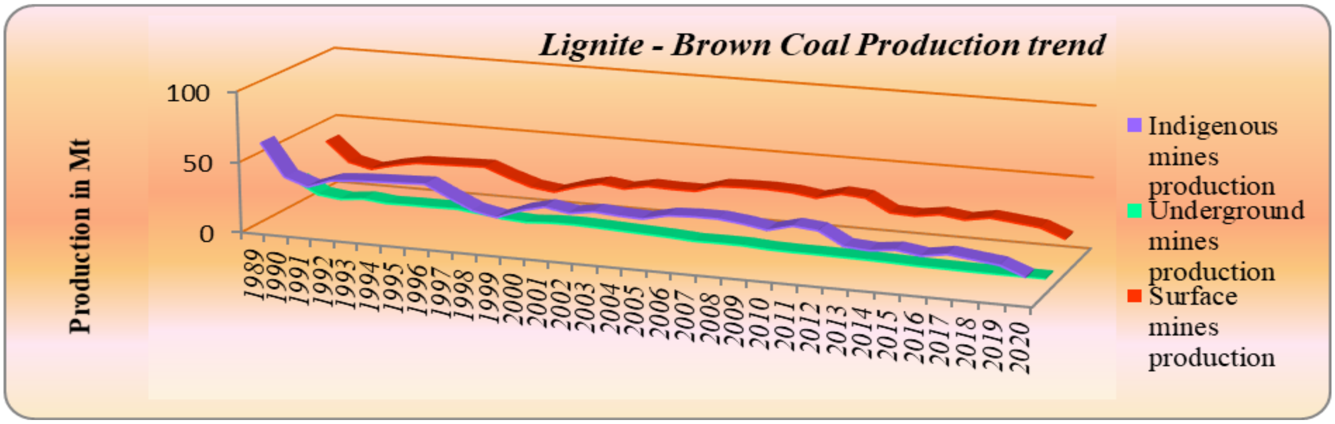
Emission factor

❖ *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 3.57 Lignite – Brown Coal Production trend



***Abandoned Underground Mines** (CRF 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 from the Jiu valley in 2013, there are still four mines of the National Hard Coal Company (CNH Petrosani) that still operate: *Lonea*, *Lupeni*, *Livezeni and Vulcan*. A plan for the Lonea mine to be closed at the end of 2020 year, and for Lupeni mine by 2021 was postponed.

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 4.1.3.2, 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 3.58 Underground Mines category and Solid Fuel Transformation category emissions trend

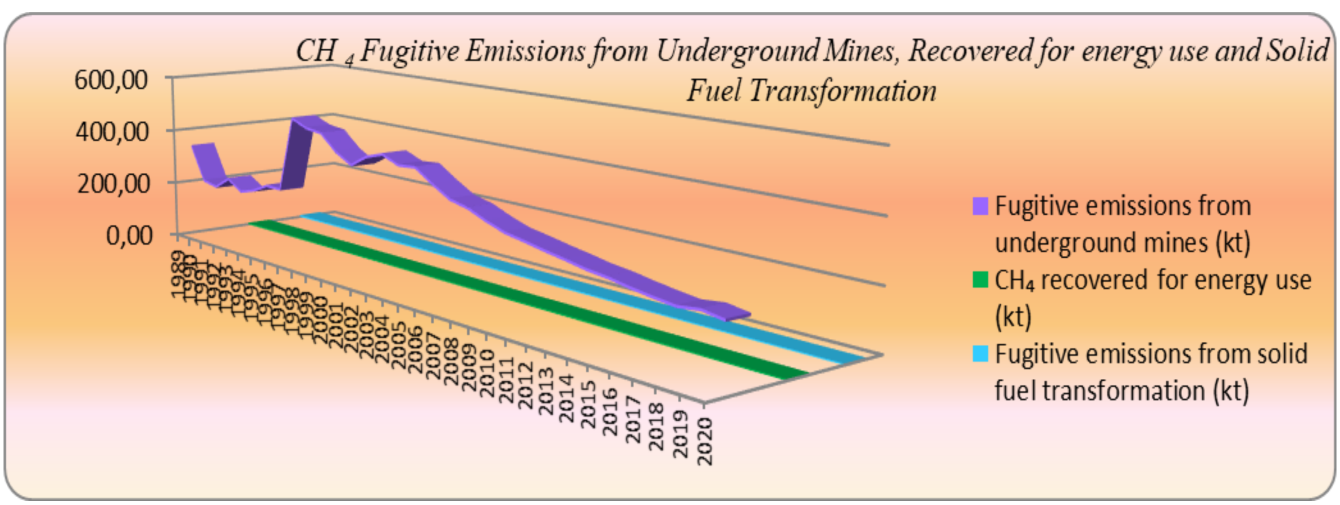


Table 3.20 Fugitive Emissions of CH_4 from Underground Mines and CH_4 Recovered for energy use

Year	Underground mines		
	CH_4 fugitive emissions (kt)	CH_4 Recovered for energy use (kt)	CH4 recovery rate (%)
1989	297.03	1.36	0.46
1990	189.12	1.25	0.66
1995	232.65	0.58	0.25
2000	415.36	0.45	0.11
2005	424.39	0.59	0.14
2007	348.61	0.58	0.17
2008	334.20	0.91	0.27
2009	309.72	0.95	0.31
2010	288.89	1.02	0.35
2011	277.60	0.93	0.34
2012	265.30	0.76	0.29
2013	254.60	0.37	0.15
2014	242.68	0.49	0.20
2015	236.12	0.55	0.23
2016	224.33	0.51	0.23
2017	215.23	0.38	0.18
2018	207.30	0.46	0.22
2019	216.01	0.45	0.21
2020	205.04	0.41	0.20

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

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 - 2020 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 anyway. For the 1989-1999 period: *Surface Coal Production (Mt):* IEA/Eurostat Questionnaire 2020 - Indigenous Production (Lignite/Brown Coal - 76 %). For the 2000 – 2020 period: *Surface Coal Production (Mt):* IEA/Eurostat Questionnaire 2020 - 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 (CRF 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 2020 - for entire 1990 – 2020 time series have been used.

- *Coking Coal Production (Mt):* IEA/Eurostat Questionnaire 2020 – Transformation Sector (Coking Coal – 100 %,).

Emission Factor

Emission Factors for the Solid Fuels transformation reporting are used.

- *Default Emission Factor*: EFDB of IPCC - Database on Greenhouse Gas Emission Factors;

❖ *The default value of 0.35 kg CH_4/t* according to EFDB of IPCC - Database on Greenhouse Gas Emission Factors has been used.

3.3.2.3 Uncertainties and time-series consistency

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

❖ ***Coal Mining and Handling sub-source category*** *(CRF 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*** *(CRF 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 6.3.

Due to the fact that all activity data were provided through the IEA/Eurostat Questionnaire 2020 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 1989-2020 is consistent.

3.3.2.4 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 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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

In 2012 year, 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.

The unconformities noted and solved as part of the 2012 NGHGI; these activities are described in the Chapter 3.3.2.5 – 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 their solving are described at the Chapter 3.3.2.5 – Source-specific recalculations, including changes made in response to the review process.

3.3.2.5 Category-specific recalculations, if applicable, 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:

❖ ***emissions***:

- recalculations have been made for the 2015 - 2016 period, and for the year 2019 for CH_4, due to an error of transcription from the spreadsheet in the CRF tables, in subcategory 1.B.1.a.iii – Abandoned underground mines.

The impact of recalculations on GHG emission estimates in the category 1.B.1 – Solid fuels are presented in the table below:

Table 3.21 Change made at emissions and their effects on CH_4 emission estimates in Abandoned underground mines subcategory (CRF 1.B.1.a.1.iii)

Year	Effects of changes on emission estimates for CH_4 [Gg]		Diff [%]
	NGHGI 2021	NGHGI 2022	
1995	94.04	94.04	0.00
2000	320.30	320.30	0.00
2005	359.54	359.54	0.00
2007	295.56	295.56	0.00
2008	282.80	282.80	0.00
2009	271.83	271.83	0.00
2010	255.65	255.65	0.00
2015	214.19	221.51	3.42
2016	208.58	212.40	1.83
2017	206.48	206.48	0.00
2018	201.38	201.38	0.00
2019	196.81	211.45	7.44
2020		200.26	

3.3.2.6 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(CRF 1.B.2)

3.3.3.1 Category description

The source category "Oil and Natural Gas” is a key source of CH_4 and CO_2 emissions in terms of both emissions level and trend. 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 National Society of Oil, OMV PETROM S.A., has the exclusive right to extract oil from all of the Romanian oil-fields. 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: OMV Petrom, Amromco Energy, Romgaz, Raffles Energy, Foraj Sonde, Stratum Energy Romania LLC, Hunt Oil Company of Romania, Serinus Energy Romania, Mazarine Energy Romania, 3 operators for underground storage: Romgaz, Amgaz, Depomures, 31 companies supplying and distributing natural gas to captive consumers - the largest being Distrigaz Sud and Delgaz Grid, 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. 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 13,925 km of the transporting pipelines and of the feeding points plus over 369 km of pipelines for the international transit. According to data from the Romanian Energy Regulator Authority (RERA), in 2020, the gas distribution network in Romania reached a total length of almost 54,209 kilometers; compared to 2019, the expansion of the national natural gas distribution network by 1,950 km is noticeable, wich represents an increase of about 3.7%. During the year 2020, the national transport system has undergone the following changes:

- ✓ 8 new regulation-measuring stations were modernized;
- ✓ 3 new cathodic protection stations were put into operation, their total number reaching 1,041;
- ✓ the international transport pipeline has two new points of interconnection with the neighboring transport systems, which leads to the increase of the efficiency of the SNT operation, by increasing the import/export capacity;
- ✓ 80 new gas odorization stations were put into operation, bringing their total number to 982;
- ✓ a new gas compression station was put into operation, reaching 6.

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 2015, there were decreased of 1.2% of the crude oil production and the natural gas production increased with 0.2% compared with 2014;
- in 2016 among the primary energy resources, crude oil had the highest growth (+ 6.5%); the natural gas increased with 0.4% and the imported coke recorded an increase with 1.2%;
- 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 (Source – Romanian National Institute for Statistics).

Figure 3.59 Total GHG Oil and Natural Gas source category emissions trend

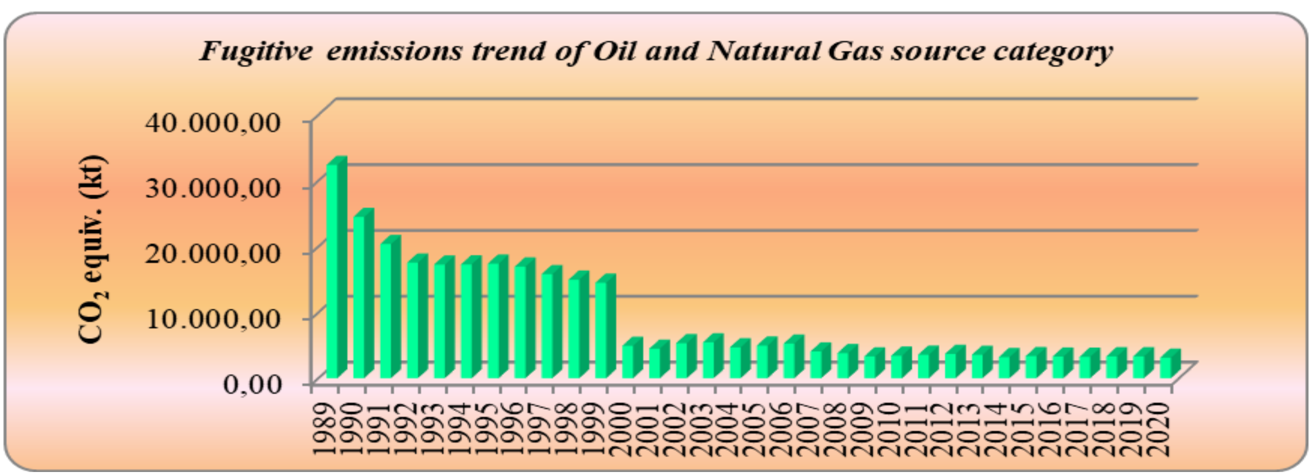
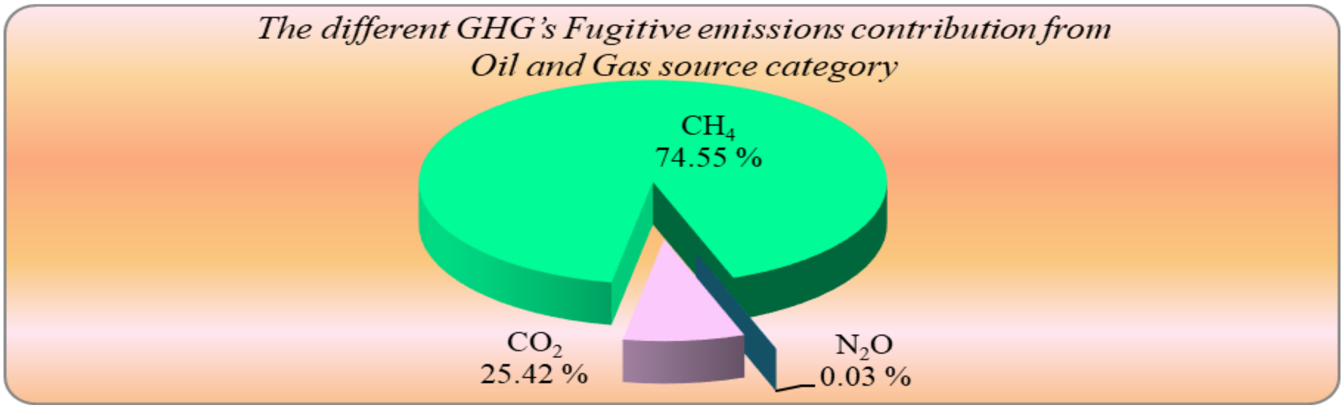


Figure 3.60 The contribution of GHG s Fugitive emission per gas from Oil and Natural Gas source category



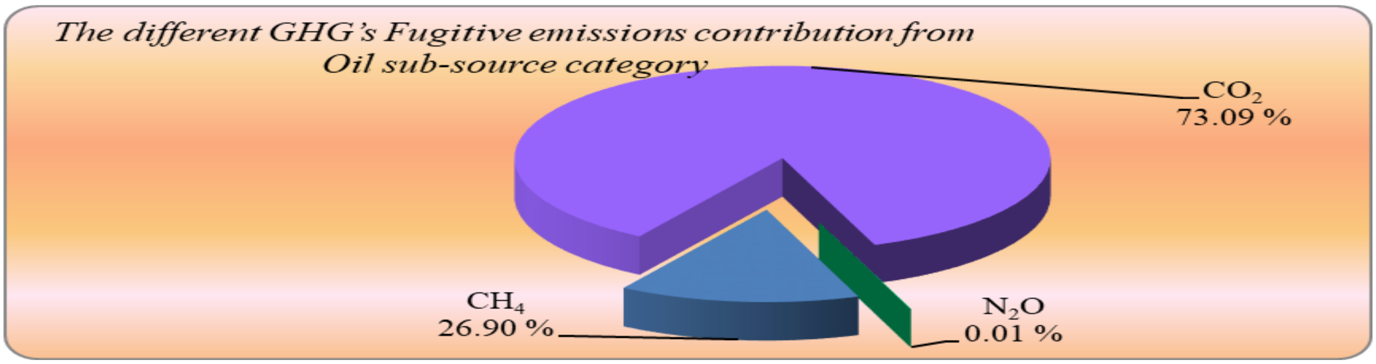
3.3.3.2 Methodological issues

3.3.3.2.1 Oil (CRF 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. ***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 GL. Thus, starting with 2019 submission the 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" (which, were used until now for entire time series) were replaced with the 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" for 2000 - 2020 period. Also, these values have been selected considering that the best available techniques/equipments used in oil industry are aligned with those used in the European Union based on applicable legislation. The formula used in the calculations is *Equation 4.2.1* from the 2006 IPCC GL, Volume. 2, Chapter 4.2.2.2, page 4.41.

Figure 3.61 The different GHG's Fugitive emissions contribution from Oil sub-source category



Exploration oil (CRF 1.B.2.a.1)

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 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	0.000051	0.00085	0.0004505	Gg per 10^3 m^3 total oil production
CO_2	0.009	0.15	*0.0795*	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 – 2020* 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	*0.000033*	-	*0.000033*	Gg per 10^3 m^3 total oil production
CO_2	*0.009*	-	*0.009*	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 2020 - for entire 1990 - 2020 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 2020 - 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 (CRF 1.B.2.a.2)

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: “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 – N.A.

For *<u>2000 – 2020</u>* 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 – N.A.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 - 2020 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 2020 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons in [kJ/kg].

Oil Transport (CRF 1.B.2.a.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 *<u>1989 – 2020</u>* 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 – N.A.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 - 2020 time series have been used. From *IEA/Eurostat Questionnaire 2020 - Indigenous Production + Import + Export:*

- ❖ Crude Oil, Natural Gas Liquids and Other Hydrocarbons;
- ❖ *NCV* - from IEA/Eurostat Questionnaire 2020 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg].

Refining / Storage (CRF 1.B.2.a.4)

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 – 2020* 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 2020 - for entire 1990 - 2020 time series have been used. From *IEA/Eurostat Questionnaire 2020* Refinery Intake (Observed):

- ❖ Crude oil, Natural Gas Liquids and Other Hydrocarbons;
- ❖ *NCV* - from IEA/Eurostat Questionnaire 2020 – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg]

Distribution of oil products (CRF 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 oil products (CRF 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 (CRF 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 1989 – 2006 period.

Tier 2 and **tier 3** combined Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 are used for 2007 – 2012 period.

Tier 3 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and *Country Specific Emission Factors* the reporting are used for 2013 - 2020 period.

Emission factor

The country specific 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

Refining Storage	
Years	**CO_2 (kt/PJ)**
2020	93.53

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for the 1990 - 2006 time series have been used. From *IEA/Eurostat Questionnaire 2020* Refinery fuel:

❖ Petroleum Coke used in refineries as catalytic regenerator

For the 2007 – 2012 time series, activity data from the refineries operators and from IEA/Eurostat Questionnaire 2020 were used.

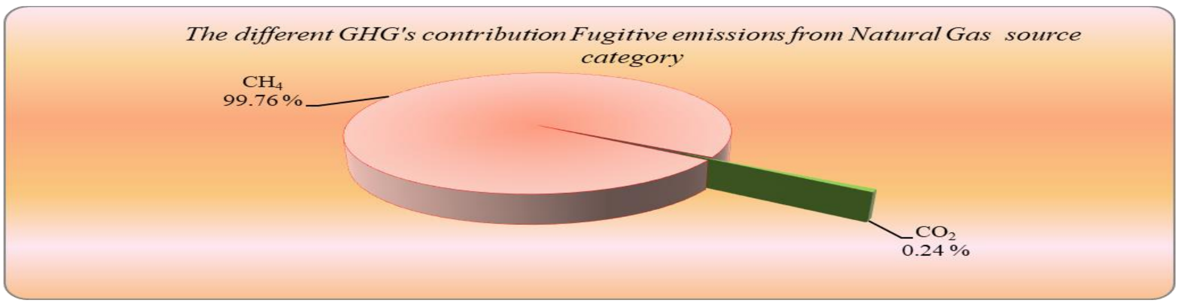
For 2013 – 2020 period, only activity data from the refineries operators were used.

3.3.3.2.2 Natural Gas (CRF 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). **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, 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. Thus, starting with 2019 submission 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’’ (which, were used until now for entire time series) were replaced with 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" for 2000 - 2020 period. 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) (CRF 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 - 2020 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 3.62 The different GHG's Natural Gas sub-source category emissions contribution



Production (CRF 1.B.2.b.2)

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: "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 – N.A.

For *2000 – 2020* period have been used:

Default Emission Factors: "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 – N.A.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 - 2020 time series have been used. From *IEA/Eurostat Questionnaire* 2020 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 (CRF 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: "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 – N.A.

For *2000 – 2020* 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 4.49, 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 – N.A.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 - 2020 time series have been used. From *IEA/Eurostat Questionnaire* 2020 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 (CRF 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 the reporting 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 – N.A.

For *2000 – 2020* 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

N_2O – N.A.

***Activity data** (Transmission)*

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 – 2020 time series have been used. From *IEA/Eurostat Questionnaire* 2020 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 – 2020* 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 2020 - for entire 1990 - 2020 time series have been used. From *IEA/Eurostat Questionnaire* 2020 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 (CRF 1.B.2.b.5)

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 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 – N.A.

For *2000 – 2020* 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 – N.A.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 - 2020 time series have been used. From *IEA/Eurostat Questionnaire* 2020 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 (CRF 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 the reporting 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 – 2020* 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 2020 for 1990-2007 time series have been used; for 2007-2020 period, the IEA/Eurostat Questionnaire 2020 and EU – ETS data have been used.

- ***Natural Gas*** **-** sheet "2a_Consumption" row 18 (Energy Sector) + sheet "2ii_TFC_EnergyUse" row 10 (Industry Sector) 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 the reporting 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 – 2020* 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 2020 - for entire 1990 - 2020 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 (CRF – 1.B.2.c.)

- Emissions: CH_4, CO_2, N_2O
- Key source: Yes

Venting Oil* and *Venting Gas (CRF – 1.B.2.c.1)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors the reporting are used.

Emission Factor - Venting Oil (CRF - 1.B.2.c.1.i)

For *1989 – 1999* period have been used:

Default Emission Factor: "Default weighted total" 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 – N.A.

For *2000 – 2020* period have been used:

Default Emission Factor: "Default weighted total" 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 – N.A.

Emission Factor – Venting Gas (CRF - 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 – N.A.

For *2000 – 2020* 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

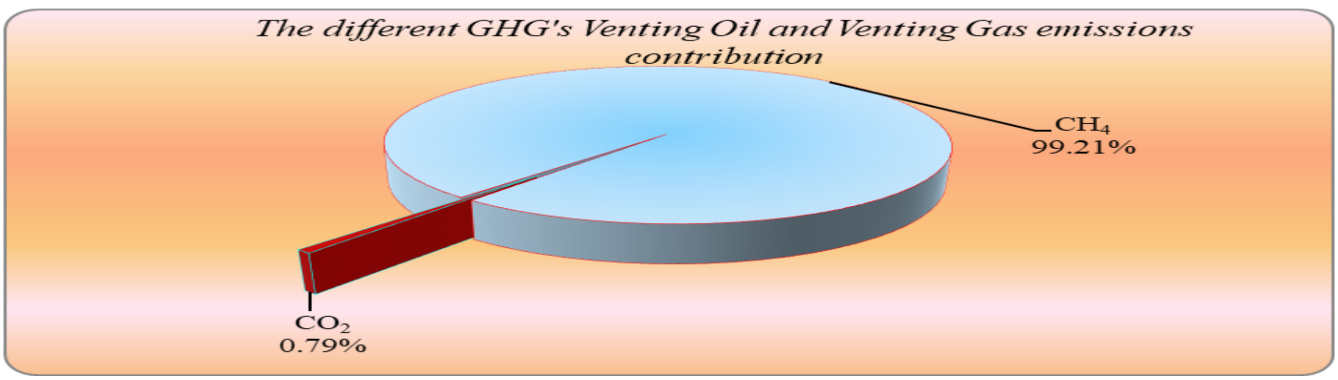
Activity Data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 - 2020 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 3.63 The different GHG's Venting oil and Venting Gas emissions contribution



Flaring Oil and Flaring Gas (CRF – 1.B.2.c.2)

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors the reporting are used.

Emission factor

Emission factor – Flaring Oil (CRF - 1.B.2.c.2.i)

For *1989 – 1999* period have been used:

Default Emission Factor: "Default weighted total" 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 – 2020_ period have been used:

Default Emission Factor: "Default weighted total" 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 (CRF 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 – 2020_ 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

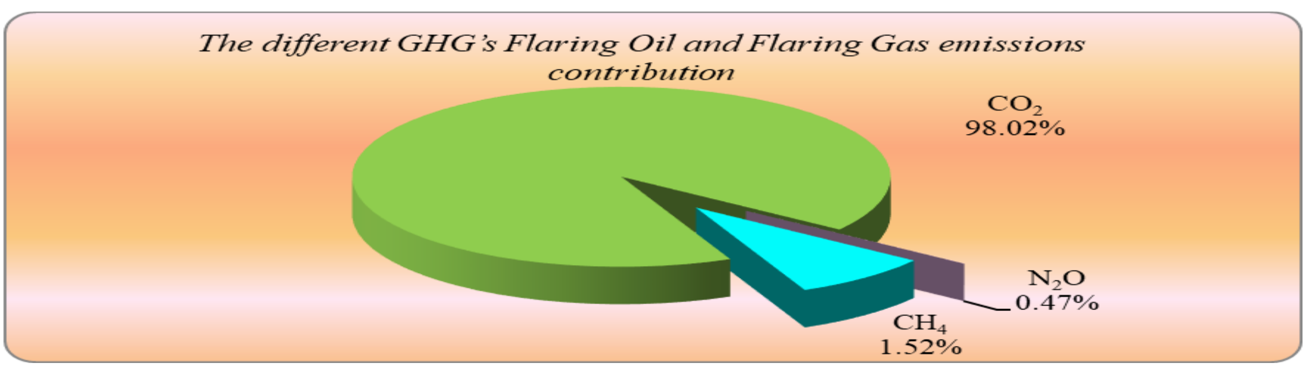
Flaring gas	lower	upper	average	units
N_2O	0.000000021	-	*0.000000021*	Gg per 10^6 m^3 gas production

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2020 - for entire 1990 - 2020 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 3.64 The different GHG's Flaring Oil and Flaring Gas emissions contribution



3.3.3.3 Uncertainties and time-series consistency

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

- ***Oil sub-source category (CRF 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 (CRF 1.B.2.b)***

- AD: 2.24 %;
- EF:
  - CO_2: 50 %;
  - CH_4: 50 %;
  - 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 (CRF 1.B.2.c.1)*****:**

- AD: 2.24 %;
- EF:
  - CO_2: 50 %;
  - CH_4: 50 %;
  - 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 (CRF 1.B.2.c.2)*****:**

- AD: 3 %;
- EF:
  - CO_2: 50 %;
  - CH_4: 50 %;
  - 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 6.3. Due to the fact that all activity data were provided through the IEA/Eurostat Questionnaire 2020 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 1989-2020 is consistent.

3.3.3.4 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 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.

Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

In 2012 year, 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.

The unconformities noted were solved as part of the 2012 NGHGI; they are described in the Chapter 3.3.3.5 – 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 their solving are described at the Chapter 3.3.3.5 – Source-specific recalculations, including changes made in response to the review process. 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 6.3.

3.3.3.5 Category-specific recalculations, if applicable, 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:

1) *Oil category (CRF 1.B.2.a)*

❖ ***Oil - Exploration (1.B.2.a.1) subcategory:***

- ***activity data***: recalculations of activity data values for 1992 – 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;
- ***emissions factors***: the Default Emission Factor values for CO_2 and CH_4, for 1989-1999 period have been modified, according to the 2006 IPCC GL for “Flaring and Venting”, volume 2, chapter 4.2.2.3, page 4.55, Table 4.2.5; also, for 2000 – 2020 period, the Default Emission Factor values for CO_2 and CH_4 have been modified according to the 2006 IPCC GL for “Flaring and Venting”, volume 2, chapter 4.2.2.3, page 4.48, Table 4.2.4;
- ***emissions***: recalculations of the CO_2 emissions and CH_4 emissions for the 1989 - 2019 period have been made due to improvements of the Activity Data and Default Emission Factors.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.22 Change made at activity data and their effects on CO_2 emission estimates CH_4 emission estimates Oil and Natural Gas, subcategory Oil - Exploration (CRF 1.B.2.a.1)

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CO_2 emission estimates [kt]		Difference [%]	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	372.84	372.84	0.00	837.30	827.76	-1.14	17.72	4.69	-73.53
1990	322.25	322.25	0.00	723.75	715.50	-1.14	15.32	4.05	-73.56
1995	284.72	282.56	-0.76	652.65	645.21	-1.14	13.81	3.66	-73.50
2000	257.82	255.54	-0.88	67.13	66.37	-1.13	1.43	0.24	-83.22
2005	234.52	232.46	-0.88	63.02	62.32	-1.11	1.34	0.23	-82.84
2007	200.93	199.05	-0.94	53.45	52.86	-1.10	1.14	0.19	-83.33
2008	193.39	191.78	-0.83	50.31	49.75	-1.11	1.07	0.18	-83.18
2009	183.78	182.79	-0.54	47.45	46.92	-1.12	1.01	0.17	-83.17
2010	175.27	174.22	-0.60	45.34	44.83	-1.12	0.97	0.16	-83.51
2011	172.87	171.58	-0.75	44.91	44.41	-1.11	0.96	0.16	-83.33
2012	162.90	161.82	-0.66	42.21	41.74	-1.11	0.90	0.15	-83.33
2013	168.66	167.88	-0.46	43.45	42.97	-1.10	0.93	0.16	-82.80
2014	165.45	164.67	-0.47	42.64	42.17	-1.10	0.91	0.15	-83.52
2015	163.57	162.68	-0.54	42.24	41.77	-1.11	0.90	0.15	-83.33
2016	155.53	154.51	-0.66	40.30	39.85	-1.12	0.86	0.15	-82.56
2017	148.57	147.72	-0.57	38.40	37.97	-1.12	0.82	0.14	-82.93
2018	146.17	145.36	-0.55	37.76	37.33	-1.14	0.80	0.14	-82.50

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CO_2 emission estimates [kt]		Difference [%]	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2019	146.15	145.01	-0.78	38.00	37.57	-1.13	0.81	0.14	-82.72
2020		140.50			36.39			0.13	

❖ ***Oil - Production (1.B.2.a.2) subcategory:***

- ***emissions***: recalculations of the CO_2 emissions for the 1992 - 2019 period have been made due to update of the Activity Data.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.23 Change made at emissions and their effects on CO_2 emissions estimates at Oil and Natural Gas, subcategory Oil - Production (CRF 1.B.2.a.2)

Year	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]
	NGHGI 2021	NGHGI 2022	
1989	25.93	25.93	0.00
1990	22.41	22.41	0.00
1995	20.21	19.05	-5.75
2000	2.06	1.93	-6.66
2005	1.94	1.81	-6.40
2007	1.64	1.53	-6.90
2008	1.55	1.45	-6.39
2009	1.46	1.40	-4.29

Year	Effects of changes on emission estimates for CO_2 [Gg]		Diff [%]
	NGHGI 2021	NGHGI 2022	
2010	1.39	1.33	-4.77
2015	1.30	1.24	-4.35
2016	1.24	1.17	-5.23
2017	1.18	1.13	-4.57
2018	1.16	1.11	-4.39
2019	1.17	1.10	-6.16
2020		1.06	

❖ ***Oil - Transport (1.B.2.a.3) subcategory:***

- ***activity data:*** recalculations of activity data values for 1989, 1995 – 2008 period and 2015 – 2018 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;
  - ***emissions***: recalculations of the CO_2 emissions and CH4 emissions for the year 1989 have been made due to update of the Activity Data.

Table 3.24 Change made at emissions and their effects on CO_2 emissions and CH_4 emissions estimates at Oil and Natural Gas, subcategory Oil - Transport (CRF 1.B.2.a.3)

Year	Effects of changes on Activity Data [PJ]		Diff. [%]	Effects of changes on CO_2 emission estimates [kt]		Diff. [%]	Effects of changes on CH_4 emission estimates [kt]		Diff. [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	372.84	1,259.26	237.75	0.01	0.02	237.75	0.06	0.19	237.75

Year	Effects of changes on Activity Data [PJ]		Diff. [%]	Effects of changes on CO_2 emission estimates [kt]		Diff. [%]	Effects of changes on CH_4 emission estimates [kt]		Diff. [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1990	974.88	974.88	0.00	0.01	0.01	0.00	0.15	0.15	0.00
1995	647.09	647.19	0.02	0.01	0.01	0.00	0.10	0.10	0.00
2000	457.05	457.17	0.03	0.01	0.01	0.00	0.07	0.07	0.00
2005	595.99	596.10	0.02	0.01	0.01	0.00	0.09	0.09	0.00
2007	558.05	558.14	0.02	0.01	0.01	0.00	0.08	0.08	0.00
2008	546.12	546.18	0.01	0.01	0.01	0.00	0.08	0.08	0.00
2009	472.87	472.87	0.00	0.01	0.01	0.00	0.07	0.07	0.00
2010	423.20	423.20	0.00	0.01	0.01	0.00	0.06	0.06	0.00
2011	405.16	405.16	0.00	0.01	0.01	0.00	0.06	0.06	0.00
2012	380.44	380.44	0.00	0.01	0.01	0.00	0.06	0.06	0.00
2013	393.88	393.88	0.00	0.01	0.01	0.00	0.06	0.06	0.00
2014	448.34	448.34	0.00	0.01	0.01	0.00	0.07	0.07	0.00
2015	440.91	441.96	0.24	0.01	0.01	0.00	0.07	0.07	0.00
2016	468.95	470.06	0.24	0.01	0.01	0.00	0.07	0.07	0.00
2017	475.85	475.33	-0.11	0.01	0.01	0.00	0.07	0.07	0.00
2018	492.91	492.14	-0.16	0.01	0.01	0.00	0.07	0.07	0.00
2019	509.56	509.56	0.00	0.01	0.01	0.00	0.08	0.08	0.00
2020		438.98			0.01			0.07	

❖ ***Oil - Other (1.B.2.a.6) subcategory:***

- ***activity data:*** recalculations of activity data values for 2007 - 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been improved and combined with data from the refineries operators, and higher tier were used;
- ***emissions***: recalculations of the CO_2 emissions for the 2007 - 2019 period have been made due to update of the Activity Data.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.25 Change made at emissions and their effects on CO_2 emissions estimates at Oil and Natural Gas, subcategory Oil - Transport (CRF 1.B.2.a.6)

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CO_2 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1995	12.00	12.00	0.00	35.33	35.33	0.00
2000	202.00	202.00	0.00	594.72	594.72	0.00
2005	276.00	276.00	0.00	812.59	812.59	0.00
2007	329.00	190.84	-41.99	968.63	561.88	-41.99
2008	364.00	135.36	-62.81	1,118.07	415.79	-62.81
2009	287.00	74.93	-73.89	824.70	215.31	-73.89
2010	286.00	102.54	-64.15	842.95	302.21	-64.15
2011	186.00	11.05	-94.06	558.36	406.19	-27.25
2012	179.00	18.69	-89.56	544.97	619.46	13.67
2013	91.00	173.08	90.19	269.59	609.00	125.90
2014	123.00	168.95	37.36	362.32	320.26	-11.61
2015	114.00	162.20	42.28	345.20	558.90	61.91

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CO_2 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2016	113.00	187.34	65.79	341.25	620.73	81.90
2017	106.39	188.45	77.14	319.00	569.94	78.66
2018	117.89	189.85	61.04	349.54	658.39	88.36
2019	130.59	189.65	45.22	388.40	658.75	69.60
2020		169.19			598.46	

2) Natural Gas (CRF 1.B.2.b):

❖ ***Natural gas – Transmission and storage (1.B.2.b.4) subcategory:***

- ***activity data:*** recalculations of activity data values for the years 2016 and 2019 have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;
- ***emissions***: recalculations of the CH_4 emissions for the 2001 - 2019 period have been made due to updates of the Activity Data.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.26 Change made at emissions and their effects on CH_4 emissions estimates at Oil and Natural Gas, subcategory Natural Gas – Transmission and storage (CRF 1.B.2.b.4)

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	52,382.35	52,382.35	0.00	33.16	33.16	0.00
1990	35,667.00	35,667.00	0.00	22.58	22.58	0.00
1995	24,001.00	24,001.00	0.00	15.19	15.19	0.00

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2000	17,120.00	17,120.00	0.00	4.67	4.67	0.00
2005	18,636.00	18,636.00	0.00	4.78	4.74	-0.66
2007	18,244.00	18,244.00	0.00	4.52	4.47	-1.04
2008	18,124.00	18,124.00	0.00	4.37	4.31	-1.33
2009	15,527.00	15,527.00	0.00	3.68	3.62	-1.54
2010	14,960.00	14,960.00	0.00	3.63	3.59	-1.26
2011	15,851.00	15,851.00	0.00	3.87	3.82	-1.20
2012	15,934.00	15,934.00	0.00	3.83	3.77	-1.38
2013	14,339.00	14,339.00	0.00	3.41	3.36	-1.48
2014	13,514.00	13,514.00	0.00	3.22	3.18	-1.45
2015	13,201.00	13,201.00	0.00	3.13	3.08	-1.52
2016	13,131.00	13,109.22	-0.17	3.13	3.08	-1.46
2017	13,351.26	13,351.26	0.00	3.25	3.22	-1.21
2018	13,145.27	13,145.27	0.00	3.25	3.22	-1.04
2019	15,434.57	15,401.72	-0.21	3.52	3.45	-1.98
2020		12,995.42			3.02	

❖ ***Natural gas - Other (1.B.2.b.6) subcategory:***

- ***activity data:*** recalculations of activity data values for 2007 - 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;
- ***emissions***: recalculations of the CH_4 emissions for the 2007 - 2019 period have been made due to updates of the Activity Data.

The implications of all changes made on emission estimates are described in the Tables below:

Table 3.27 Change made at emissions and their effects on CH_4 emissions estimates at Oil and Natural Gas, subcategory Natural Gas - Other (CRF 1.B.2.b.6)

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	945.44	945.44	0.00	246.54	246.54	0.00
1990	809.19	809.19	0.00	208.07	208.07	0.00
1995	461.26	461.26	0.00	115.79	115.79	0.00
2000	344.16	344.16	0.00	25.56	25.56	0.00
2005	370.89	370.89	0.00	26.71	26.71	0.00
2007	299.10	269.94	-9.75	20.33	17.77	-12.55
2008	313.51	277.96	-11.34	21.82	18.71	-14.25
2009	278.68	234.02	-16.03	18.60	14.70	-21.01
2010	281.77	289.78	2.84	18.73	19.43	3.74
2011	286.23	301.55	5.35	19.25	20.59	6.96
2012	284.12	306.82	7.99	18.63	20.62	10.66
2013	264.53	258.50	-2.28	17.08	16.55	-3.09
2014	267.63	240.02	-10.32	17.87	15.46	-13.52
2015	238.41	215.51	-9.61	15.22	13.22	-13.16
2016	238.68	217.66	-8.80	15.14	13.30	-12.15
2017	251.79	229.46	-8.87	15.88	13.93	-12.30

Year	Effects of changes on Activity Data [PJ]		Difference [%]	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2018	257.91	245.81	-4.69	16.23	15.17	-6.52
2019	251.78	235.36	-6.52	15.73	14.30	-9.13
2020		240.93			14.48	

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

No source-specific planned improvements are envisaged.

3.4 CO_2 transport and storage (CRF 1.C)

CO_2 transport and CO_2 storage are not occurring in Romania.

3.5 Memo items (CRF 1.D)

Multilateral operations (CRF 1.D.2) are not occurring in Romania.

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF Sector 2)

4.1 Overview of sector

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 (CRF sector 1.A.2). GHG emissions from Industrial Processes and Product Use are grouped in the following Sub-sectors: Mineral Industry (CRF 2.A), Chemical Industry (CRF 2.B), Metal Industry (CRF 2.C), Non-energy products from fuels and solvent use (CRF 2.D), Electronics Industry (CRF 2.E), Product uses as substitutes for ODS (CRF 2.F), Other product manufacture and use (CRF 2.G) and Other (CRF 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

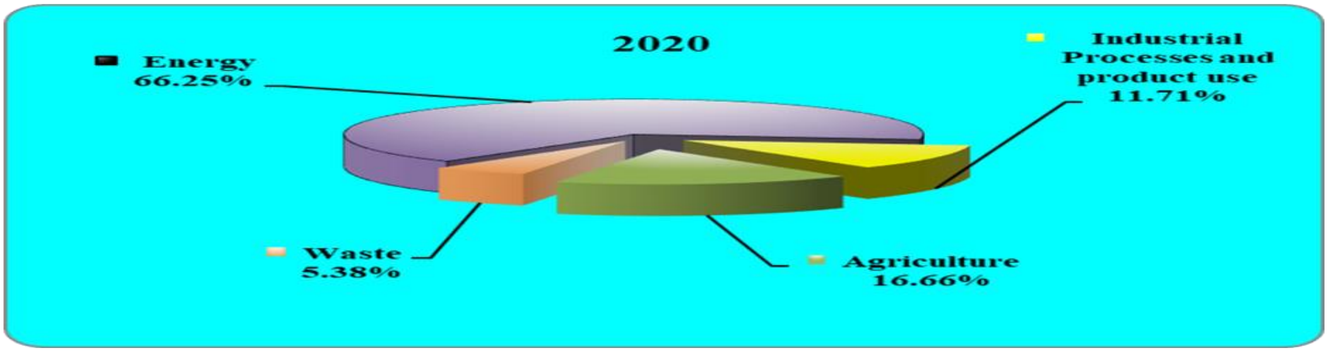
2 INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions estimation status			
IPCC category	**CO_2**	**CH_4**	**N_2O**	**PFC**
2.B.4.b. GLYOXAL 2.B.4.c. GLYOXYLIC ACID				
2.B.5.a. SILICON CARBIDE PRODUCTION	IE	√	NA	NA
2.B.5.b. CALCIUM CARBIDE PRODUCTION	√	NA	NO	NO
2.B.6. TITANIUM DIOXIDE PRODUCTION	NO	NO	NO	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	NO	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	NA	NA
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 PFCS FROM OTHER PRODUCT USE	NO	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 2020 the GHG emissions from Industrial Processes and Product Use Sector contributed with 11.71%

to the total GHG emissions in Romania.

Figure 4.1 The contribution of Industrial Processes and Product Use Sector to the total GHG emissions in Romania, in 2020 year



Emissions from this sector estimated in 2020 decreased by 72.06% compared with 1989 and increased with 0.64% compared with 2019. The decrease from 1989 to 2020 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).

Mineral Industry and Chemical Industry are the two other main contributing Subsectors with 36.67% and 13.13%, respectively, of the total GHG emissions in this sector in 2020. Metal Industry contributes with 29.87% to the total GHG emissions from Industrial Processes and Product Use Sector in 2020. The contribution of Non-energy product from fuels and solvent use Subsector to the overall sector is low: 4.23%. The contribution of Product uses as ODS substitutes Subsector to the overall sector is 15.45%. Other product manufacture and use contributes with 0.65% to the total GHG emissions from Industrial Processes and Product Use Sector in 2020. In the base year, various Industrial Processes and Product Use Sub-sectors contributions were: Mineral Industry 16.77%, Chemical Industry 29.47%, Metal Industry 50.64%, Non-energy product from fuels and solvent use 3.11%, Product uses as ODS substitutes 0.0003% and Other product manufacture and use 0.0021%.

Figure 4.2 Total GHG emissions trend in Industrial Processes and Product Use Sector, for 1989–2020 period

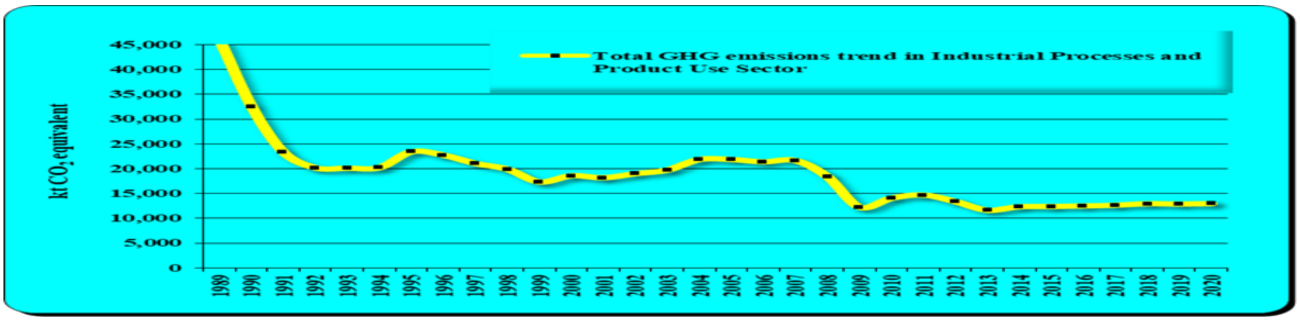


Figure 4.3 GHG emissions trends in in Industrial Processes and Product Use Sector, by sub-sectors, for 1989–2020 period

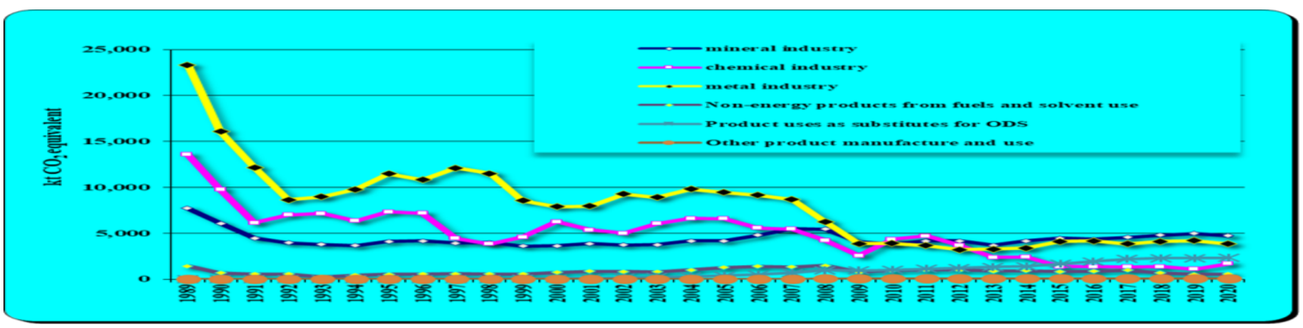
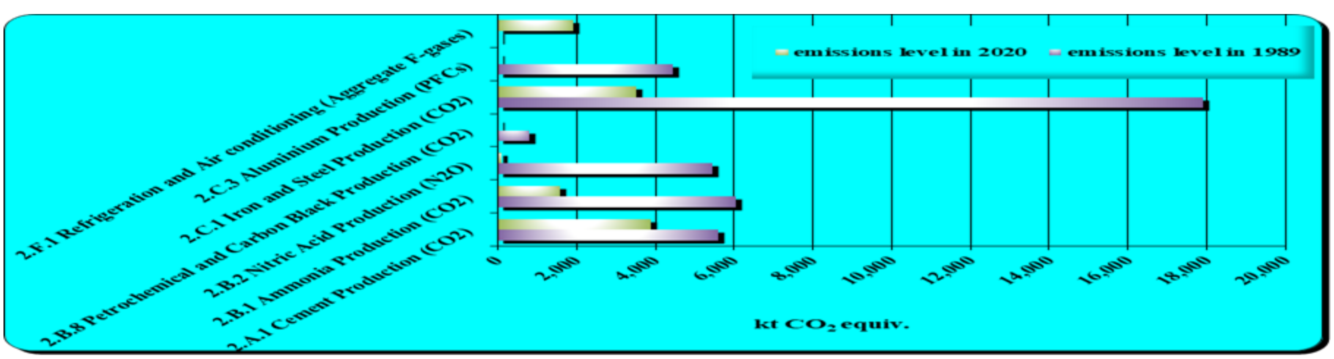


Figure 4.4 Key categories in Industrial Processes and Product Use Sector in 2020 year, both by level and trend criteria



The Tier 1 key category analysis performed for 2020 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 2020 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	3.55%	CS, T_2
2.C.1 Iron and Steel Production	CO_2	L,T	3.20%	T_3
2.F.1 Refrigeration and Air conditioning	Aggregate F-gases	L,T	1.76%	T_2
2.B.1 Ammonia Production	CO_2	L,T	1.44%	T_3
2.B.2 Nitric Acid Production	N_2O	T	0.08%	T_3
2.C.3 Aluminium Production	PFCs	T	0.0032%	T_2
2.B.8 Petrochemical and Carbon Black Production (CO_2)	CO_2	T	0.000%	T_2

4.2 Mineral Industry (CRF 2.A)

4.2.1 Category description

GHG emissions reported include estimates for the following categories: Cement Production (CRF 2.A.1), Lime Production (CRF 2.A.2), Glass Production (CRF 2.A.3), Other Process Uses of Carbonates (CRF 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 2020 CO_2 emissions from production of cement contributed with 3.55% to total greenhouse gas emissions). In the base year, these emissions accounted for 1.83% 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. Mineral Industry Sub-sector was responsible for 36.67% of the Industrial Processes and Product Use Sector related GHG emissions in 2020.

Figure 4.5 GHG emissions trend in the Mineral Industry Sub-sector for 1989–2020 period

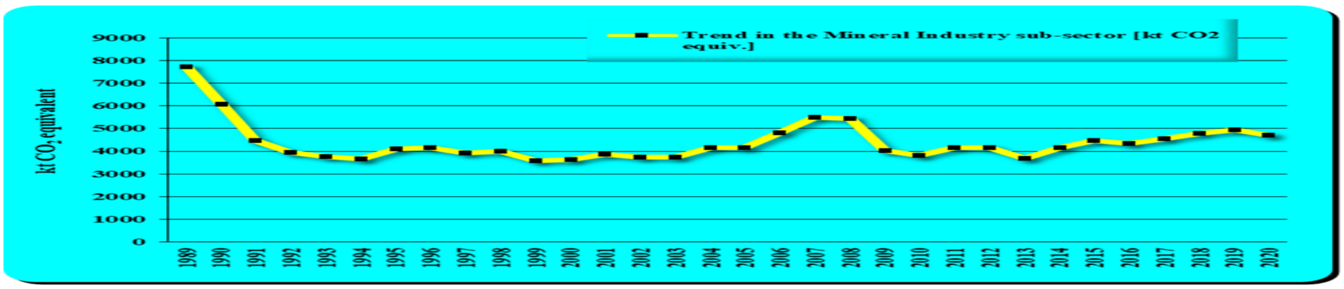
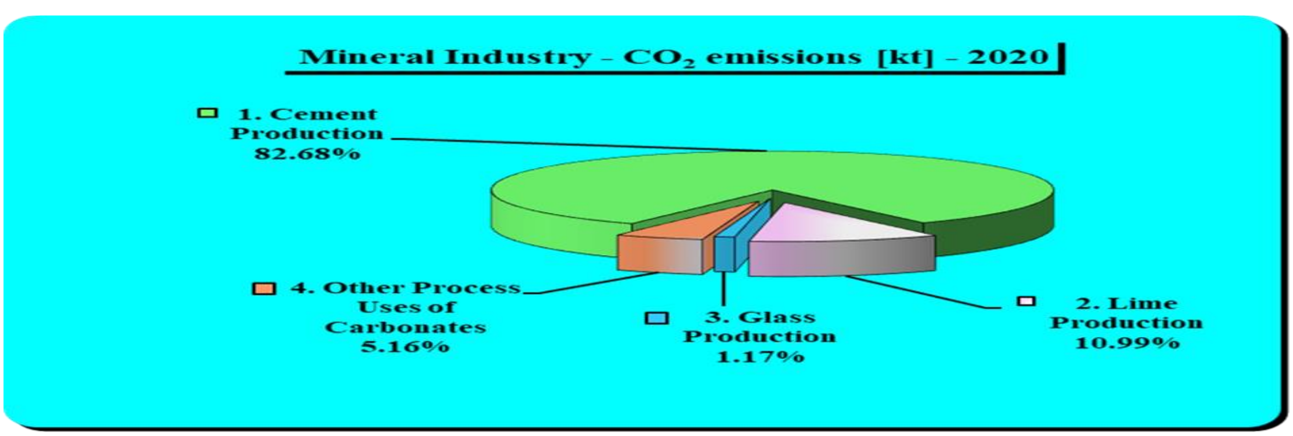


Table 4.3 CO_2 emissions in the Mineral Industry Sub-sector, , in the 2020 year

Sector	CO_2 emissions [kt]
2.A Mineral Industry	**4,718.38**
2.A.1 Cement Production	3,901.03
2.A.2 Lime Production	518.78
2.A.3 Glass Production	55.25
2.A.4 Other Process Uses of Carbonates	243.31

Figure 4.6 Structure of the Mineral Industry Sub-sector, in 2020 year



4.2.2 Methodological issues

4.2.2.1 Cement Production (CRF 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 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 1989-2020 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 2008-2020, 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. 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.

For the 2008-2019 period, EF for clinker is calculated based on the below presented IPCC formula.

Equation 4.1 Calculation of EF for clinker

$$EF_{clinker} = 0.785 \times CaO_{Content\ (Weight\ Fraction)\ in\ Clinker} + 1.091 \times MgO_{Content\ (Weight\ Fraction)\ in\ Clinker}$$

For the 2020 year, activity data on clinker production and bypass dust, emission factor for clinker and emission factor for bypass dust were taken from the ETS reports. 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 data are similar.

Table 4.4 Clinker Production data and CO_2 emissions from Clinker Production in the 2008–2020 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
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	0.5220	3,901.03

4.2.2.2 Lime Production (CRF 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 CRF 2.A.2. – Lime Production needs the collection of data and information from economic operators based on questionnaires for the period 1989–2020. 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 1989–2020

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 2019-2020 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 1989–2020

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 2016-2020 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. 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

Year	*Average content of CaO in the high calcium lime*
2011	0.8990
2012	0.8995
2013	0.9054
2014	0.9232
2015	0.9295
2016	0.9259
2017	0.9306
2018	0.9309
2019	0.9274
2020	0.9327

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 CO_2 emissions from Lime Production in the period 1989–2020

Year	Emissions from Lime Production Sub-sector
	CO_2 emissions [kt]
1989	1,885.65
1990	1,449.69
1995	844.10

Year	Emissions from Lime Production Sub-sector
	CO_2 emissions [kt]
2000	890.24
2005	908.89
2007	1,221.51
2008	1,073.24
2009	776.29
2010	841.07
2011	835.26
2012	720.84
2013	699.14
2014	911.80
2015	781.51
2016	787.32
2017	838.14
2018	868.14
2019	760.72
2020	518.78

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).

4.2.2.3 Glass Production (CRF 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 (CRF 2.A) – Glass Production category (CRF 2.A.3) is based on the yearly national production (structured on types of glass) for each year (1989–2020) 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 CRF 2.A.3. – Glass production, was collected data and information from economic operators based on questionnaires for the period 1989–2020. 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 2013–2020 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 2006–2020 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%.

For the period 2008–2020 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 2018-2020 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 1.

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 1. For the period 1989-2006 the value of 17% was used, and for the period 2007-2020 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 1. For the period 1989-2007 the value of 16.91% was used and for the 2008-2015 and 2018-2020 periods the average values reported by the economic operators were used.

Table 4.7 CO_2 emissions from Glass Production in the 1989–2020 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
2011	65.31
2012	62.38
2013	62.29
2014	55.90
2015	58.52

Year	Emissions from Glass Production Sub-sector
	CO_2 emissions [kt]
2016	56.64
2017	53.39
2018	50.82
2019	42.41
2020	55.26

4.2.2.4 Other Process Uses of Carbonates (CRF 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. Following the consideration of the ERT recommendation, Romania revised the CO_2 emission estimates for CRF 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 2007-2020 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 1989–2020 period

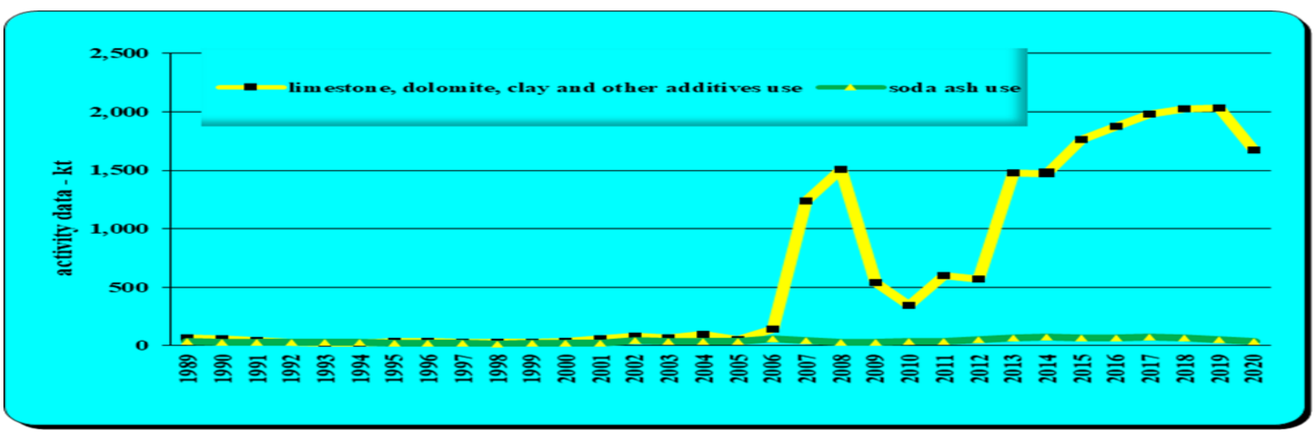
Year	**Activity data and CO_2 emissions from Other Process Uses of Carbonates Sub-sector**			
	Limestone, dolomite, clay, fly ash and other additives use (2.A.4.a Ceramics)	**Limestone and Dolomite Use (2.A.4.d Other)**	**Soda ash use (2.A.4.b Other uses of Soda Ash)**	**CO_2 emission from Other Process 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

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]
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

Emission factors

The default emission factors 440 kg CO_2/tonne limestone, 477 kg CO_2/tonne dolomite, 522 kg CO_2/tonne magnesite and 415 kg CO_2/tonne soda ash are used. In 2020, emissions have declined as consumption has been lower due to reduced pandemic orders.

Figure 4.7 Consumption of carbonates from Other Process Uses of Carbonates in the 1989–2020 period



4.2.3 Uncertainties and time series consistency

4.2.3.1 Cement Production (CRF 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 6.3.

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 1989–2020.

4.2.3.2 Lime Production (CRF 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 6.3.

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 1989–2020.

4.2.3.3 Glass Production (CRF 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 6.3.

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 1989–2020.

4.2.3.4 Other Process Uses of Carbonates (CRF 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 6.3.

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 1989–2020.

4.2.4 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.

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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

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 data are similar.

The CO_2 emissions from 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 6.5.

4.2.5 Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend

No recalculations were made relative to previous submission.

4.2.6 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 (CRF 2.B)

4.3.1 Category description

CRF Sector 2.B includes: Ammonia Production (CRF 2.B.1), Nitric Acid Production (CRF 2.B.2), Adipic Acid Production (CRF 2.B.3), Caprolactam, glyoxal and glyoxylic acid production (CRF 2.B.4), Silicon Carbide Production (CRF 2.B.5.a), Calcium Carbide Production (CRF 2.B.5.b), Titanium dioxide production (CRF 2.B.6), Soda ash production (CRF 2.B.7), Petrochemical and carbon black production (CRF 2.B.8), Fluorochemical production (CRF 2.B.9) and Other (CRF 2.B.10). Chemical Industry Sub–sector was responsible for 13.13% of the total Industrial Processes Sector GHG emissions in 2020. GHG emissions trend in the Chemical Industry Sub-sector for 1989–2020 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).

Figure 4.8 GHG emissions trend in the Chemical Industry Sub-sector for 1989–2020 period

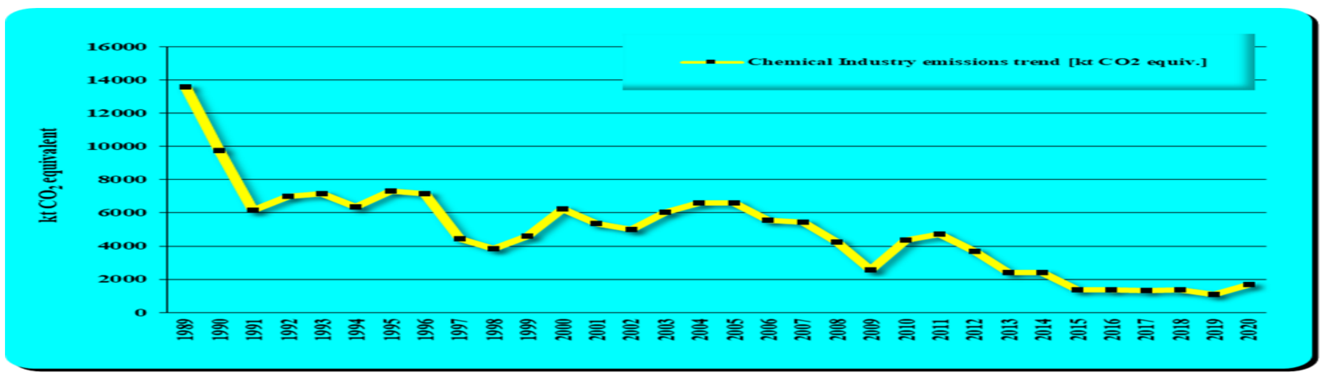


Table 4.9 GHG emissions from the Chemical Industry Sector, in 2020 year

Sector	CO_2	CH_4	N_2O
	[kt] - 2020		
2.B Chemical Industry	**1,591.25**	**0.23**	**0.31**
2.B.1 Ammonia Production	1,586.76	NA	NA
2.B.2 Nitric Acid Production	NA	NA	0.31
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	0.23	NA
2.B.5.b Calcium Carbide Production	4.49	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] - 2020		
2.B Chemical Industry	**1,591.25**	**0.23**	**0.31**
2.B.9 Fluorochemical production	NO	NO	NO
2.B.10 Other	NO	NO	NO

4.3.2 Methodological issues

4.3.2.1 Ammonia Production (CRF 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 3.4) 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 both level and 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 3.4, 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).

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.

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 of 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 3.1 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 2013-2020, 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, 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).

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 1989–2020 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
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

Year	The amount of urea exported (kt/year)
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

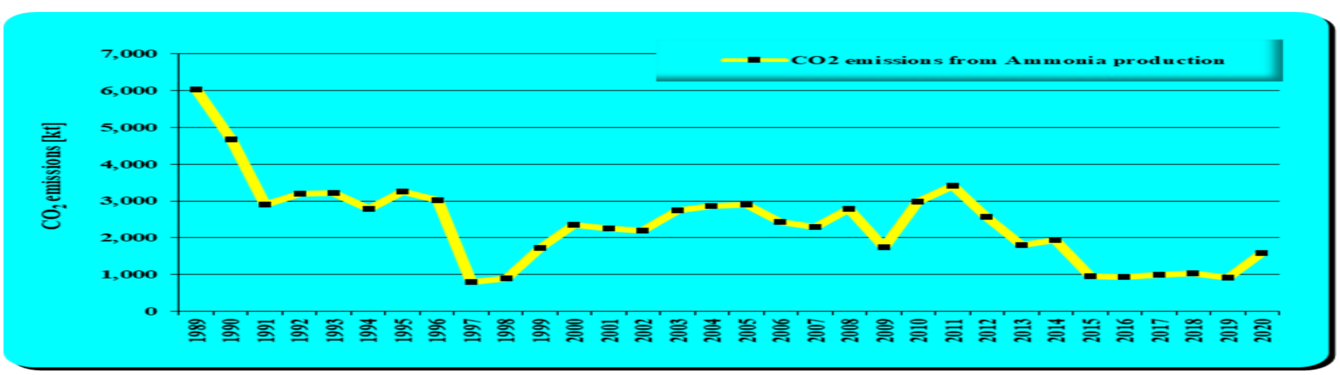
(Source: National Institute of Statistics)

Table 4.11 Ammonia Production related to the CO_2 emissions in the 1989–2020 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)
1989	2,707.96	6,033.02	117.30	0.00	0.00
1990	2,101.40	4,677.85	115.68	0.00	0.00
1995	1,943.01	3,262.93	53.93	1,123.48	0.00
2000	1,314.41	2,357.36	42.19	611.45	0.00
2005	1,615.83	2,900.82	52.75	755.23	0.00
2007	1,279.31	2,301.04	46.81	581.28	0.00

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)
2008	1,443.92	2,776.70	49.35	493.33	0.00
2009	1,039.08	1,734.31	52.20	556.90	0.00
2010	1,504.20	2,974.37	53.91	494.22	0.00
2011	1,732.17	3,413.00	55.25	676.75	0.00
2012	1,449.87	2,567.02	51.13	1,053.02	0.00
2013	974.04	1,801.85	60.65	375.28	0.00
2014	1,013.22	1,937.06	53.42	350.79	0.00
2015	469.67	946.12	62.95	57.69	0.00
2016	459.19	936.83	60.71	48.40	0.00
2017	510.63	984.17	67.24	116.51	0.00
2018	523.50	1,040.34	82.63	64.86	1.39
2019	470.54	915.82	80.40	72.68	1.61
2020	859.88	1,586.76	82.67	303.40	1.77

Figure 4.9 The trend of CO_2 emissions from Ammonia Production in the 1989–2020 period



4.3.2.2 Nitric Acid Production (CRF 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 2016-2019 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 2020 year there are currently two chemical plants, where four HNO_3 production facilities are in operation. 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 4.12 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 1989–2020 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
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

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 2016-2019 period, four facilities were in operation in two chemical plants. In 2020 year there are currently two chemical plants, where four HNO_3 production facilities are in operation.

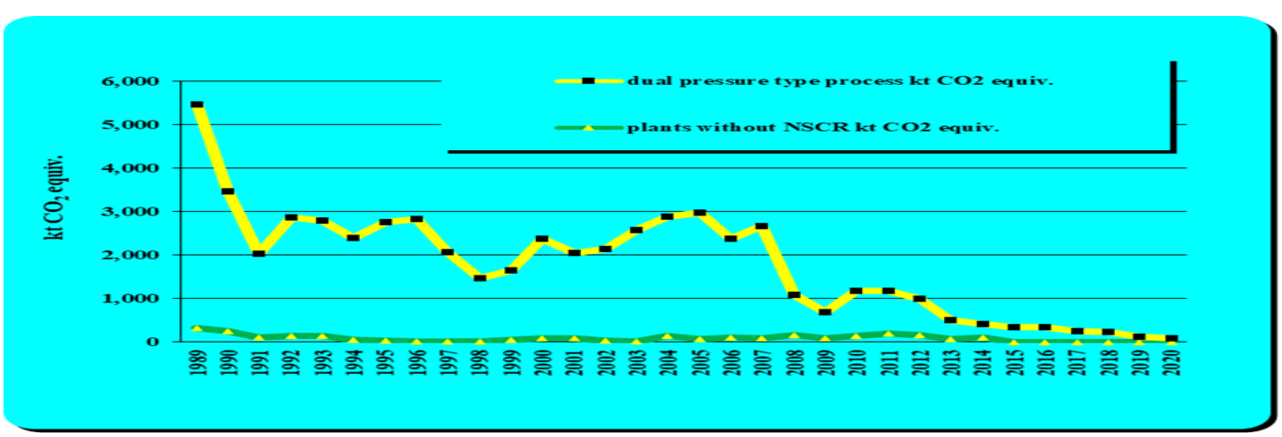
N_2O emission level trend

- 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 85-95.93% for the 2020 year.

Figure 4.10 The trend of CO_2 emissions from Nitric Acid Production, 1989–2020 period



4.3.2.3 Adipic Acid Production (CRF 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 (CRF 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 (CRF 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 (CRF 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; starting with 2007 year, the production was stopped; 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 1989–2020 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

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]**
2017	NO	5.85	5.85
2018	NO	5.79	5.79
2019	NO	5.69	5.69
2020	NO	4.49	4.49

4.3.2.7 Titanium Dioxide Production (CRF 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 (CRF 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, 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 4.11 CO_2 emissions from Soda Ash Production the 1989–2020 period

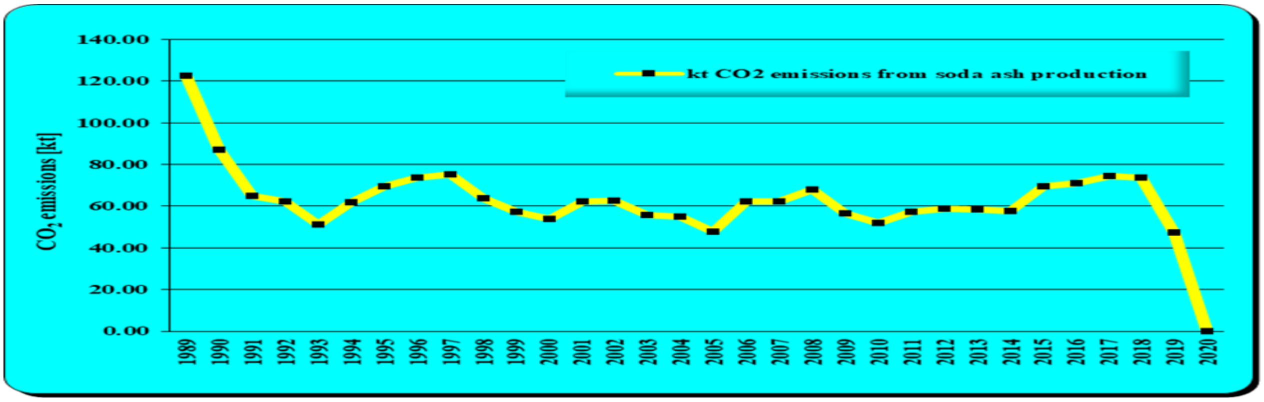


Table 4.15 CO_2 emissions from Soda Ash Production in the 1989–2020 period

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

Year	Emissions from Soda Ash Production Sub-sector
	CO_2 emissions [kt]
2019	47.35
2020	NO

4.3.2.9 Petrochemical and carbon black Production (CRF 2.B.8)

Methodology

The Petrochemical and Carbon Black Production is a key category from trend point of view (Tier 1, excluding LULUCF). 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 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 (Commission Regulation No 601/2012, Article 25), 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 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 (CRF 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 Other Production (CRF 2.B.10)

Other emissions are not known to be occurring.

4.3.3 Uncertainties and time series consistency

4.3.3.1 Ammonia Production (CRF 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 6.3.

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 1989–2020.

4.3.3.2 Nitric Acid Production (CRF 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 6.3.

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 1989–2020.

4.3.3.3 Adipic Acid Production (CRF 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 6.3.

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 1989–2020.

4.3.3.4 Caprolactam, Glyoxal and Glyoxylic Acid Production (CRF 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 6.3.

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 1989–2020.

4.3.3.5 Silicon Carbide Production (CRF 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 6.3.

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 1989–2020.

4.3.3.6 Calcium Carbide Production (CRF 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 6.3.

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 1989–2020.

4.3.3.7 Titanium Dioxide Production (CRF 2.B.6)

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 6.3.

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 1989–2020.

4.3.3.8 Soda Ash Production (CRF 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 6.3.

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 1989–2020.

4.3.3.9 Petrochemical and carbon black Production (CRF 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 6.3.

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 1989–2020.

4.3.3.10 Fluorochemical Production (CRF 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 6.3.

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 1989–2020.

4.3.3.11 Other Production (CRF 2.B.10)

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 6.3.

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 1989–2020.

4.3.4 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.

Following these activities there were no unconformities recorded.

Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

4.3.5 Category-specific recalculations, if applicable, 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:

- ***activity data:***
  - Methanol production (CRF 2.B.8.a)
- ***emission factor:***
  - Ammonia production (CRF 2.B.1)
  - Methanol production (CRF 2.B.8.a)

Table 4.16 The effects of recalculations in Chemical Industry Subsector

The effects of recalculations in Chemical Industry Subsector			
Years	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	kt CO_2 equiv.		
1989	13,575.29	13,570.03	-0.04
1990	9,748.46	9,745.35	-0.03
1991	6,148.19	6,146.31	-0.03
1992	7,003.71	7,002.31	-0.02
1993	7,146.25	7,144.44	-0.03
1994	6,358.19	6,354.32	-0.06
1995	7,335.86	7,332.85	-0.04
1996	7,173.89	7,171.35	-0.04
1997	4,448.83	4,444.51	-0.10
1998	3,824.08	3,822.25	-0.05
1999	4,583.17	4,581.75	-0.03
2000	6,260.61	6,256.21	-0.07
2001	5,370.09	5,367.05	-0.06
2002	4,999.94	4,995.62	-0.09
2003	6,058.92	6,052.17	-0.11
2004	6,611.45	6,603.21	-0.12
2005	6,599.13	6,593.18	-0.09
2006	5,561.09	5,553.76	-0.13
2007	5,436.44	5,433.03	-0.06
2008	4,233.92	4,231.52	-0.06
2009	2,566.74	2,564.96	-0.07
2010	4,349.41	4,346.82	-0.06
2011	4,701.91	4,701.41	-0.01
2012	3,682.36	3,681.52	-0.02
2013	2,388.30	2,388.89	0.02
2014	2,414.90	2,416.94	0.08
2018	1,357.17	1,365.59	0.62

The effects of recalculations in Chemical Industry Subsector			
Years	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	kt CO_2 equiv.		
2019	1,096.28	1,101.35	0.46
2020		1,689.24	

Ammonia Production

Recalculations have been made for the 2019 year due to the recalculation of the values for NCV and EFox for natural gas (errors were identified in the calculation formulas for NCV and EFox for this year). The CO_2 emission value of 914.31 kt has been replaced by 915.82 kt.

Table 4.17 The effects of recalculations in Methanol production category

The effects of recalculations in Methanol production category			
Years	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	CO_2 emissions [kt]		
1989	194.33	189.07	-2.70
1990	115.30	112.19	-2.70
1991	69.58	67.70	-2.70
1992	51.69	50.29	-2.70
1993	66.60	64.80	-2.70
1994	143.14	139.26	-2.70
1995	111.33	108.32	-2.70
1996	93.93	91.39	-2.70
1997	159.54	155.22	-2.70
1998	67.59	65.76	-2.70
1999	52.68	51.26	-2.70
2000	162.52	158.12	-2.70
2001	112.32	109.28	-2.70
2002	160.03	155.71	-2.70
2003	249.49	242.75	-2.70
2004	304.66	296.42	-2.70

The effects of recalculations in Methanol production category			
Years	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	CO_2 emissions [kt]		
2005	219.67	213.73	-2.70
2006	271.36	264.02	-2.70
2007	126.24	122.82	-2.70
2008	88.96	86.56	-2.70
2009	66.10	64.31	-2.70
2010	95.92	93.33	-2.70
2011	18.39	17.89	-2.70
2012	30.81	29.98	-2.70
2013	1.40	1.99	42.25
2014	4.47	6.28	40.32
2018	NO	7.72	100.00
2019	5.00	8.56	71.19
2020		NO	

Methanol Production

Recalculations of CO_2 emissions from methanol production for the 1989-2014 and 2018-2019 periods:

- for the years 2013, 2014, 2018 and 2019, by choosing the tier 2 approach by using EU-ETS data on methanol production and CO_2 emissions (calculated on the basis of mass balance);
- for the period 1989-2012, by using the IEF calculated for 2014 (emission / activity data) from EU-ETS data.

Recalculations of CH_4 emissions for 2014 and 2018 due to the improvement of activity data by taking into account EU-ETS data. The new values of CH_4 emissions are 0.029854 kt for 2014 and 0.02314 kt for 2018.

4.3.6 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 (CRF 2.C)

4.4.1 Category description

The emission estimates cover sub-categories Iron and Steel Production (CRF 2.C.1), Ferroalloys Production (CRF 2.C.2), Aluminium Production (CRF 2.C.3), Magnesium Production (CRF 2.C.4), Lead Production (CRF 2.C.5), Zinc Production (CRF 2.C.6) and Other (CRF 2.C.7). The use of SF_6 in Aluminium and Magnesium Foundries is not applicable in Romania. Metal Industry Subsector is responsible for 29.87% of the total Industrial Processes and Product Use Sector GHG emissions in 2020. 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 2020 CO_2 emissions from production of iron and steel contributed 3.20% to total greenhouse gas emissions). In the base year, these emissions accounted for 5.83% from the total GHG emissions. GHG emissions trend in the Metal Industry Sub-sector for 1989–2020 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.

Figure 4.12 GHG emissions trend in the Metal Industry Sub–sector for 1989–2020 period

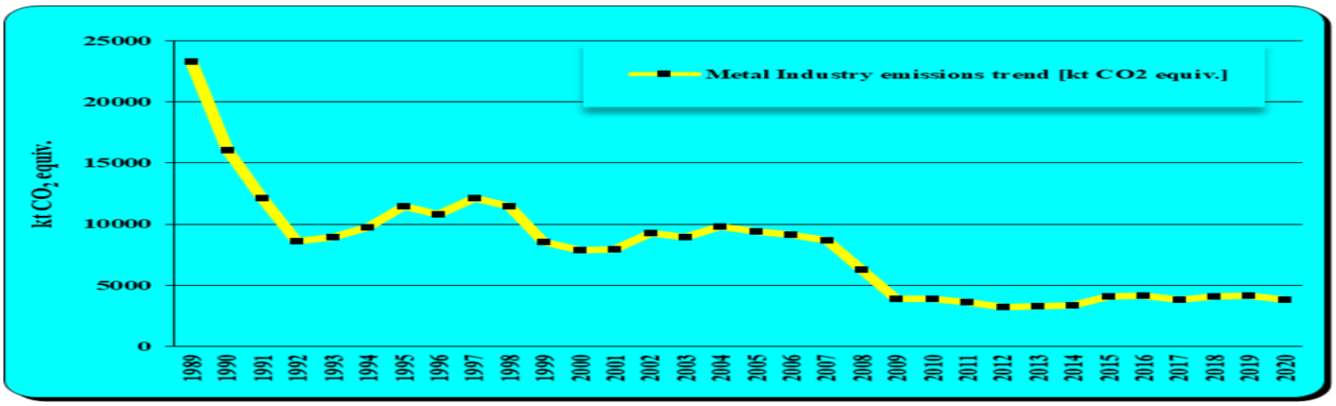
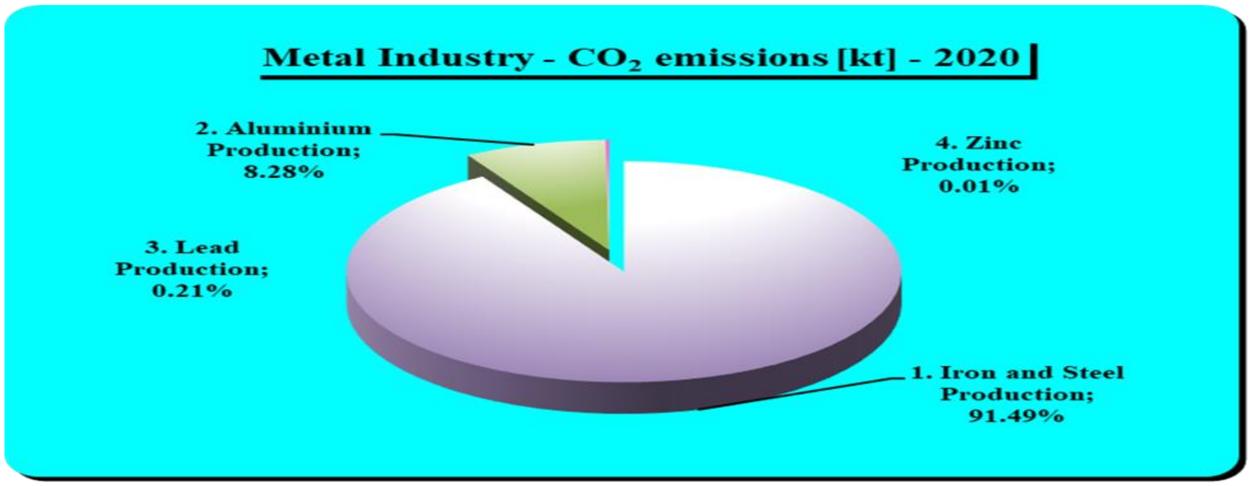


Table 4.18 GHG emissions from Metal Industry Sub–sector, in the 2020 year

Sector	CO_2	CH_4	PFCs
	CO_2 equivalent [kt] - 2020		
2.C Metal Industry	**3,836.09**	**4.08**	**3.52**
2.C.1 Iron and Steel Production	3,512.67	4.08	NA
2.C.2 Ferroalloys Production	NO	NO	NO
2.C.3 Aluminium Production	314.90	NA	3.52
2.C.4 Magnesium Production	NO	NO	NO
2.C.5. Lead Production	7.97	NA	NA
2.C.6. Zinc Production	0.55	NA	NA

Figure 4.13 Structure of the Metal Industry Sub–sector, in 2020 year



4.4.2 Methodological issues

4.4.2.1 Iron and Steel Production (CRF 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 2020. The data requested for the assessment of the emissions from sinter production and iron and steel production are shown in the tables below.

Table 4.19 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	√	√
Limestone	√	√
Dolime	√	√
Other materials with carbon content	√	√
Sinter produced	√	√
Coke gas used in sinter production	√	√
BF gas used in sinter production	√	√

Table 4.20 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)	√	√
Steel	√	√
Pig iron produced and not transformed in steel	√	√
Coke gas used to BF/BOF	√	√
BF gas transferred outside installation (sold)	√	√

Parameter type	Quantity, t or GJ	Average carbon content, tC/t product or tC/GJ
BF gas transferred to sinter plant	√	√

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 (CRF 2.C.1) for 1989–2020 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 reported by this unit include the sinter production sector and the iron production in furnaces and steel 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 1989-2020. 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.

For the period 2014-2020, the emissions from the consumption of iron, ferroalloys and lime were also taken into account in the inventory in this submission, these data being available under the EU-ETS. The table below shows the CO_2 emissions estimated for the period 1989-2020.

Table 4.21 CO_2 emissions estimated for the 1989–2020 period

Year	CO_2 emissions [kt]
1989	11,661.95
1990	8,846.24
1995	6,872.59
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

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 crise 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 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 available under the EU ETS and were included in inventory in this submission. 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 1989–2020 period. This emission factor was applied to the difference between the EAF steel production and the quantities provided by NIS (National Institute of Statistics) for the 1989-2007 period and for the 2009 year, and to the difference between the EAF steel production and the quantities provided by operators for the 2008 year and for the 2010-2020 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. The table below shows the CO_2 emissions estimated for the 1989–2020 period.

Table 4.22 CO_2 emissions estimated for the 1989–2020 period

Year	Total CO_2 emissions EAF [kt]
1989	224.23
1990	135.04
1991	111.84
1992	82.52
1993	88.76
1994	78.17
1995	75.17
1996	68.29
1997	63.21
1998	50.29

Year	Total CO_2 emissions EAF [kt]
1999	38.77
2000	51.09
2001	52.51
2002	42.32
2003	43.66
2004	50.29
2005	56.33
2006	49.93
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

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 4.23 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 (CRF 2.C.1)

CO_2 emissions for Iron and Steel Production during the period 1989-2020, represent the sum of CO_2 emissions for the flows/technologies shown in the previous subchapters. Table 4.24 shows these emissions, as well as the total corresponding to Iron and Steel Production category (CRF 2.C.1). In the emissions from steel production category 2C1a (steel) are also included emissions from the iron production 2C1b.

Table 4.24 CO_2 emissions from Iron and Steel Production for the 1989–2020 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

Figure 4.14 The trend of CO_2 emissions from Iron and Steel Production (BOF, EAF and OHF) in the 1989–2020 period

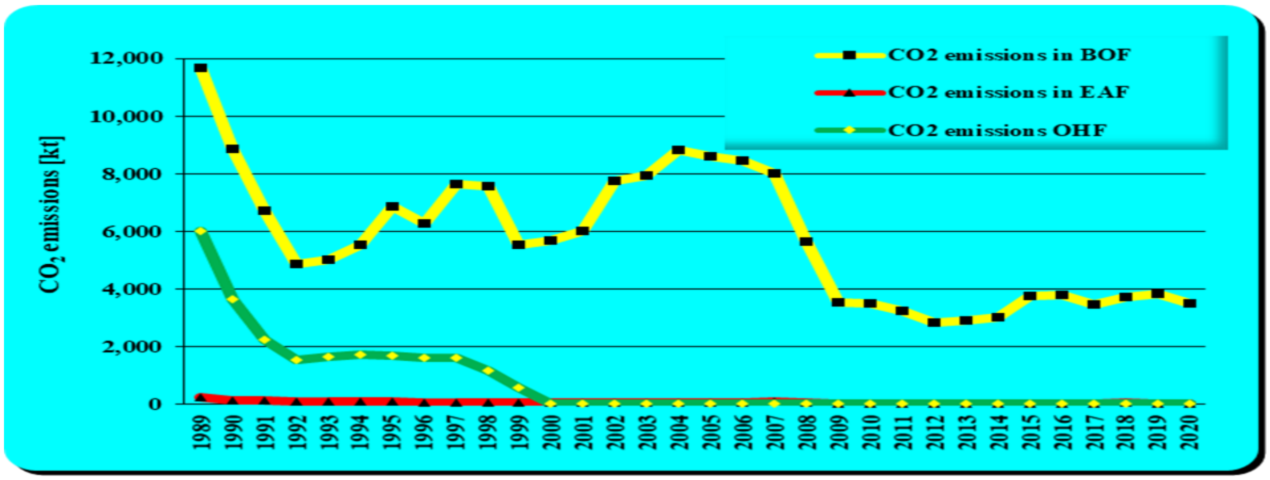
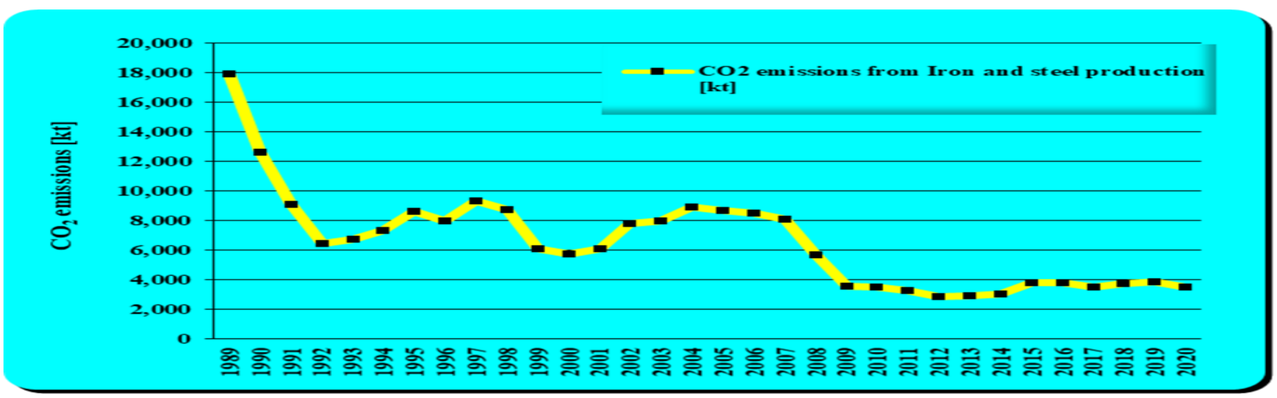


Figure 4.15 The trend of CO_2 emissions from Iron and Steel Production in the 1989–2020 period



Estimation of CH_4 Emissions for Iron and Steel Production (CRF 2.C.1) for the 1989–2020 period

The CH_4 emissions for the period 1989–2020 were estimated based on the Tier 1 methodology in IPCC 2006 (sinter production data x default emission factor). Table 4.25 shows the CH_4 emissions for category CRF 2.C.1 – Iron and Steel Production.

Table 4.25 CH_4 emissions for Iron and Steel production for the 1989-2020 period

Year	Sinter [kt]	Emission factor [kg/t]	CH_4 emissions [kt CO_2 equivalent]
1989	13,626.00	0.07	23.846

Year	Sinter [kt]	Emission factor [kg/t]	CH_4 emissions [kt CO_2 equivalent]
1990	11,357.00	0.07	19.875
1995	6,671.00	0.07	11.674
2000	3,875.00	0.07	6.781
2005	6,600.00	0.07	11.550
2007	6,359.22	0.07	11.129
2008	3,445.55	0.07	6.030
2009	1,806.98	0.07	3.162
2010	1,977.60	0.07	3.461
2011	1,841.84	0.07	3.223
2012	1,705.94	0.07	2.985
2013	2,111.45	0.07	3.695
2014	2,165.68	0.07	3.790
2015	2,661.89	0.07	4.658
2016	2,592.59	0.07	4.537
2017	2,346.47	0.07	4.106
2018	2,458.20	0.07	4.302
2019	2,457.75	0.07	4.301
2020	2,331.37	0.07	4.080

4.4.2.2 Ferroalloys Production (CRF 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 4.26 CO_2 emission from Ferroalloys Production in the 1989–2020 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
2013-2020	NO

Table 4.27 CH_4 emission from Ferroalloys Production in the 1989–2020 period

Years	**Emissions from Ferroalloys Production Subsector**
	CH_4 emissions [kt]
1989	0.07
1990	0.05
1995	0.02
2000	0.01
2005-2020	NO

4.4.2.3 Aluminium Production (CRF 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. At these emissions are added the emission from decomposition of sodium carbonate (ash) used in electrolysis cell;
- **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 1989–2020:

- 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 (1989–2020), 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. 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 **CWPB** (Centre Worked Pre-baked). **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**. At these emissions are added the emission from **decomposition of sodium carbonate** used in electrolysis cell. The **PFC emissions** are calculated based on **IPCC 2006 Methodology (Tier 2 Method –** Equation 3.11**)**, 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**.

Table 4.28 The activity data, PFC and CO_2 emissions from Aluminium Production Sub–sector in the 1989–2020 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
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

Emission factors

Along the period 1989–2020 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 **C2F6/CF4 = 0.252 for SWPB.**

- From **1997 to 2002** period 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 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 **C2F6/CF4 = 0.252 for SWPB and 0.121 for CWPB**.
- **Starting with 2003** the technology was changed to **CWPB** (Centre Worked Pre-baked).

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.

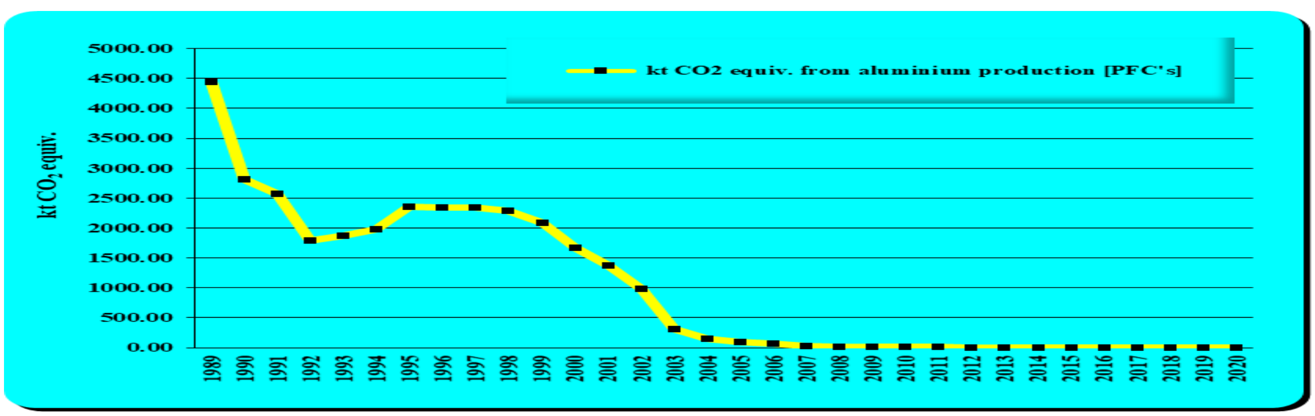
II. The PFC emissions are calculated based on **IPCC 2006 Methodology (Tier 2 Method)**, using **Overvoltage Method** and considering the plant specific data and also average parameters from measurements at numerous facilities.

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 1989–2020 period



4.4.2.4 MagnesiumProduction (CRF 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 (CRF 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 1989–2020.

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 (CRF 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 1989–2020.

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 (CRF 2.C.7)

Other emissions are not known to be occurring.

4.4.3 Uncertainties and time series consistency

4.4.3.1 Iron and Steel Production (CRF 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 6.3.

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 1989–2020.

4.4.3.2 Ferroalloys Production (CRF 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 6.3.

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 1989–2020.

4.4.3.3 Aluminium Production (CRF 2.C.3)

4.4.3.3.1 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 6.3.

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 1989–2020.

4.4.3.3.2 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 6.3.

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 1989–2020.

4.4.3.4 Magnesium Production (CRF 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 6.3.

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 1989–2020.

4.4.3.5 Lead Production (CRF 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 6.3.

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 1989–2020.

4.4.3.6 Zinc Production (CRF 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 6.3.

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 1989–2020.

4.4.4 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.

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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

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 6.5.

4.4.5 Category-specific recalculation, including changes made in response to the review process and impact on emission trend

No recalculations were made relative to previous submission.

4.4.6 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 (CRF 2.D)

4.5.1 Category description

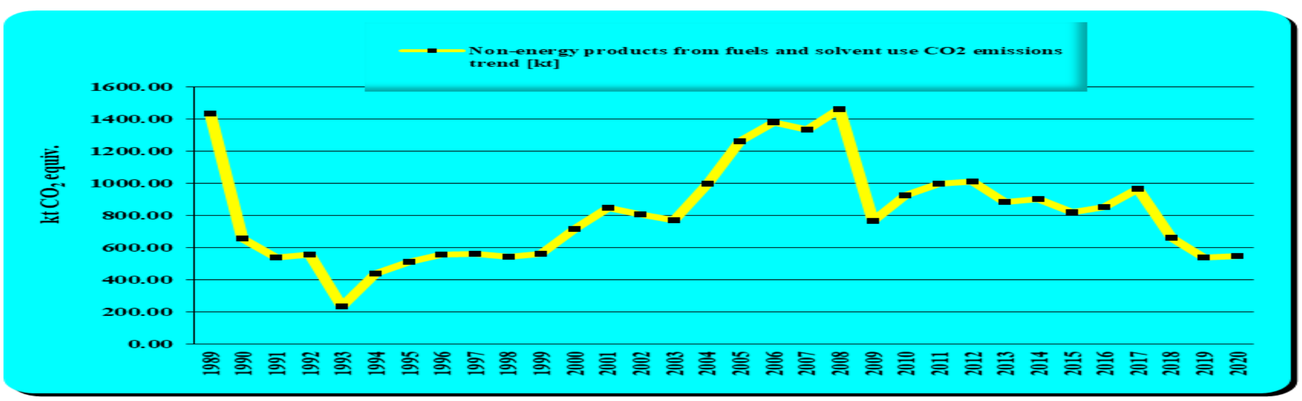
The emission estimates cover sub-categories Lubricant use (CRF 2.D.1), Paraffin wax use (CRF 2.D.2) and Other (CRF 2.D.3: Solvent use (CRF 2.D.3.a), Road paving with asphalt (CRF 2.D.3.b), Asphalt roofing (CRF 2.D.3.c). Non-energy products from fuels and solvent use Sub-sector is responsible for

4.23% of the total Industrial Processes and Product Use Sector GHG emissions in 2020.

Table 4.29 CO_2 emissions from Non-energy products from fuels and solvent use Sub–sector, in the 2020 year

Sector	CO_2 emissions [kt] - 2020
2.D Non-energy products from fuels and solvent use	**544.27**
2.D.1 Lubricant use	59.34
2.D.2 Paraffin wax use	4.48
2.D.3.a Other - Solvent use	100.99
2.D.3.d Other - Petroleum coke use	377.70
2.D.3.d Other - Urea use	1.77

Figure 4.17 CO_2 emissions trend in the Non-energy products from fuels and solvent use Sub–sector for 1989–2020 period



4.5.2 Methodological issues

4.5.2.1 Lubricant use (CRF 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_2020_0000, Lubricants - Gross inland deliveries for non energy use (Annex 4.2).

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 (CRF 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_2020_0000, Paraffin waxes - Gross inland deliveries for non energy use (Annex 4.2).

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 (CRF 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;
- 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), under seal treatment and conservation of vehicles.

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 2019, using the correspondence between IPCC categories and SNAP codes (Table 4.30).

Table 4.30 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

IPCC categories	SNAP codes
Chemical Products, Manufacture and Processing	0603 Chemical products manufacturing and processing
Other	0604 Other use of solvents & related activities

Activity data

For 2022 submission the AD used to calculate emissions are provided by the National Statistics and economic agents but the main data source is National Statistics.

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.

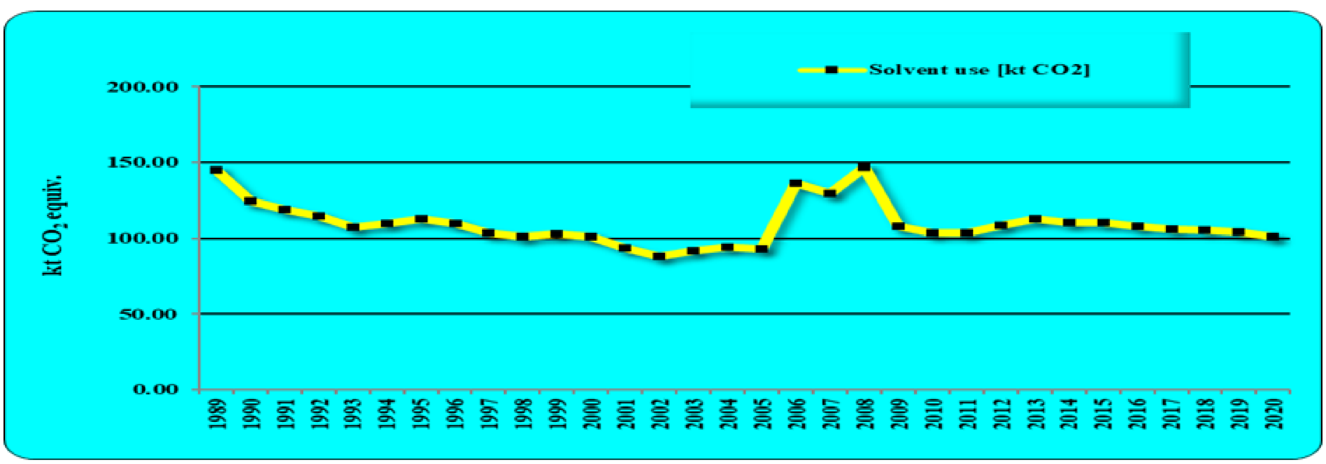
Table 4.31 CO_2 emissions resulted from Solvent Use in the 1989–2020 period

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
1990	2.33	8.36	41.93	71.72	124.34
1995	2.64	11.33	27.35	71.35	112.67
2000	1.97	8.02	20.20	70.65	100.84
2005	4.32	1.79	20.49	66.03	92.63
2007	4.60	2.14	58.38	64.44	129.55
2008	13.61	1.18	61.11	70.68	146.58
2009	11.26	1.06	26.38	68.97	107.68
2010	9.67	1.27	22.86	69.48	103.28
2011	10.38	1.21	22.30	69.50	103.39
2012	10.72	1.23	28.45	68.17	108.57
2013	11.68	1.31	31.89	68.05	112.94
2014	11.80	1.41	29.45	67.36	110.03
2015	13.45	1.28	28.45	67.32	110.50

Solvents Use					
Year	Paint application	Degreasing and Dry Cleaning	Chemical Products, Manufacture and Processing	Other	Total
	CO_2 emissions [kt]				
2016	12.43	1.02	29.40	65.05	107.90
2017	10.44	0.93	29.09	65.52	105.98
2018	10.18	0.76	30.81	63.39	105.14
2019	8.05	0.56	30.95	64.53	104.08
2020	5.73	0.31	31.09	63.87	100.99

The trend of emissions resulted from this sector follow the general emission trend: emissions have been decreased after 1989, then the emissions are relatively stable from 1990 to 2005 and after 2005 emissions are started to increase, as an increase in economic activities (automobile manufacture, construction and buildings); after 2008 the emissions decreased and are relatively stable from 2009 to 2020.

Figure 4.18 The trend of CO_2 emissions resulted from Solvent Use Sector, , in the 2020 year



4.5.2.4 Other - Petroleum coke use (CRF 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_2020_0000, Petroleum coke - Gross inland deliveries for non energy use (Annex 4.2).

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).

4.5.3 Uncertainties and time series consistency

4.5.3.1 Lubricant use (CRF 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 6.3.

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 series 1989–2020.

4.5.3.2 Paraffin wax use (CRF 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 6.3.

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 1989–2020.

4.5.3.3 Solvent use (CRF 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 6.3.

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 1989–2020.

4.5.3.4 Other - Petroleum coke use (CRF 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 6.3.

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 1989–2020.

4.5.4 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.

Following these activities there were no unconformities recorded.

Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

4.5.5 Category-specific recalculations, if applicable, 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:

- ***activity data:***
  - *Solvent use (CRF 2.D.3.a)*
- ***emission factor:***
  - *Petroleum coke use (CRF 2.D.3.d)*

Table 4.32 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	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	CO_2 emissions [kt]		
1990	665.49	658.55	-1.04
1991	546.83	539.91	-1.26

The effects of recalculations in Non-energy products from fuels and solvent use Sector			
Years	NGHGI 2021	NGHGI 2022	Differences [%]
	CO_2 emissions [kt]		
1992	564.13	557.23	-1.22
1993	241.99	235.11	-2.84
1994	447.85	440.99	-1.53
1995	517.64	513.79	-0.74
1996	566.06	559.24	-1.20
1997	570.87	560.41	-1.83
1998	551.32	543.86	-1.35
1999	563.77	561.33	-0.43
2000	724.65	715.51	-1.26
2001	861.25	847.25	-1.63
2002	827.45	809.28	-2.20
2003	786.88	771.56	-1.95
2004	1,016.41	1,000.38	-1.58
2005	1,267.31	1,262.17	-0.41
2006	1,388.08	1,381.16	-0.50
2007	1,340.23	1,334.06	-0.46
2008	1,467.04	1,461.84	-0.35
2009	768.65	765.48	-0.41
2010	928.94	926.22	-0.29
2011	1,003.33	999.40	-0.39
2012	1,013.64	1,010.49	-0.31
2013	886.06	882.92	-0.35
2014	905.78	902.94	-0.31
2015	825.29	822.96	-0.28
2016	853.99	851.10	-0.34
2017	967.58	964.62	-0.31
2018	667.44	661.26	-0.93
2019	535.17	541.25	1.14

The effects of recalculations in Non-energy products from fuels and solvent use Sector			
Years	NGHGI 2021	NGHGI 2022	Differences [%]
	CO_2 emissions [kt]		
2020		544.27	

Table 4.33 The effects of recalculations in Solvent use category

The effects of recalculations in Solvent use category			
Years	NGHGI 2021	NGHGI 2022	Differences [%]
	CO_2 emissions [kt]		
1990	131.29	124.34	-5.29
1991	126.10	119.19	-5.49
1992	121.65	114.75	-5.67
1993	114.24	107.36	-6.03
1994	116.34	109.48	-5.90
1995	116.53	112.67	-3.31
1996	116.39	109.57	-5.85
1997	113.77	103.31	-9.19
1998	108.14	100.68	-6.90
1999	105.37	102.93	-2.31
2000	109.98	100.84	-8.31
2001	107.43	93.43	-13.03
2002	106.26	88.10	-17.09
2003	107.00	91.68	-14.32
2004	109.89	93.86	-14.59
2005	97.77	92.63	-5.26
2006	143.47	136.56	-4.82
2007	135.72	129.55	-4.55
2008	151.78	146.58	-3.43
2009	110.85	107.68	-2.86
2010	106.00	103.28	-2.57
2011	107.32	103.39	-3.66

The effects of recalculations in Solvent use category			
Years	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	CO_2 emissions [kt]		
2012	111.72	108.57	-2.82
2013	116.08	112.94	-2.71
2014	112.87	110.03	-2.52
2015	112.83	110.50	-2.07
2016	110.78	107.90	-2.60
2017	108.94	105.98	-2.72
2018	111.32	105.14	-5.55
2019	97.93	104.08	6.29
2020		100.99	

Solvent use (CRF 2.D.3.a)

Recalculations have been made for the 1990-2019 period. Recalculations were made as a result of due to an improvement in activity data for 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 under Directive 2001/81/EC and under the UNECE Convention on Long-range Transboundary Air Pollution.

Other - Petroleum coke use (CRF 2.D.3.d)

Recalculations have been made for the 2019 year due to the recalculation of the values for NCV and EFox for petroleum coke (errors were identified in the calculation formulas for NCV and EFox for this year). The CO_2 emission value of 367.25 kt has been replaced by 367.17 kt.

4.5.6 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.

4.6 Electronics Industry (CRF 2.E)

4.6.1 Category description

CRF Sector 2.E includes: Integrated circuit or semiconductor (CRF 2.E.1), TFT flat panel display (CRF 2.E.2), Photovoltaics (CRF 2.E.3), Heat transfer fluid (CRF 2.E.4), Other (CRF 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.

4.6.3 Uncertainties 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 6.3.

4.6.4 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.

Following these activities there were no unconformities recorded.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

4.6.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

No recalculations were made relative to previous submission.

4.6.6 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 (CRF 2.F)

4.7.1 Category description

Under this F-gases category are considered the following subcategories: Domestic refrigeration (CRF 2.F.1.b), Commercial and industrial refrigeration and air-conditioning (CRF 2.F.1.a, 2.F.1.c, and 2.F.1.f), Transport refrigeration (CRF 2.F.1.d), Mobile air-conditioning (CRF 2.F.1.e), Foam blowing (CRF 2.F.2), Fire protection (CRF 2.F.3), Aerosols/Metered dose inhalers (CRF 2.F.4), Solvents (CRF 2.F.5) and Other applications (CRF 2.F.6). Product uses as substitutes for ODS Subsector is responsible for 15.45% of the total Industrial Processes and Product Use Sector GHG emissions in 2020. In 2020 year, the actual emissions from CRF 2.F category are equal to 1,988.58 kt CO_2 eq. and are presented in the Table 4.34. 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 1989–2020 period

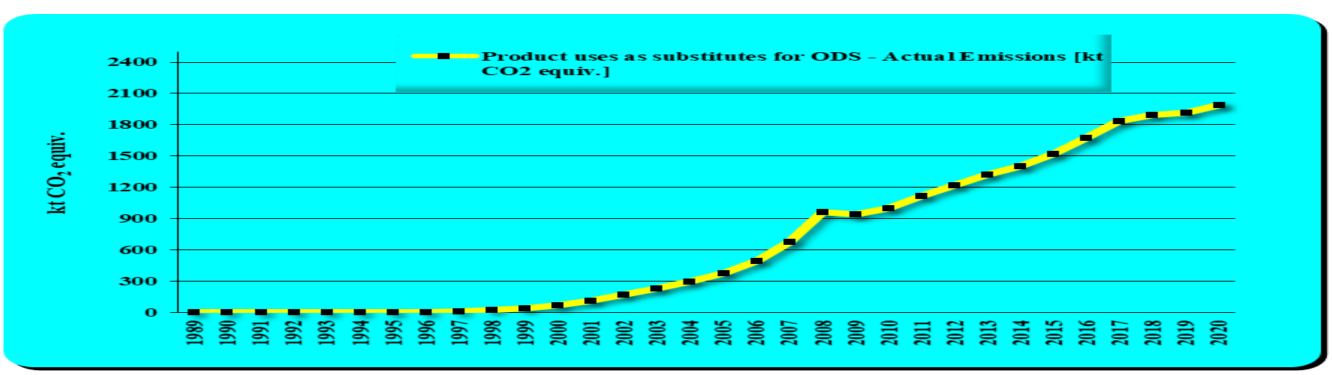
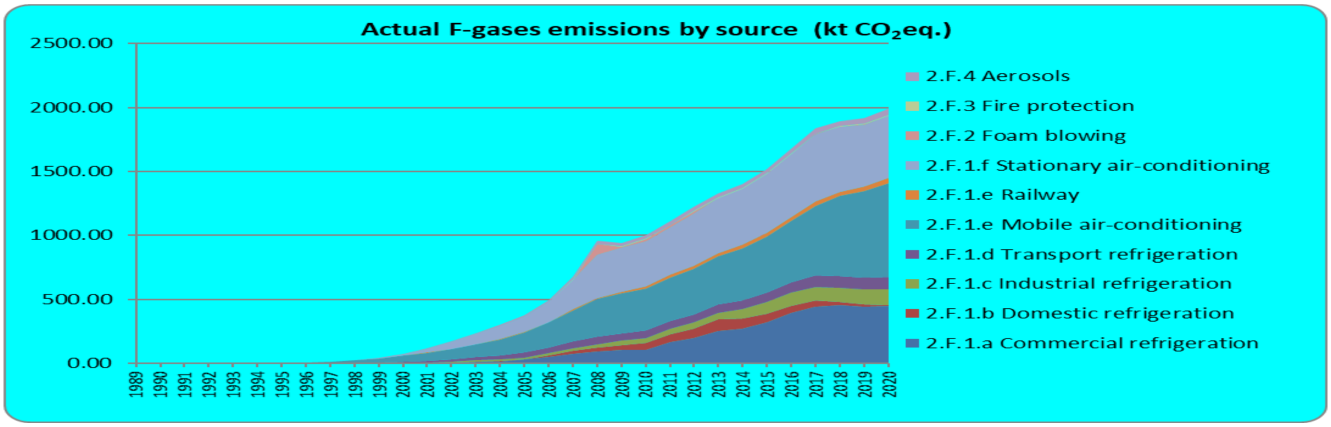


Table 4.34 The Actual emissions in the Product uses as substitutes for ODS Sub–sector for 1989 – 2020 period

Year	Actual emissions [kt CO_2eq.]
1989	0.16
1990	0.18
1995	2.66
2000	72.16
2005	374.57
2007	675.11
2008	959.99
2009	941.00
2010	1,002.11
2011	1,114.11
2012	1,221.82
2013	1,324.80
2014	1,400.94
2015	1,520.45
2016	1,676.68
2017	1,835.24
2018	1,894.35
2019	1,917.14
2020	1,988.58

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 1989–2020 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 4.35 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, NIR Germany)	15 (D, EC 2011, NIR 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)	100 (CS)	0
Industrial refrigeration	2.F.1c	Tier 2a	HFC, PFC	15 (D)	1 (D) (NIR Germany)	10 (EC 2011, NIR 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

	QG	Method	Gas	Lifetime	Production	Application	End of life emissions	
			HFC	[years]	Emission factor (%)	Emission factor (%)	Disposal losss factor (%)	Recovery rate (%)
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 (CRF 2.F.1)

Refrigeration and Air Conditioning Equipment (2.F.1) is a key category from both level and trend point of view (Tier 1, excluding and including LULUCF).

4.7.2.1.1 Commercial Refrigeration (CRF 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-134a, R-404A, R-410A, and R-407C. Other currently used refrigerants are R-422D, R-417A, R-508A, R-407F, R-448A, R-449A, R-452A. In 2019, compared to 2018, there is a decrease in emissions, this decrease due to the introduction on the market of a new refrigerant R-744F50 (CO_2). In 2020, F-gas emissions increased due to the increase in the consumption of refrigerated agents in the service / maintenance activities of refrigeration / air conditioning equipment. The aggregated actual emission estimates are equal to of 447.73 kt CO_2eq. for 2020 year. The quantity of banked HFCs for this subcategory is estimated at 999.511 t in 2020 year and is presented in Table 4.36.

Figure 4.21 Actual emissions of the Comercial Refrigeration for 1989–2020 period

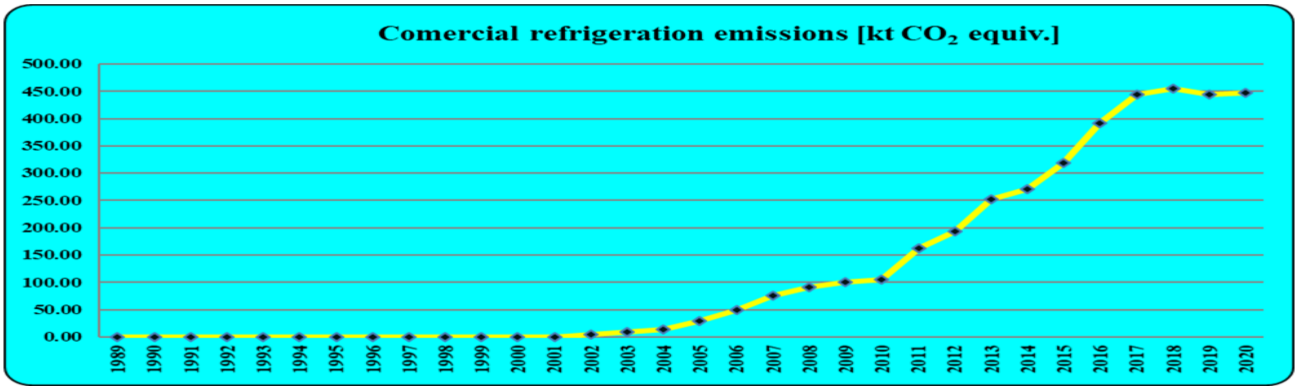


Table 4.36 The quantity of banked HFC of the Commercial Refrigeration for 1989–2020 period

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_2eq.]
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1995	0	0	0	0	0	0
2000	0	0	0	0	0	0
2005	33	55	0.29	8	0	29.05
2007	64	144	0.50	22	0	75.94
2008	56	179	0.35	27	0	91.56
2009	50	202	0.23	30	0	101.04
2010	41	212	0.11	32	0	104.80
2011	127	307	0.95	46	0	162.71
2012	111	372	0.65	56	0	193.71
2013	182	498	1.26	75	0	251.52
2014	122	545	0.47	82	0	270.48
2015	180	644	0.99	97	0	318.03
2016	245	792	1.48	119	0	391.35
2017	226	893	1.01	134	1	444.47
2018	199	948	0.62	142	2	454.76

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_2eq.]
2019	158	954	0.27	143	1	443.50
2020	218	1,000	0.78	150	4.35	447.73

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 2020 year the questionnaire has been sent to 289 companies, only 149 provided the quantities of HFCs they used for servicing commercial refrigeration and air-conditioning equipment. 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. 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%).

4.7.2.1.2 Domestic Refrigeration (CRF 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 – 2020 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. The actual emissions for 2020 year from production, operation and decommissioning are equal to 6.69 kt CO_2eq., of which operation emissions are equal to 0.08 kt CO_2eq. The detailed results are presented in the Table 4.37.

Figure 4.22 Actual emissions of the Domestic Refrigeration for 1989–2020 period

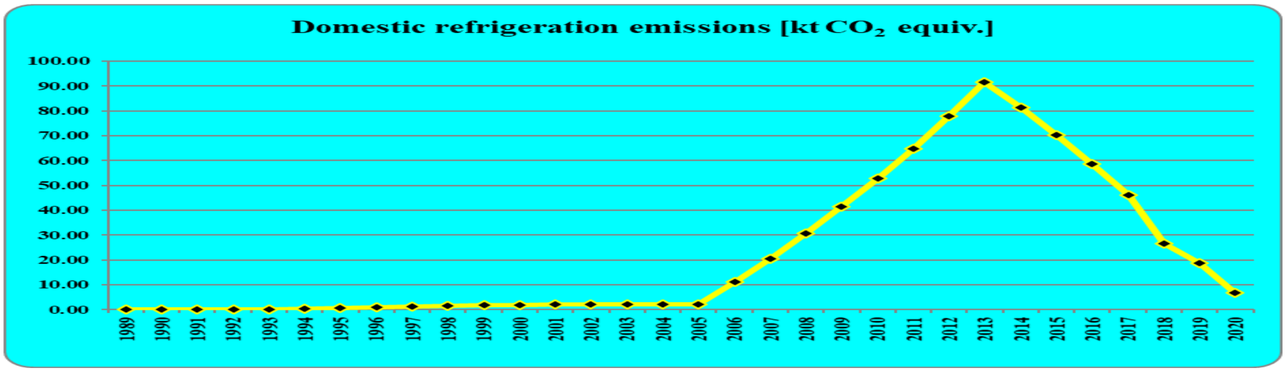


Table 4.37 The result detailed of the Domestic Refrigeration for 1989–2020 period

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_2eq.]
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1995	145,893.00	310,973.00	18.00	37.00	107.00	105.00	321.00	0.00	0.61
2000	305,233.00	425,453.00	37.00	51.00	382.00	220.00	1,146.00	0.00	1.95
2005	43,075.00	40,087.00	5.00	5.00	489.00	31.00	1,468.00	0.00	2.14
2007	67,442.00	59,430.00	8.00	7.00	479.00	49.00	1,438.00	12,940.00	20.63
2008	61,455.00	48,547.00	7.00	6.00	464.00	44.00	1,391.00	20,065.00	30.75
2009	58,843.00	34,436.00	7.00	4.00	439.00	42.00	1,317.00	27,641.00	41.47
2010	68,549.00	50,242.00	8.00	6.00	408.00	49.00	1,224.00	35,672.00	52.83
2011	0.00	0.00	0.00	0.00	362.49	0.00	1,087.46	44,225.12	64.80
2012	0.00	0.00	0.00	0.00	307.97	0.00	923.90	53,432.02	77.73
2013	0.00	0.00	0.00	0.00	243.83	0.00	731.49	63,211.10	91.44
2014	0.00	0.00	0.00	0.00	186.80	0.00	560.40	56,298.33	81.31
2015	0.00	0.00	0.00	0.00	137.44	0.00	412.31	48,804.54	70.38
2016	0.00	0.00	0.00	0.00	96.31	0.00	288.93	40,714.59	58.64
2017	0.00	0.00	0.00	0.00	63.98	0.00	191.93	32,043.06	46.10

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_2eq.]
2018	0.00	0.00	0.00	0.00	45.30	0.00	135.90	18,485.37	26.63
2019	0.00	0.00	0.00	0.00	32.08	0.00	96.24	13,083.93	18.85
2020	0.00	0.00	0.00	0.00	27.39	0.00	82.16	4,598.46	6.69

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 4.38.

Table 4.38 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 2003-2020, and for the imports and exports it was for the period 2000-2020. 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

1,207,000 units were placed on the market in 2020. 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 2011-2020 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

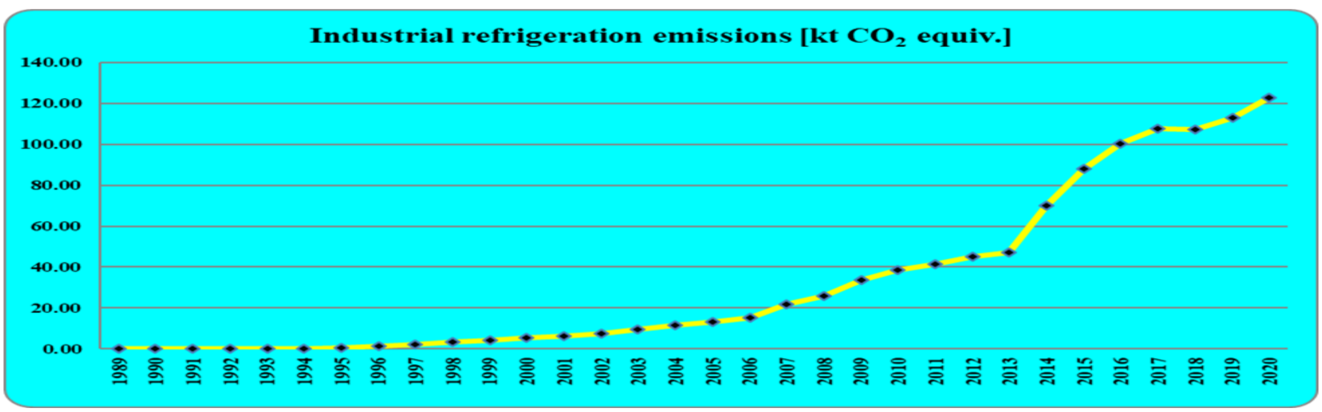
The manufacturing emissions are calculated as a percentage of the initial charge that is released during assembly. The emission factor used for estimating the manufacturing emissions is the default Emission Factor (EF) of 0.6% from the IPCC 2006. The operation emissions are calculated based on The EF for operation is 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 (NIR) of Austria, Germany and others. Regarding the disposal EF – since the questionnaires sent to recycling companies did not provide any evidence that F-gases are reclaimed from WEEE, a conservative assumption that 100% of all remaining F–gases contained in the disposed equipment are emitted. In order to determine a **country-specific disposal emission factor**, we have requested additional data and, depending on the result of the analysis, the value of the disposal loss factor may be updated accordly. A further analysis was performed. Additional information on Waste Electrical and Electronic Equipment was requested from the Waste Directorate of NEPA. **Information received was only for 2015 year**. Of the total number of waste electrical and electronic equipment containing HFCs collected for decommissioning, about 70% are sent to treatment to economic operators holding a permit to treat WEEE equipment (treated in the country). 97% 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. Approximately 13% of the total waste of electrical and electronic equipment containing HFCs collected for decommissioning is sent for treatment to foreign countries. **The remaining 17% are decommissioned without refrigerant recovery**. Because the information received was only for one year, **the value of 17% can not be used as a national value for disposal emission factor**.

4.7.2.1.3 Industrial Refrigeration (CRF 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 R-404A, HFC-134a, R-407C and R-410A. Other currently used refrigerants are R-417A, R-422A, R-422D, R-507A, R-508B, R-407F, R-448A, R-449A. 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 122.98 kt CO_2eq. for 2020 year. The actual emissions for the period 1989–2020 are represented in the Figure 4.23.

Figure 4.23 Actual emissions of the Industrial Refrigeration for 1989–2020 period



The quantity of banked HFCs for this subcategory is estimated at 412.88 t in the 2020 year and is presented in Table 4.39.

Table 4.39 The quantity of banked HFC of the Industrial Refrigeration for 1989–2020 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_2eq.]
1989	0	0	0	0	0	0.00
1990	0	0	0	0	0	0.00

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_2eq.]
1995	1.2	1.2	0.0	0.1	0.0	0.5
2000	3.73	13.10	0.03	1.31	0.00	5.24
2005	8.28	36.99	0.05	3.70	0.00	13.20
2007	21.27	59.91	0.17	5.99	0.00	21.87
2008	18.63	72.55	0.13	7.25	0.00	25.96
2009	31.81	97.10	0.25	9.71	0.00	33.50
2010	28.44	114.62	0.18	11.46	0.18	38.49
2011	27.22	128.22	0.14	12.82	0.32	41.60
2012	27.48	140.63	0.12	14.06	0.34	45.04
2013	22.61	146.85	0.06	14.68	0.35	47.18
2014	76.67	206.37	0.60	20.64	0.37	69.95
2015	95.11	278.16	0.72	27.82	0.40	88.23
2016	69.48	316.80	0.39	31.68	0.45	100.18
2017	64.66	345.91	0.29	34.59	0.58	107.74
2018	38.08	343.14	0.01	34.31	0.94	107.29
2019	71.46	374.64	0.32	37.46	0.85	113.04
2020	80.79	412.88	0.38	41.29	0.76	122.98

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 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

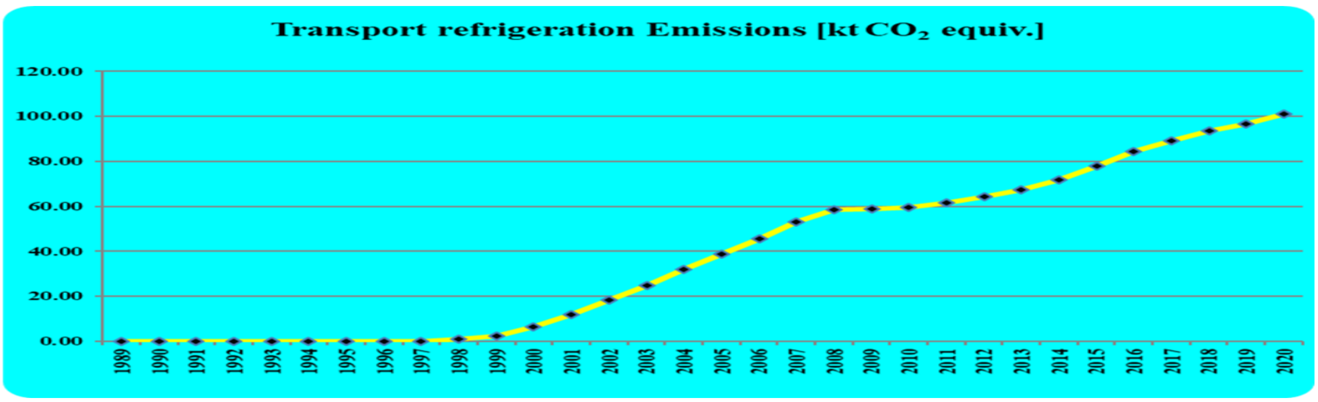
The IPCC 2006 Guidelines provide a very broad range regarding the annual leakage rate – between 7 and 25%. The emissions estimates were prepared by using an annual leakage rate of 10%, based on information provided in various studies (EC 2011, National Inventory Reports of Germany, Austria and Estonia). 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 (CRF 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 100.99 kt CO_2eq. for 2020 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 1989–2020 are represented on the Figure 4.24.

Figure 4.24 Actual emissions of the Transport Refrigeration for 1989–2020 period



The quantity of banked HFCs for this subcategory is estimated at 140.79 t in 2020 year and is presented in Table 4.40.

Table 4.40 The quantity of banked HFC of the Transport Refrigeration for 1989–2020 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_2eq.]
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1995	20	0	0	9	0	0.01
2000	3,174	3	10	2,237	0	6.28
2005	13,591	3	54	11,815	0	38.61
2007	17,903	6	73	15,969	0	52.99
2008	19,890	6	81	17,670	0	58.49
2009	20,291	1	82	17,857	0	58.79
2010	20,522	1	83	18,040	2	59.35
2011	21,559	3	86	18,774	4	61.42

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_2eq.]
2012	23,001	4	90	19,775	34	64.24
2013	24,400	4	94	20,759	116	67.49
2014	25,988	5.29	99.41	21,968	331	71.60
2015	27,687	5.78	105.19	23,282	913	77.72
2016	29,953	8.55	113.74	25,177	1,097	84.43
2017	32,198	7.41	121.15	26,875	1,012	89.18
2018	34,742	8.18	129.33	28,761	745	93.64
2019	36,152	3.70	133.03	29,665	907	96.51
2020	38,323	7.76	140.79	31,407	684	100.99

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 Directorate on Driving Licenses and Vehicles Registration (DDLVRC). 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 2020 as about 21,660 refrigerated vans and 16,660 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 4.41).

Table 4.41 The total number of Refrigeration trucks with HFC-containing units (%) for 1993–2020 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%**
2002	94%	44%
2003	**100%**	**56%**
2004	100%	69%
2005	**100%**	**81%**
2006	**100%**	**91%**
2007	**100%**	**98%**
2008	**100%**	**100%**
2009-2020	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 (CRF 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 727.55 kt CO_2eq. for 2020, 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 1989-2020 are represented on the Figure 4.25. The initial emissions are estimated to be around 0.86 t of HFC-134a, while the operation emissions are around 462 t and the disposal emissions are around 46 t. There is a large quantity of banked HFCs, estimated at 4,385.10 t in 2020 year and is presented in Table 4.42.

Figure 4.25 Actual emissions of the Mobile Air-Conditioning for 1989–2020 period

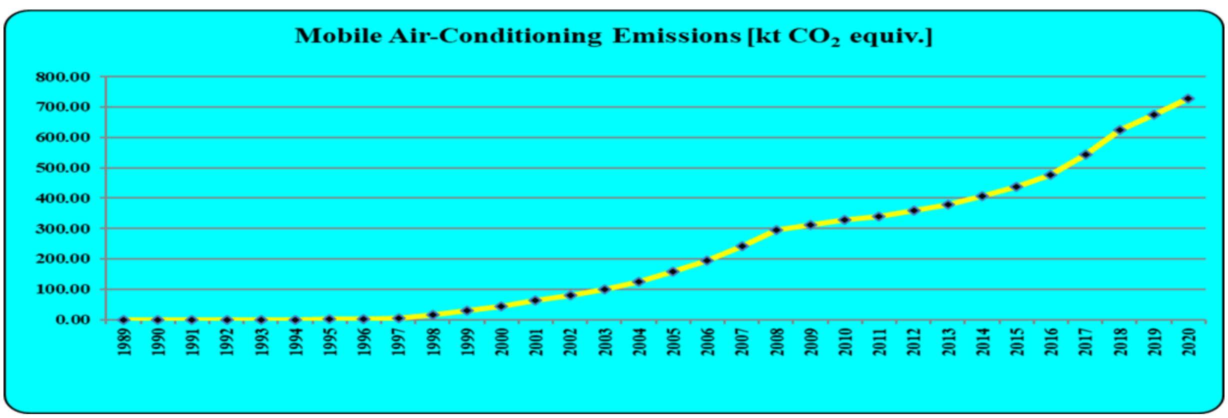


Table 4.42 The quantity of banked HFC of the Mobile Air-Conditioning for 1989–2020 period

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.]
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1995	8,577.10	3,240.46	7.76	0.96	4.24	38.79	514.05	0.00	0.79
2000	55,817.14	270,830.27	42.70	85.58	272.11	213.50	31,163.65	0.00	44.87
2005	170,518.75	1,117,593.88	114.09	74.34	982.22	570.45	109,948.21	0.00	158.04
2007	224,741.96	1,927,513.61	145.96	140.22	1,553.42	729.81	168,989.80	0.00	242.70
2008	225,569.36	2,424,280.03	145.63	212.00	1,896.47	728.13	204,861.93	0.00	293.99
2009	274,306.72	2,658,758.51	174.86	87.78	2,026.50	874.28	218,061.11	0.00	313.08
2010	323,104.91	2,871,236.57	204.15	33.95	2,137.56	1,020.76	229,544.64	0.00	329.71
2011	302,850.32	3,013,307.82	191.35	18.99	2,212.32	956.73	237,334.75	0.00	340.76
2012	305,493.25	3,225,001.78	192.16	87.91	2,333.69	960.78	249,975.82	0.00	358.84
2013	369,747.18	3,456,943.15	231.38	108.64	2,465.38	1,156.92	263,680.31	0.00	378.72
2014	344,057.80	3,768,437.39	215.63	118.37	2,647.02	1,078.14	282,614.70	202.04	405.97
2015	332,239.46	4,118,189.35	208.66	141.26	2,850.80	1,043.31	303,949.91	517.50	436.88
2016	301,042.88	4,517,425.09	189.66	185.21	3,116.93	948.30	331,741.81	962.84	477.12
2017	53,502.60	5,080,289.17	34.55	288.89	3,484.93	172.74	369,575.08	10,599.38	543.90
2018	43,637.44	5,578,572.91	28.32	263.84	3,813.92	141.60	403,577.82	32,791.40	624.21
2019	54,331.35	6,032,730.47	35.44	250.80	4,111.38	177.22	434,032.31	37,544.74	674.61
2020	25,982.06	6,449,331.28	17.25	221.10	4,385.10	86.27	462,336.16	46,352.11	727.55

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 2016-2020 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. In the year 2020 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%** and for **2020 result the value of 6%**. 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 DDLVRC, 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 – 2020 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 and 6% value for 2020)**, 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 4.43).

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

$$MAC_y = N_y * P_y + N_{y-1} * P_{y-1} + \ldots + N_{1993} * P_{1993}$$

Table 4.43 The number of new cars, all cars, trucks and busses with HFC-containing units of MAC for1993–2020 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%

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
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%
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%

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 2000 IPCC GPG propose an average value of 0.8 kg per MAC unit, which according to various studies is an overestimate for the recent passenger cars and underestimate for trucks and busses. 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. For the selection of appropriate quantity of refrigerant, a number of foreign studies have been reviewed. 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 4.44). 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 2000 IPCC GPG gives an average value of 12 years, while 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.

Table 4.44 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

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
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
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

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 2017-2020 period. 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 2017-2020 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. 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

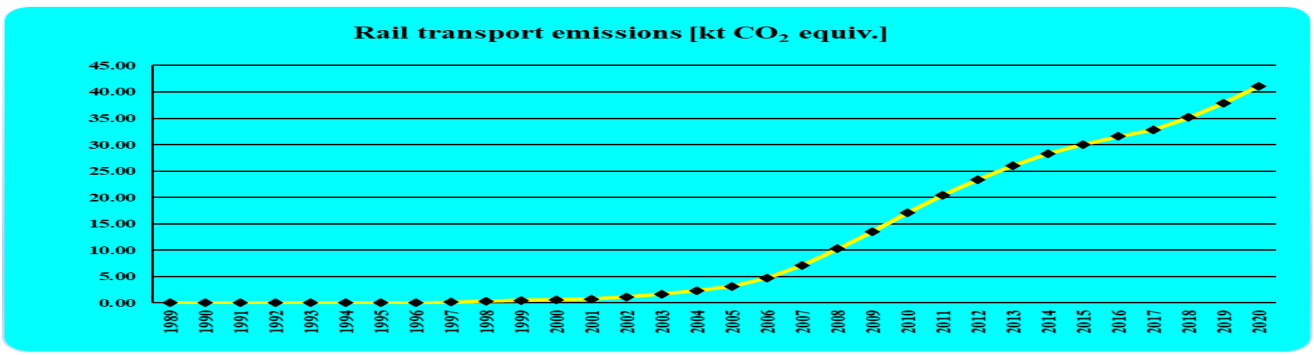
Methodology and activity data

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 this 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 1999 and are used as refrigerants HFC-134a and R-407C. The aggregated actual emission estimates are equal to of 41.13 kt CO_2eq. for 2020 year. The actual emissions for the period 1989–2020 are represented in the Figure 4.26. The quantity of banked HFCs for this subcategory is estimated at 97.99 t in 2020 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 2016 year, but are relatively small.

Figure 4.26 Actual emissions of the Rail transport for 1989–2020 period



Total actual emissions from Mobile Air-Conditioning (CRF 2.F.1.e category) are presented in the next table.

Table 4.45 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.
1989	0.00	0.00	0.00
1990	0.00	0.00	0.00
1991	0.00	0.00	0.00
1992	0.00	0.00	0.00
1993	0.09	0.00	0.09
1994	0.32	0.00	0.32
1995	0.79	0.00	0.79

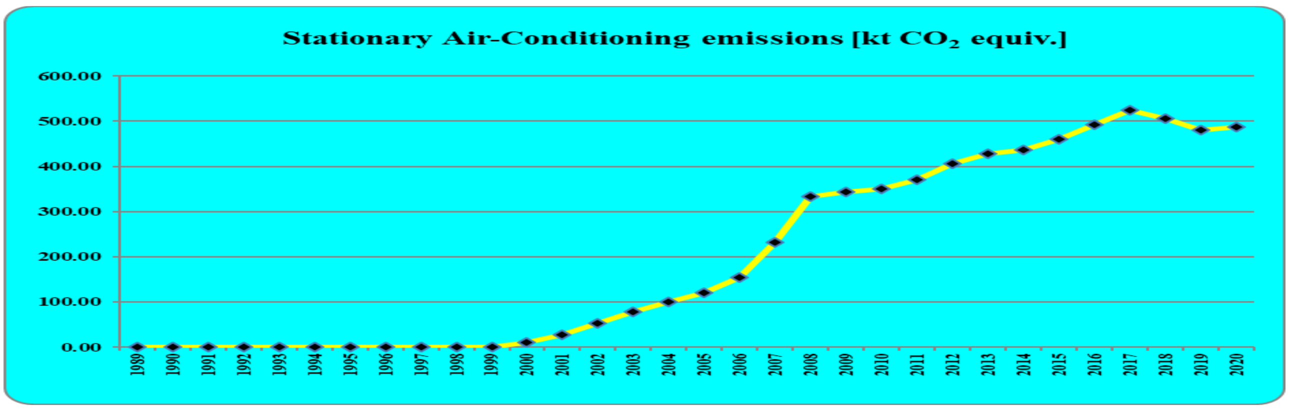
Year	Actual emissions (Mobile AC) kt CO_2 eq.	Actual emissions (Rail transport) kt CO_2 eq.	Total Actual emissions kt CO_2 eq.
1996	1.65	0.05	1.71
1997	5.73	0.19	5.92
1998	16.73	0.35	17.08
1999	29.64	0.48	30.12
2000	44.87	0.64	45.51
2001	62.10	0.77	62.87
2002	79.43	1.13	80.56
2003	98.71	1.68	100.38
2004	125.80	2.34	128.14
2005	158.04	3.17	161.21
2006	195.31	4.77	200.08
2007	242.70	7.15	249.85
2008	293.99	10.28	304.27
2009	313.08	13.55	326.63
2010	329.71	17.11	346.81
2011	340.76	20.45	361.21
2012	358.84	23.38	382.22
2013	378.72	26.07	404.79
2014	405.97	28.35	434.32
2015	436.88	30.04	466.92
2016	477.12	31.60	508.72
2017	543.90	32.88	576.77
2018	624.21	35.16	659.37
2019	674.61	37.90	712.51
2020	727.55	41.13	768.68

4.7.2.1.6 Stationary Air-Conditioning (CRF 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 1989–2020 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 2020 year banked quantities are equal to more than 4,100 tons, with additional 321 tons in heat pump units (see Table 4.46). Combined with a higher operation emission factor (related to domestic refrigeration), this leads to significant emission equal to 454.31 kt CO_2 eq. from AC equipment and 32.66 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 4.47.

Table 4.46 The quantity of banked HFC of the Domestic Air-Conditioning for 1989–2020 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.]
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0
2000	28	63,241	0	109	109	0	4,952	0	10
2005	0	151,391	0	244	1,292	0	61,097	0	120
2007	5,298	532,436	8	820	2,459	48	117,827	0	232
2008	5,835	728,756	9	1,108	3,514	53	170,161	0	334
2009	2,991	129,844	4	202	3,607	27	174,605	0	343
2010	0	122,350	0	191	3,676	0	177,891	0	349
2011	0	199,237	0	309	3,890	0	188,307	0	370
2012	0	250,740	0	383	4,267	0	207,011	0	407
2013	0	118,350	0	184	4,493	0	218,191	0	429
2014	0	169,098	0	261	4,580	0	222,490	0	437
2015	0	154,031	0	241	4,555	0	221,449	12,995	460.58
2016	2,243	280,883	3	431	4,685	20	228,240	22,077	491.75
2017	2,256	307,753	3	473	4,795	20	234,119	33,028	524.79
2018	2,406	112,472	4	180	4,547	22	221,971	35,183	505.14
2019	0	96,696	0	156	4,317	0	210,856	33,353	479.71
2020	0	333,155	0	513	4,480	0	219,186	28,749	486.97

Table 4.47 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 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 3 years. In general, the domestic production is insignificant compared to the imports. Around 321,400 AC units and 11,700 heat pumps were placed on the market in 2020 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 2020 year around 482 t of refrigerant have been introduced to the market as contained in AC equipment and 31 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. The refrigerant split is adopted from the EC 2011 study and are shown in Table 4.48. From 2009 year onwards, the refrigerant split remains constant.

Table 4.48 Assumptions on data for imports in Bulgaria for Domestic Air-Conditioning

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
R-407C	80%	77%	75%	70%	60%	55%	50%	45%	40%	30%
R-410A	0%	3%	5%	10%	30%	40%	45%	50%	60%	70%
R-404A	20%	20%	20%	20%	10%	5%	5%	5%	0%	0%

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 only 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. 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, for 2.F.1.f Stationary air-conditioning category the default recovery assumption of 85% was adopted, which is at the upper end of the range proposed by the 2006 IPCC Guidelines (0-90%) and for disposal loss factor the value of the 15% was considered.

4.7.2.2 Foam Blowing (CRF 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 2020 year, the actual emissions from foam blowing were 0.52 kt CO_2eq. (90.52% from the products manufactured were exported) (see Figure 4.28).

The banked quantities of HFCs are estimated to be around 240.62 t in 2020 year and are shown in Table 4.49.

Figure 4.28 Actual emissions of the Foam Blowing for 1989–2020 period

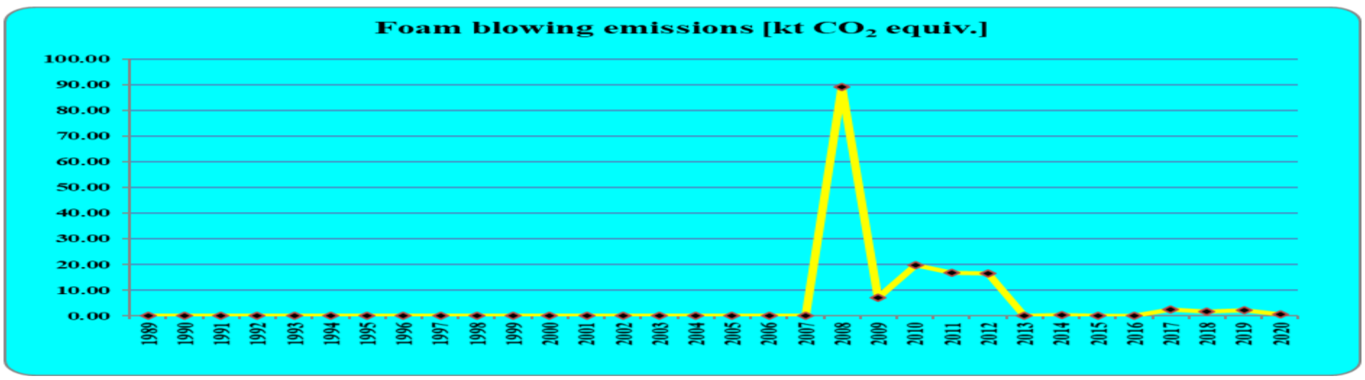


Table 4.49 The quantity of banked HFC of the Foam Blowing for 1989–2020 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFCs]	Operation emissions [kg HFCs]	Actual emissions [kt CO_2eq.]
1989	0.0	0.0	0	0	0.0
1990	0.0	0.0	0	0	0.0
1995	0.0	0.0	0	0	0.0
2000	0.0	0.0	0	0	0.0
2005	0.0	0.0	0	0	0.0
2007	0.0	0.0	0	0	0.0
2008	62.3	0.0	62,299	0	89.09
2009	4.9	0.0	4,875	0	6.97
2010	13.9	0.02	13,874	0.35	19.84
2011	12.2	0.43	11,796	6.50	16.84

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFCs]	Operation emissions [kg HFCs]	Actual emissions [kt CO_2eq.]
2012	12.2	1.09	11,528	16.43	16.45
2013	0.625	1.61	93.73	24.15	0.12
2014	1.97	3.26	294.95	48.86	0.34
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	2.55
2018	71.50	167.80	10,725.65	2,516.93	1.68
2019	90.83	242.48	13,624.02	3,637.22	2.18
2020	2.09	240.62	313.12	3,609.27	0.52

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. 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. 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 and 1.5% per annum thereafter.

4.7.2.3 Fire Protection (CRF 2.F.3)

Methodology

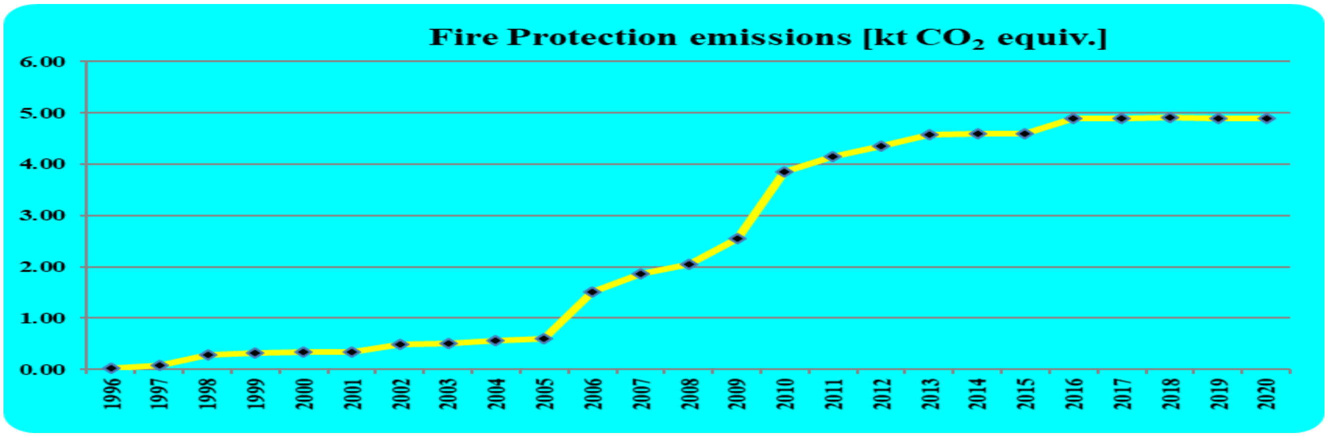
HFC use in fire protection equipment is relatively limited – its main area of application is mostly in flooding systems in datacenters, server and computer rooms, where equipment protection is of extreme importance and this could justify the higher equipment cost. There is no production of such equipment 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 30.415 t in 2020 year and while its usage in Romania started in 1996 year, the market started to grow significantly after 2006 year (see Table 4.50). 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 4.50 The quantity of banked HFC of the Fire Protection for 1989–2020 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Operation emissions [kg HFC]	Actual emissions [kt CO_2eq.]
1989	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00
2000	0.08	2.07	103.61	0.33
2005	0.19	3.70	184.97	0.60
2007	2.13	11.56	578.24	1.86
2008	1.18	12.75	637.38	2.05
2009	3.12	15.86	793.16	2.55
2010	8.01	23.87	1193.59	3.84
2011	1.90	25.77	1288.34	4.15
2012	1.32	27.09	1354.35	4.36
2013	1.34	28.42	1421.14	4.58
2014	0.17	28.59	1429.74	4.60
2015	0.00	28.59	1,429.74	4.60
2016	1.78	30.37	1,518.71	4.89
2017	0.00	30.37	1,518.71	4.89
2018	0.08	30.46	1,522.81	4.90
2019	0.00	30.42	1,520.76	4.90
2020	0.00	30.42	1,520.76	4.90

The actual emissions in 2020 year are estimated to be about 4.90 kt CO_2 eq (Figure 4.29).

Figure 4.29 Actual emissions of the Fire Protection for 1989–2020 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]. 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.

Emission factors

The 2006 IPCC Guidelines provide an updated range of 2 to 6% annual leakage. The 2000 IPCC GPG provide a default emission factor of 5% annually. Recent research (EC 2011) suggests that the emission factor is 2.5%, which is twice as low compared to the default EF. 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 introduced in the country. For fire extinguishers containing fluorinated greenhouse gases EF from decommissioning is NA (the bottles used are returned to the manufacturer).

[1]http://www2.dupont.com/FE/en_US/assets/downloads/pdf_fm/k17649_FM-200_physical_properties_si.pdf

4.7.2.4 Aerosols/Metered Dose Inhalers (CRF 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 2018-2019 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 2020 more than 2.1 mln. MDIs were sold on the market, the emissions from which amount to 49.11 kt CO_2 eq (see Table 4.51). 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. Although the 2000 IPCC GPG does not distinguish between different methodological tiers, it defines two possible approaches whether the estimates are prepared on application or sub-application level. In the 2006 IPCC Guidelines these approaches are defined as 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.

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[2] http://www.aerosol.org/about-fea/members

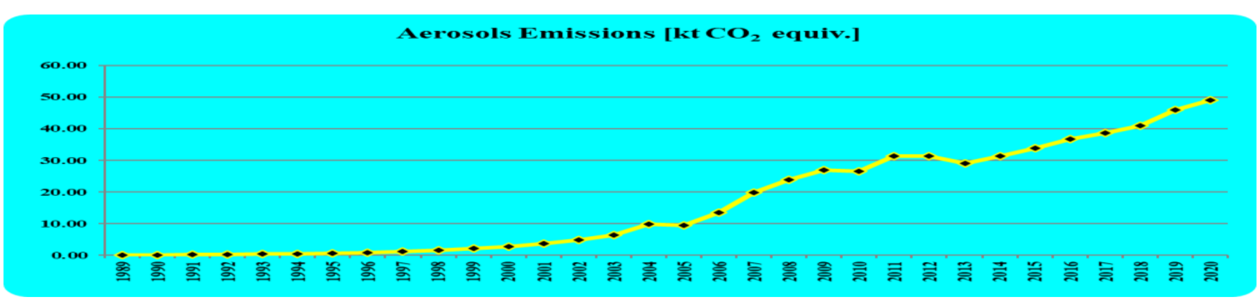
[3] http://www.aerosol.org/publications-news/publications/statistics/statistics-2

[4] http://www.aerosoleurope.de/wp-content/uploads/MarketSurvey_AE0211.pdf

Table 4.51 The The quantity of banked HFC of the Aerosols/Metered Dose Inhalers for 1989–2020 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	0.16
1990	0.14	0.07	72.11	54.59	0.18
1995	0.57	0.29	285.74	218.10	0.72
2000	2.25	1.13	1,127.38	858.22	2.84
2005	4.56	2.28	2,279.06	4,374.64	9.51
2007	13.33	6.66	6,663.40	7,175.09	19.79
2008	20.03	10.02	10,016.62	6,663.40	23.85
2009	17.71	8.86	8,855.65	10,016.62	26.99
2010	19.60	9.80	9,798.32	8,855.65	26.68
2011	24.41	12.20	12,203.56	9,798.32	31.46
2012	19.56	9.78	9,779.65	12,203.56	31.44
2013	21.16	10.58	10,579.09	9,779.65	29.11
2014	22.66	11.33	11,328.28	10,579.09	31.33
2015	24.82	12.41	12,410.87	11,328.28	33.95
2016	26.47	13.23	13,233.36	12,410.87	36.67
2017	27.71	13.85	13,854.37	13,233.36	38.74
2018	29.26	14.63	14,629.03	13,854.37	40.93
2019	33.27	16.64	16,635.58	14,629.03	45.94
2020	32.18	16.09	16,088.73	16,635.58	49.11

Figure 4.30 Actual emissions of the Aerosols/Metered Dose Inhalers for 1989–2020 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 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.

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 (CRF 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 (CRF 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 Uncertainties 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 8.1), 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 1989–2020.

4.7.3.1 Commercial Refrigeration (CRF 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%.

4.7.3.2 Domestic Refrigeration (CRF 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%.

4.7.3.3 Industrial Refrigeration (CRF 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%.

4.7.3.4 Transport Refrigeration (CRF 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%.

4.7.3.5 Mobile Air-Conditioning (CRF 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%.

4.7.3.6 Stationary Air-Conditioning (CRF 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%.

4.7.3.7 Foam Blowing (CRF 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%.

4.7.3.8 Fire Protection (CRF 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%.

4.7.3.9 Aerosols/Metered Dose Inhalers (CRF 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%.

4.7.4 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.

Following these activities there were no unconformities recorded.

Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

4.7.5 Category-specific recalculation, 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:

- activity data:
  - Mobile air-conditioning (CRF 2.F.1.e)
  - Fire Protection (CRF 2.F.3)
- emission factor:
  - Stationary air-conditioning (CRF 2.F.1.f)

Table 4.52 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	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	HFC emissions [kt CO_2 equivalent]		
1996	4.91	4.97	1.04
1997	10.63	10.82	1.75
1998	24.27	24.62	1.44
1999	40.29	40.77	1.19
2000	71.57	72.16	0.82
2001	113.86	114.53	0.59
2002	169.63	170.61	0.58
2003	230.91	232.23	0.57
2004	296.98	298.63	0.55
2005	372.47	374.57	0.56
2006	488.28	491.60	0.68
2007	669.78	675.11	0.79
2008	951.78	959.99	0.86

The effects of recalculations in Product uses as substitutes for ODS Sector			
Years	**NGHGI 2021**	**NGHGI 2022**	**Differences [%]**
	HFC emissions [kt CO_2 equivalent]		
2009	929.59	941.00	1.23
2010	987.24	1,002.11	1.51
2011	1,096.03	1,114.11	1.65
2012	1,200.96	1,221.82	1.74
2013	1,301.38	1,324.80	1.80
2014	1,375.34	1,400.94	1.86
2015	1,638.48	1,520.45	-7.20
2016	1,894.41	1,676.68	-11.49
2017	2,174.09	1,835.24	-15.59
2018	2,255.10	1,894.35	-16.00
2019	2,256.01	1,917.14	-15.02
2020		1,988.58	

2.F.1.e Mobile air-conditioning

Recalculations of the HFC emissions have been made for the 1996-2019 period due to improvement in activity data for the rail transport (an operator transmitted data for these years).

2.F.1.f Stationary air-conditioning

Recalculations have been made for the period 2015-2019 due to the change in the disposal loss factor used to estimate the actual emissions from disposal (the default recovery assumption of 85% was adopted).

2.F.3 Fire protection

Recalculations have been made for the 2009-2019 period due to improvement in activity data regarding the quantity of banks in the fire protection equipments.

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

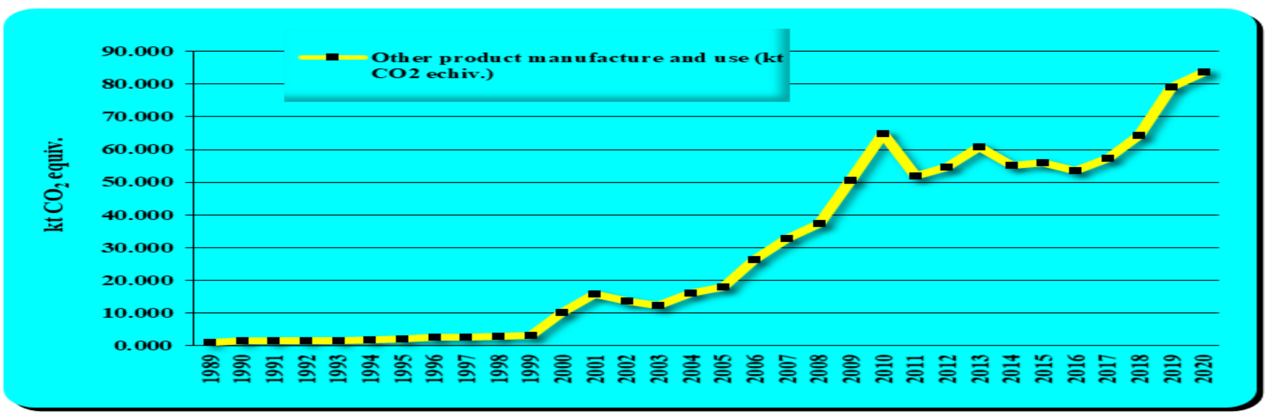
More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

4.8 Other product manufacture and use (CRF 2.G)

4.8.1 Category description

Under this F-gases category are considered the following subcategories: Electrical equipment (CRF 2.G.1), SF_6 and PFCs from other product use (CRF 2.G.2), N_2O from product uses (CRF 2.G.3) and Other (CRF 2.G.4). Other product manufacture and use contributes with 0.64% to the total GHG emissions from Industrial Processes and Product Use Sector in 2020.

Figure 4.31 GHG emissions trend in the Other product manufacture and use Sub–sector for 1989–2020 period



4.8.2 Methodological issues

4.8.2.1 Electrical Equipment (CRF 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. Most of the banked quantities of SF_6 are contained in closed pressure equipment (around 70.8% of the total quantity or 103.51 t in 2020 year), while the rest is banked in sealed pressure equipment (29.2 t in 2020 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 81.73 kt CO_2eq. in 2020 year (see Table 4.53). Emissions from the electrical equipment subcategory were estimated using a bottom-up approach (Tier 2a lifecycle emission factor approach from the 2000 IPCC Guidelines, which is equal to Tier 1 method from the 2006 IPCC guidelines).

Figure 4.32 Actual emissions of the Electrical Equipment for 1989–2020 period

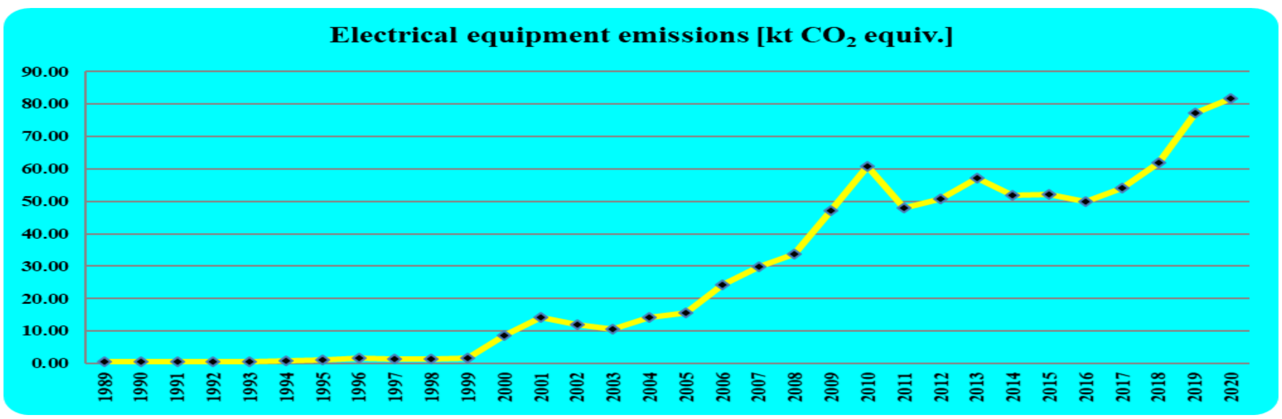


Table 4.53 The quantity of banked HFC of the Electrical Equipment for 1989–2020 period

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	0.47
1990	0.00	0.80	0.00	20.83	0.00	0.47
1995	0.17	1.10	14.28	28.52	0.00	0.98
2000	3.06	5.44	249.26	130.80	0.00	8.68

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.]
2005	2.32	20.34	171.09	461.73	49.20	15.67
2007	7.98	34.39	532.22	763.59	14.70	29.88
2008	9.17	43.56	529.97	931.58	21.15	33.81
2009	13.72	57.28	842.95	1,197.02	22.65	47.03
2010	21.35	78.63	1,105.44	1,551.84	4.45	60.69
2011	8.20	86.83	386.93	1,677.49	33.14	47.82
2012	8.03	94.86	393.48	1,804.65	27.68	50.75
2013	7.53	102.39	528.10	1,968.82	12.15	57.21
2014	5.38	107.76	212.75	2,039.64	18.48	51.78
2015	4.36	112.12	165.95	2,095.22	28.61	52.21
2016	2.51	114.63	46.56	2,113.38	24.24	49.80
2017	3.54	118.17	181.28	2,171.64	23.72	54.19
2018	5.99	124.16	383.64	2,291.95	42.94	61.98
2019	11.01	135.17	793.80	2,538.10	50.63	77.12
2020	11.08	146.25	766.68	2,776.74	41.04	81.73

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.

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 (CRF 2.G.2)

Other emissions are not known to be occurring.

4.8.2.3 N_2O from product uses (CRF 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 2007-2020 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 (CRF 2.G.4)

Other emissions are not known to be occurring.

4.8.3 Uncertainties and time series consistency

4.8.3.1 Electrical Equipment (CRF 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%.

4.8.3.2 N_2O from product uses (CRF 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 6.3.

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 1989–2020.

4.8.4 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.

Following these activities there were no unconformities recorded.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the

European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

4.8.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

No recalculations were made relative to previous submission.

4.8.6 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 (CRF Sector 3)

5.1 Overview of sector

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	NA

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
3.B.2.4.2. Buffalo	NA	✓	NA
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

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
3.D.1.6 Cultivation of Organic Soils	NA	✓	NA
3.D.1.7.Other	NA	✓ , NO	NA
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 1989–2020 period

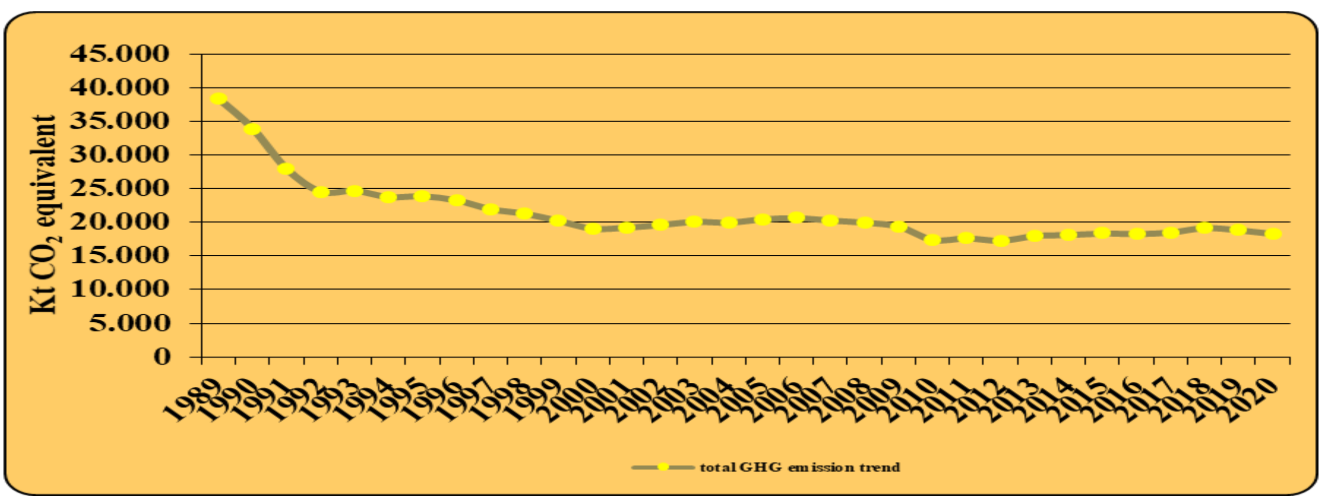
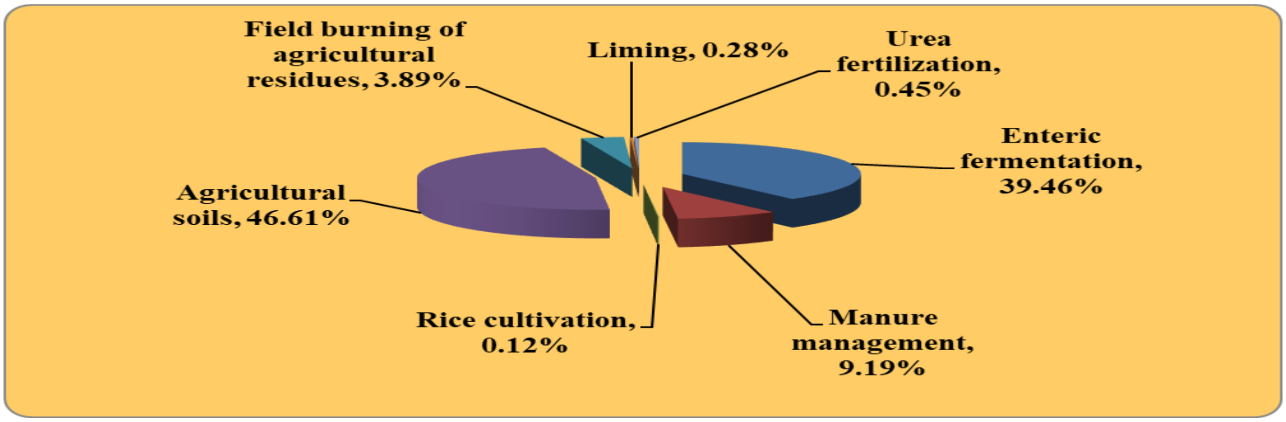


Figure 5.2 Contribution of the sub-sectors in the total GHG emissions from Agriculture, in 2020 year



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 1989-2020 period. Emissions from prescribed burning of savannas do not occur in Romania. The Agriculture Sector accounted for 16.66% of the total GHG emissions in 2020, reaching 109,934.32 kt CO_2 equivalent (Table 5.2). Within the GHG emissions from the agriculture sector, the CH_4 emissions have the largest contribution (in 2020, CH_4 emissions contribution is 44.51 to the total Agriculture Sector's CO_2 equivalent emissions), followed by the N_2O emissions (that account for the remaining 53.42). Over the period 1989 – 2020, the GHG emissions resulted from Agriculture Sector decreased by 52.25% (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 2020 there were registered 315,702 heads Annex 3.5.1 (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 2004-2020 period, sheep and goats livestock number is only growing slightly; for the rest of species, their downward trend of 1989-2003 period continued. Comparatively with the 2019 year, in 2020 were slowly increased some livestock categories for exemple:goats and horses. 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 2020 a significantly reduced emission compared to the base year 1989 due to the decrease of areas (85.15% decrease comparing with the base year). In case of agricultural soils, the emissions decreased over the period (47.04% decrease in 2020 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 2020 with 52.25% compared to basic (see Annex 3.5.1 - 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 2020 with 46.90% comparing with the base year (see Annex 3.5.1 - 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, 2007–2020

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	307,045.72	38,358.51	12.49	19,667.15	51.27	18,425.05	48.03
1990	249,696.53	33,917.37	13.58	17,481.17	51.54	16,253.69	47.92
1995	184,936.24	23,903.10	12.93	12,516.40	52.36	11,288.99	47.23
2000	138,979.50	19,105.79	13.75	10,598.69	55.47	8,404.20	43.99
2005	146,902.60	20,489.82	13.95	10,671.53	52.08	9,679.75	47.24
2007	151,887.14	20,300.57	13.37	11,330.39	55.81	8,852.74	43.61
2008	147,982.51	19,987.45	13.51	10,519.55	52.63	9,330.91	46.68
2009	127,058.67	19,400.30	15.27	10,089.88	52.01	9,187.37	47.36
2010	122,862.63	17,432.03	14.19	8,545.96	49.02	8,778.85	50.36
2011	129,627.15	17,673.85	13.63	8,530.78	48.27	9,052.42	51.22
2012	127,537.24	17,321.86	13.58	8,861.21	51.16	8,384.02	48.40
2013	116,059.32	18,020.07	15.53	8,625.05	47.86	9,305.12	51.64
2014	115,292.89	18161.72	15.75	8,793.09	48.42	9,286.48	51.13
2015	114,817.69	18391.69	16.02	8,901.93	48.40	9,395.42	51.09
2016	113,456.38	18307.99	16.14	8,795.95	48.04	9,398.80	51.34

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 [%]
2017	116,701.16	18539.22	15.89	8,477.96	45.73	9,936.67	53.60
2018	117,597.48	19191.54	16.32	8,362.32	43.57	10,703.80	55.77
2019	113,939.38	18861.23	16.55	8,317.67	44.10	10,414.98	55.22
2020	109,934.33	18315.85	16.66	8,395.88	45.84	9,782.85	53.42

Table 5.2 (continued) Contribution of Agriculture sector in total GHG emissions, in 1989-1990, 1995, 2000, 2005, 2007–2020

Year	CO_2 emissions from Agriculture [kt]	Contribution of CO_2 emissions in total GHG emissions from Agriculture [%]
1989	266.30	0.694
1990	182.51	0.538
1995	97.71	0.408
2000	102.90	0.538
2005	138.54	0.676
2007	117.43	0.578
2008	136.98	0.685
2009	123.05	0.634
2010	107.22	0.615
2011	90.65	0.512
2012	76.63	0.442
2013	89.90	0.498
2014	82.15	0.452
2015	94.34	0.512
2016	113.24	0.618
2017	124.60	0.672

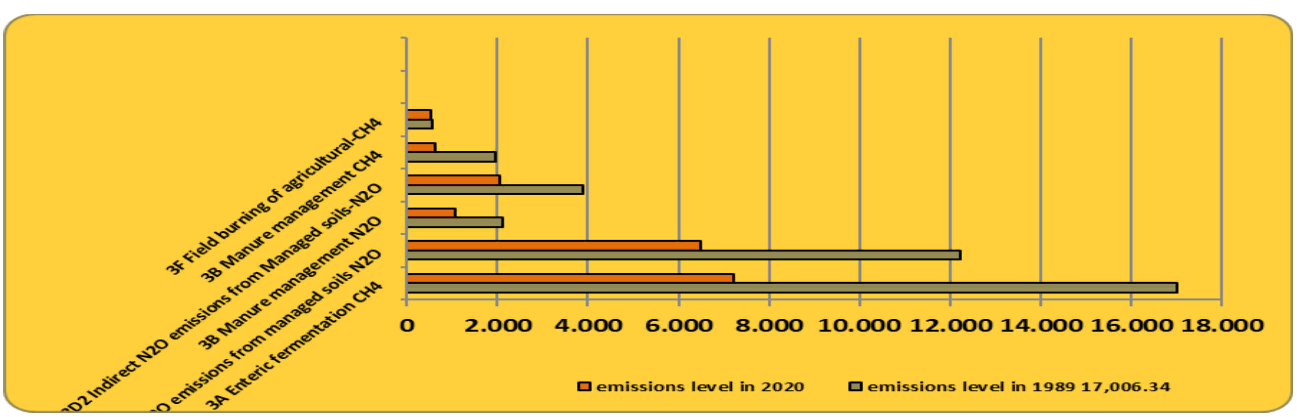
Year	CO_2 emissions from Agriculture [kt]	Contribution of CO_2 emissions in total GHG emissions from Agriculture [%]
2018	125.42	0.653
2019	128.58	0.681
2020	135.56	0.740

In 2020 year the CH_4 emissions contribute with 45.84% in total GHG emissions from Agriculture, the N_2O emissions contribute with 53.42% and CO_2 the contribution is 0.70%. 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, 2020

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	6.5	Tier 1, Tier 2
3D1 Direct N2O emissions from Managed soils	N_2O	L,T	5.9	Tier 1
3D2 Indirect N_2O emissions from Managed soils	N_2O	L,T	1.8	Tier 1
3B Manure management N_2O	N_2O	L,T	0.9	Tier 2
3B Manure management CH_4	CH_4	L	0.5	Tier 1, Tier 2
3F Field burning of agricultural-CH_4	CH_4	T	0.4	Tier 1

Figure 5.3 Key Categories in Agriculture, both by level and trend



5.2 Enteric Fermentation (CRF 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 2020, CH_4 emissions from Enteric Fermentation represented 86.07% of total CH_4 emissions in the Agriculture sector);
- ❖ is the source in the Agriculture sector (in 2020, CH_4 emissions from Enteric Fermentation as CO_2 equivalent represented 39.45% from Total Agriculture emissions);
- ❖ contributed with 6.57% to Total GHG emissions of Romania.

Compared to 1989, total CH_4 emissions from Enteric Fermentation decreased with 51.74% in 2020 (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

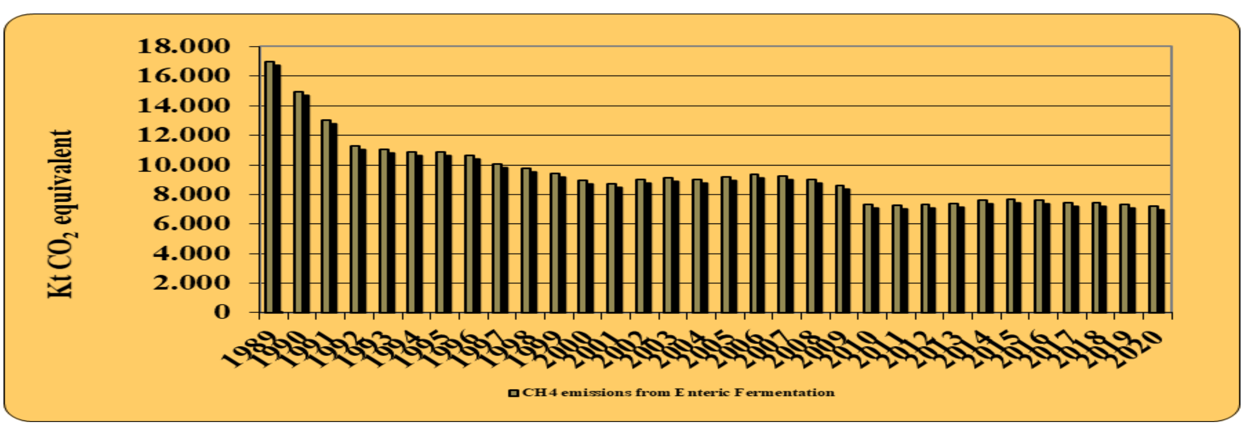


Table 5.4 Observations on source category 3A – "Enteric Fermentation"

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, 2004-2020 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, 2004-2020; 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 sows*	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2020 EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	**Buffalo**	Includes livestock data from two different *buffalo*: buffalo milk and other buffalo	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2020; EF: Default -IPCC 2006
3.A.4	**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, 2004-2020; EF: Default -IPCC 2006
3.A.4	**Horses**		AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2020; EF: Default-IPCC 2006
3.A.4	**Mules and asses**		AD: FAO, 2011, 2017;

Source indicative	Source (livestock) type	Observation	Data source
			EF: Default-IPCC 2006
3.A.4	**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, 2004-2020 EF: Default-IPCC 2006
3.A.4	**Rabbits**		AD: NIS, 1989-2020 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) (*Annex3.5.3_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) (*Annex3.5.3_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 3.5.*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 (Annex3.5.3*_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 3.5.2*_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*, *2007–2020* for dairy cows data provided of National Institute of Statistics – Statistical Yearbook of Romania, 1989 – 2020 (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 3.5.2_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, 2007–2020 (National Institute for Statistics – Statistical Yearbook of Romania, 1989 – 2020), litre/year

Year	Dairy cattle production (litre/year)
1989	4,047,700
1990	3,969,800
1995	5,243,100

Year	Dairy cattle production (litre/year)
2000	4,819,100
2005	5,497,600
2007	5,451,700
2008	5,276,100
2009	4,823,400
2010	4,258,500
2011	4,372,800
2012	4,182,300
2013	4,238,100
2014	4,371,300
2015	4,240,181
2016	4,180,166
2017	4,038,422
2018	4,047,548
2019	3,958,642
2020	3,971,479

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, Y_m value is 0.065 for developing countries. 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 1989-2020 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.1.2	***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.4.1	***BUFFALO***			
	Female 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)
	Other buffalo	55	NA	NA
3.A.4.3	***GOATS***			
	Female goats for milk and females by first mount	5	NA	NA
	Other goats	5	NA	NA
3.A.4.4	***HORSES***	18	NA	NA
3.A.4.5	***MULES AND ASSES***	10	NA	NA
3.A.4.6	***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, 2007–2020 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.1.1 Dairy cattle			
1989	97.60	228.93	0.065
1990	99.51	233.41	0.065
1995	114.93	269.60	0.065
2000	118.56	278.11	0.065
2005	122.77	287.97	0.065
2007	123.72	290.20	0.065
2008	124.75	292.61	0.065
2009	122.96	288.43	0.065
2010	125.38	294.10	0.065
2011	127.37	298.76	0.065
2012	125.76	294.98	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.1.1 Dairy cattle			
2013	126.02	295.60	0.065
2014	126.65	297.09	0.065
2015	125.29	293.89	0.065
2016	123.88	290.58	0.065
2017	123.89	290.60	0.065
2018	124.56	292.17	0.065
2019	124.33	291.62	0.065
2020	125.09	293.43	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, 2007–2020 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	7.75	18.17	0.065
1990	7.81	18.31	0.065
1995	7.75	18.19	0.065
2000	7.76	18.19	0.065
2005	7.77	18.21	0.065
2007	7.77	18.23	0.065
2008	7.71	18.07	0.065
2009	7.70	18.06	0.065
2010	7.72	18.10	0.065
2011	7.72	18.11	0.065
2012	7.72	18.11	0.065
2013	7.71	18.08	0.065
2014	7.75	18.17	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			
2015	7.75	18.16	0.065
2016	7.74	18.16	0.065
2017	7.74	18.15	0.065
2018	7.75	18.17	0.065
2019	7.75	18.17	0.065
2020	7.74	18.16	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, 2007–2020 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	8.51	19.95	0.065
1990	8.56	20.08	0.065
1995	8.51	19.96	0.065
2000	8.51	19.96	0.065
2005	8.52	19.99	0.065
2007	8.53	20.01	0.065
2008	8.46	19.85	0.065
2009	8.46	19.84	0.065
2010	8.48	19.88	0.065
2011	8.48	19.89	0.065
2012	8.48	19.88	0.065
2013	8.47	19.86	0.065
2014	8.51	19.95	0.065
2015	8.50	19.94	0.065
2016	8.50	19.93	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			
2017	8.50	19.93	0.065
2018	8.51	19.95	0.065
2019	8.51	19.95	0.065
2020	8.50	19.94	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, 2007–2020 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	8.298881	19.46607	0.065
1990	7.982162	18.72317	0.065
1995	7.981643	18.72195	0.065
2000	7.981653	18.72198	0.065
2005	7.981745	18.72219	0.065
2007	7.981838	18.72241	0.065
2008	7.981153	18.72081	0.065
2009	7.981126	18.72075	0.065
2010	7.981291	18.72113	0.065
2011	7.981317	18.72119	0.065
2012	7.981311	18.72118	0.065
2013	7.981214	18.72095	0.065
2014	7.981572	18.72179	0.065
2015	7.981552	18.72174	0.065
2016	7.981521	18.72167	0.065
2017	7.981505	18.72163	0.065
2018	7.981591	18.72183	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 Other sheep			
2019	7.981583	18.72182	0.065
2020	7.981534	18.72170	0.065

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 3.5.*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 1989-2020 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.1.1	*Dairy cattle*	NE	60	650
3.A.1.2	*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

Source indicative	Livestock (source) type	Energy digestible DE (Mj/day)	Percentage of digestible energy DE(%)	Animal weight (kg)
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.4.1	***BUFFALO***			
	Female buffalo	NA	NA	NA
	Other buffalo	NA	NA	NA
3A.4.3	***GOATS***			
	Female goats for milk and females by first mount	NA	NA	NA
	Other goats	NA	NA	NA
3.A.4.4	***HORSES***	NA	NA	NA
3.A.4.5	***MULES AND ASSES***	NA	NA	NA
3.A.4.6	***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.

2004-2020

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 3.5.1 (sheet *Primary data)* raw data on livestock in the period 1989-2020, 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 7.33% approximatively have been identified between Eurostat and NGHGI data; the differences are due to specific elements on data manipulation at the National Institute for Statistics (NGHGI 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 3.5.1 (sheet - Data obtained through the study) and for which are official data for 2004-2020. 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 3.5.1 (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 1989-2020 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 2020), 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.

2004-2020

In the Annex 3.5.1 (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 3.5.1 (sheet – *Primary data*), the values of *young cattle breeding* is the sum of *males* and *females* from Annex 3.5.1 (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 3.5.1 (sheet – *Primary data*). For *young cattle for slaughter* were used the values from in according with Annex 3.5.1 (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 3.5.1 (sheet - *Data obtained through the study*) are used in according with the Annex 3.5.1 (sheet – *Primary data*).

Sheep

The values for *ewes of milk and fitted* were taken from the Annex 3.5.1 (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 3.5.1 (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 3.5.1 (sheet – *Primary data*).

5.2.3 Uncertainties 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 6.3.

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 1989-2020 is consistent.

5.2.4 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 *Waste sector*, the results of these being mentioned on the Checklists level.Following these activities there were no unconformities recorded.

Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council regarding the mechanism of monitoring and reporting of emissions of greenhouse gases, and reporting, at national level and of the Union, of the other informations relevant for climate change and repealing of the Decision 280/2004/CE and Decision 166/2005/EC of the European Commission.

In 2012 year, 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.
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.

5.2.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

No recalculations were made.

5.2.6 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 (CRF 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 2020 CH_4 emissions from Manure Management represented 7.44% of total CH_4 emissions while N_2O accounted for 10.81% of total N_2O emissions in the Agriculture sector;
- CH_4 and N_2O emissions from Manure Management as CO_2 equivalent in 2020 represented 9.19% from Total Agriculture emissions;
- contributed with 0.57% 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 5.13. 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

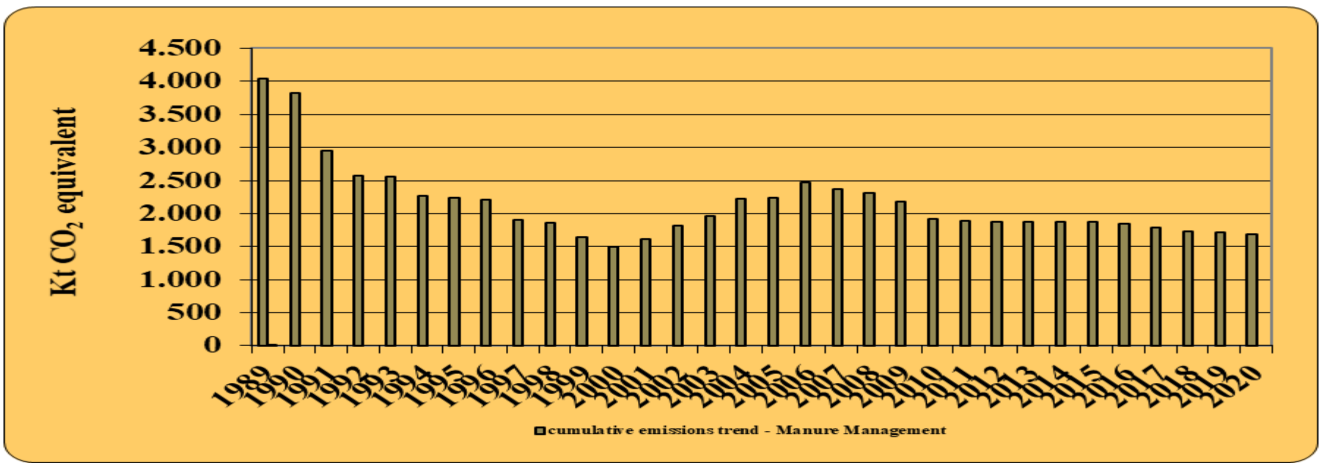


Table 5.13 Observations on source category 3B – "Manure Management"

Source indicative	Source type	Observation		Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"				
3.B.1.1	**Cattle**		Includes livestock data from nine different cattle categories: dairy cows and non-dairy cattle	AD: NIS and expert judgment, 1989-2003; NIS, 2004-2020 EF: Country specific, expert judgment, IPCC 2006
3.B.1.2	**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, 2004-2020; EF: IPCC 2006, country specific

Source indicative	Source type	Observation		Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"				
3.B.1.3	**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, 2004-2020 EF: IPCC 2006, expert judgment
3B.1.4.1	**Rabbits**			AD: NIS, 1989-2020; EF: IPCC 2006, default
3.B.1.4.2	**Buffalo**		Includes livestock data from two different buffalo:buffalo milk and other buffalo	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2020; EF: IPCC 2006, default
3.B.1.4.3	**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, 2004-2020; EF: IPCC 2006, default
3.B.1.4.4	**Horses**			AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2020; EF: IPCC 2006, default
3.B.1.4.4	**Mules and asses**			AD: FAO, 2011; EF: IPCC 2006, default
3.B.1.4.5	**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, 2004-2020 EF: IPCC 2006, default
3.B.2.1	**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

Source indicative	Source type	Observation		Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"				
		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.2.2	**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.2.3	**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
3.B.2.4.1	**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.2.4.3	**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.2.4.4	**Horses**		Includes following type of systemes of management: - Pasture/range/paddock;	AD: SY, other correspondence, NIS and expert judgment, IPCC 2006

Source indicative	Source type	Observation		Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"				
			- Daily spread; - Solid storage	EF: IPCC 2006, expert judgment
3.B.2.4.5	**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.2.4.6	**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.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 3.5.1 (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 3.5.1 *"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 5.14. In the Table 5.14 are summarized the values used in the calculation of emissions factors for 1989-2020 period for each livestock (non dairy cattle and swine). In the tables 5.15 and 5.16 are summarized the values used in the calculation of emissions factors for 1989-2020 period for dairy cattle and sheep and the Table 5.17 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 5.14 The values used in the calculation of emissions factors from Manure management for non dairy cattle and swine 1989-2020

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.1.2	***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 5.15 The values used in the calculation of emissions factors from Manure management for 1989-1990, 1995, 2000, 2005, 2007–2020 period for dairy cattle and sheep- Ewes and Ewe mounted

Livestock/ Years	3.B.1.1 Dairy cattle		3.B.1.2 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	5.02	0.04	0.35342	0.04
1990	5.12	0.04	0.35611	0.04
1995	5.91	0.04	0.35374	0.04
2000	6.10	0.04	0.35379	0.04
2005	6.31	0.04	0.35421	0.04
2007	6.36	0.04	0.35463	0.04
2008	6.42	0.04	0.35151	0.04
2009	6.32	0.04	0.35138	0.04
2010	6.45	0.04	0.35213	0.04
2011	6.55	0.04	0.35225	0.04
2012	6.47	0.04	0.35223	0.04
2013	6.48	0.04	0.35178	0.04
2014	6.51	0.04	0.35342	0.04
2015	6.44	0.04	0.35333	0.04
2016	6.37	0.04	0.35319	0.04
2017	6.37	0.04	0.35311	0.04
2018	6.41	0.04	0.35350	0.04
2019	6.39	0.04	0.35347	0.04
2020	6.43	0.04	0.3532	0.04

Table 5.16 The values used in the calculation of emissions factors from Manure management for 1989-1990, 1995, 2000, 2005, 2007–2020 period for sheep- Reproducers Rams, Other Sheep

Livestock/ Years	**3.B.1.2 Sheep - Reproducers Rams**		**3.B.1.2 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	0.378559855	0.04
1990	0.390673922	0.04	0.364112482	0.04
1995	0.388306902	0.04	0.364088812	0.04
2000	0.388353484	0.04	0.364089277	0.04
2005	0.388774139	0.04	0.364093484	0.04
2007	0.389196785	0.04	0.36409771	0.04
2008	0.386073942	0.04	0.364066482	0.04
2009	0.385948403	0.04	0.364065227	0.04
2010	0.386698977	0.04	0.364072732	0.04
2011	0.386816653	0.04	0.364073909	0.04
2012	0.386792368	0.04	0.364073666	0.04
2013	0.386348710	0.04	0.36406923	0.04
2014	0.387982599	0.04	0.364085568	0.04
2015	0.387890188	0.04	0.364084644	0.04
2016	0.387750533	0.04	0.364083248	0.04
2017	0.387676446	0.04	0.364082507	0.04
2018	0.388065873	0.04	0.364086401	0.04
2019	0.388031885	0.04	0.364086061	0.04
2020	0.387810128	0.04	0.364083844	0.04

Table 5.17 The values MCF used in calculation of emissions factor for each manure system management for all livestock in the 1989-2020 period

The period 1989-2020	**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 3.5.1 (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 1989-2020 period, and in the Annex 3.5.1 (sheet- *Emission factor manure management*) are found emission factors necessary for calculation of methane emissions from manure management. 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 could not be estimated the N_2O emissions because there are not default values for fraction of animal species/category i's manure handled using manure system j in climate region k (MS). 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 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

$$N_{ex} = \text{the amount of solid manure} \cdot 365 \cdot \text{N\% from solid manure} / 100 + \text{the amount of liquid manure} \cdot 365 \cdot \text{N\% from liquid manure} / 100$$

In the Table 5.18 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 5.18 Data necessary for calculating of Annual average N excretion per head of species/category Nex (kg N/animal/yr), in the 1989-2020 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.1.3	***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.1.4.2	***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.1.4.4	***HORSES***	16	3.6	0.6	1.55	55.4
3 B.1.4.5	***MULES AND ASSES***	11	2.2	0.6	1.55	36.53
3 B.1.4.6	***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, 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 3.5.4 "*Detalied data estimating Nex for livestock*" are found the values and the calculations for Nex for all period and weighted average on Nex. In CRF 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 CRF 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 5.19 depending to manure management system.

Table 5.19 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 2.5)

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 Uncertainties 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 6.3.

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- 2020 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 6.3.

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- 2020 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- 2020 is consistent.

5.3.4 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 *Waste sector*, the results of these being mentioned on the Checklists level.

In 2012 year, 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.

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 6.6.

5.3.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculation was made.

5.3.6 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 (CRF 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 2020, CH_4 emissions from Rice Cultivation represented 0.25% of total CH_4 emissions in the Agriculture sector);
- in 2020, CH_4 emissions from Rice Cultivation as CO_2 equivalent represented 0.12% 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 2020 the rice area cultivated is 5.8 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

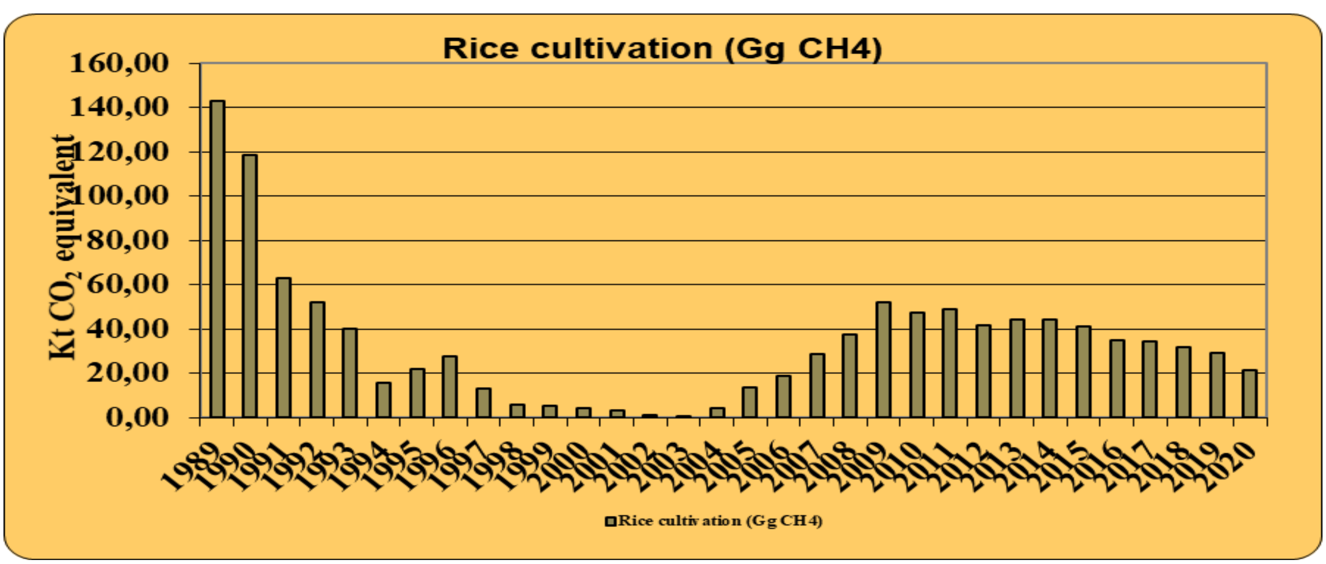


Table 5.20 Observations on source category 3C – "Rice Cultivation"

Source indicative	Source type	Observation	Data source
3.C.1.2	Rice harvested area		AD: SY, NIS, 1989-2020; 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, 2007–2020 period.

Table 5.21 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, 2007–2020 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
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

Activity data

Total rice cultivated area is provided by Romanian National Institute for Statistics (NIS) being released through Statistical Yearbook 1989-2020. 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 5.22.

Table 5.22 Harvested area data series for 1989-1990, 1995, 2000, 2005, 2007–2020 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
2018	0.83
2019	0.74
2020	0.58

5.4.3 Uncertainties 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 6.3.

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 1989-2020 is consistent.

5.4.4 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.

In 2012 year, 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.

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 3.5.1.

5.4.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

Has been make recalculations compared to the last submission. Recalculations were made for the 2019 year for CH_4 emissions for following reasons:

- was corrected the value for harvested area data for the 2019 year.

The impact of reclaculations can be found in following table.

Table 5.23 Implication of recalculations on emission estimates

The changes impacts on estimating CH_4 emissions			
Year	**CH_4 emissions (kt) for livestock**		
	NGHGI 2021	**NGHGI 2022**	**Difference**
2019	1.16130631739286	1.16135322117593	-0.000046904

5.4.6 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 (CRF 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 2020, N_2O Direct soil emissions represented 66.31% of total N_2O emissions in the Agriculture sector);
- is the first source in the Agriculture sector (in 2020, N_2O Direct soil emissions as CO_2 equivalent represented 35.42% from Total Agriculture emissions);
- contributed with 5.90% 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 7.37 kt N_2O in 2020. The quantity of synthetic fertilizer has decreased considerably after the 1989 year from 665,300 tonnes/year to 468,891tonnes/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 8.22 kt N_2O in 1989, to 3.37 kt N_2O in 2020. 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

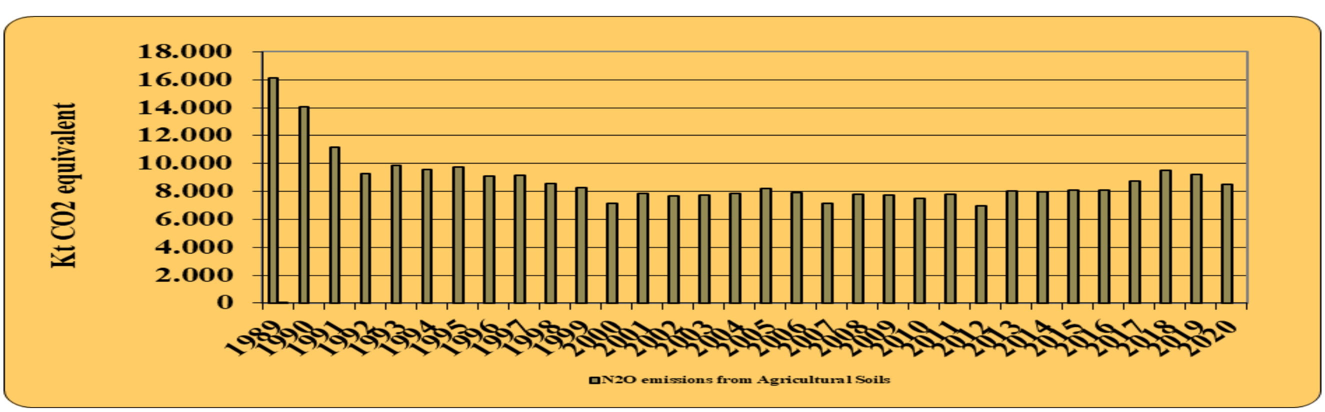


Figure 5.8 Direct N_2O emissions trends – Agricultural Soils

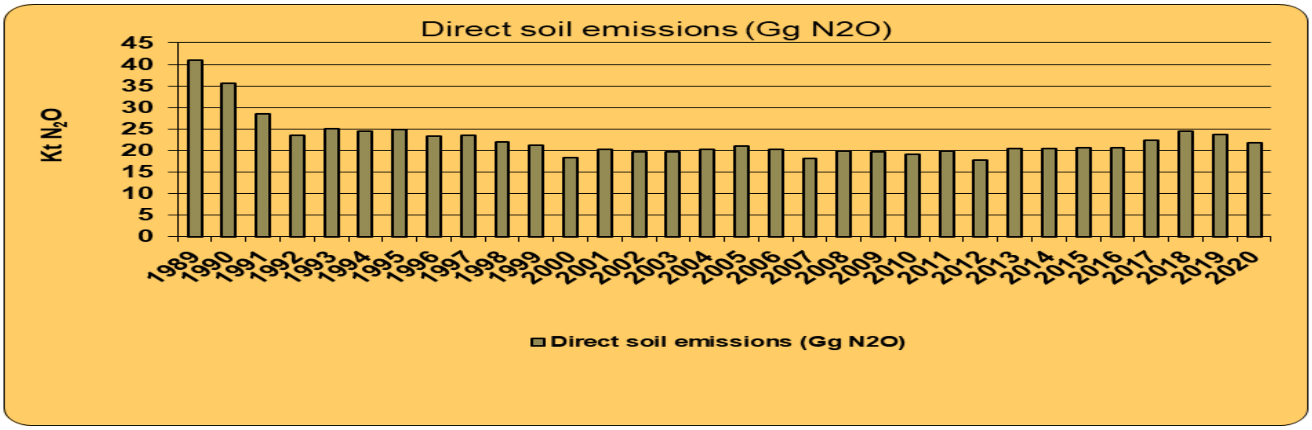


Table 5.24 Observations on source category 3D – "Managed Soils"

Source indicative	Source (livestock) type	Observation	Data source
3.D.1, 3.D.2	**Amount of N synthetic fertilizer used**		AD: SY, NIS, 1989-2020; 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, 2004-2020; 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
			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, pea beans, dry bean, other leguminous for dry bean, soybeans, Annual leguminous, lucerne, clover, other perennial leguminous.*	AD: SY, other correspondence, NIS, 1989 -2020; 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
	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,*	AD: NIS, 1989 -2020; EF: IPCC 2006

Source indicative	Source (livestock) type	Observation	Data source
		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.	
	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 -2020; 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 1989-2020. Data series are presented in Table 5.25.

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 5.26 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_{OOA})** have been used values 0 because are not available the values. It is noted in the CRF tables NO. 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 5.25 Activity data series used for calculation of F_{SN}, , for 1989-1990, 1995, 2000, 2005, 2007–2020 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

Table 5.26 Activity data series used for calculation of F_{SEW}, for 1989-1990, 1995, 2000, 2005, 2007–2020 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
2020	56000

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 1989-2020 and data base. Crop production of nitrogen fixing crop are presented in Table 5.27. 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 5.27 The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989-1990, 1995, 2000, 2005, 2007–2020 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

Table 5.27 (continued) The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989-1990, 1995, 2000, 2005, 2007–2020 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
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

Year	Crop production of nitrogen fixing crop (tonnes/year)			
	Green maize for fodder	Clover in equivalent green fodder	Other perennial forage	Perennial forage
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

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 5.28 (NIS) for the calculation F_{CR} are used the data on Crop production of nitrogen fixing crop presented in the Table 5.29. The values for pea beans, dry bean, soybeans, lucerne and clover were used in the primary data table (Table 5.28). 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 5.28 The data on Crop production of nitrogen fixing crop obtained through the dedicated study (tonnes/year), in the 1989-1990, 1995, 2000, 2005, 2007–2020 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

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
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

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 1989-2020 and data base are presented in Table 5.29.

Table 5.29 The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-1990, 1995, 2000, 2005, 2007–2020 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

Year	Productions of non-N-fixing crops (tonnes/year)							
	Rye	Wheat	Barley and two-row barley	Oats	Maize grains	Sorghum	Rice	Total Cereal grains
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

Table 5.29 (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, 2007–2020 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

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
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

Table 5.29 (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, 2007–2020 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

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
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

Table 5.29 (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, 2007–2020 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

Year	Productions of non-N-fixing crops (tonnes/year)							
	Fodder roots	Tomatoes	Eggplant	Dry onion	Dry garlic	Cabbage	Green peppers	Cultivated mushrooms
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

Table 5.29 (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, 2007–2020 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

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
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

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 5.29 (NIS) were considered the data on Crop production of non - nitrogen fixing crop presented in the Annex 3.5.1 – 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 5.29. 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 5.29). 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 **F_{CR}** are presented in the Table 5.30. 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 3.5.1. 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 5.30 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 1989-2020 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

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**
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 5.31 are presented the values associated the nitrogen non fixing crop used in the calculation **F_{CR}**.

Table 5.31 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 1989-2020 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 5.31 (continued) The values associated the nitrogen non fixing crop used in the calculation F_{CR} (AG_{DM} slope, AG_{DM} intercept, $R_{BG\text{-}BIO}$, N_{AG}, N_{BG}, $Frac_{Remove}$, $Frac_{DM}$, $Frac_{RENEW}$), in the 1989-2020 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
$R_{BG\text{-}BIO}$ (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 5.31 (continued) The values associated the nitrogen non fixing crop used in the calculation F_{CR} (AG_{DM} slope, AG_{DM} intercept, $R_{BG\text{-}BIO}$, N_{AG}, N_{BG}, $Frac_{Remove}$, $Frac_{DM}$, $Frac_{RENEW}$), in the 1989-2020 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
$R_{BG\text{-}BIO}$ (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

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**
$Frac_{Remove}$	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 5.31 (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 1989-2020 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 vegeta bles**	**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
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 1989-2020 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.

Area of organic soils cultivated

After of a collaboration between the Ministry of Environment, Water and Forests and The Forestry Research Institute of Design (ICAS) and in the context implementing the raport of the National Research and Development Institute for Soil Science, Agrochemistry and Environment (ICPA) elaborated in 2014 Histosols of Romania occupy an area cultivated of 6387 ha. This amount include vines.

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.

Indirect N_2O emissions from Managed soils ***(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.

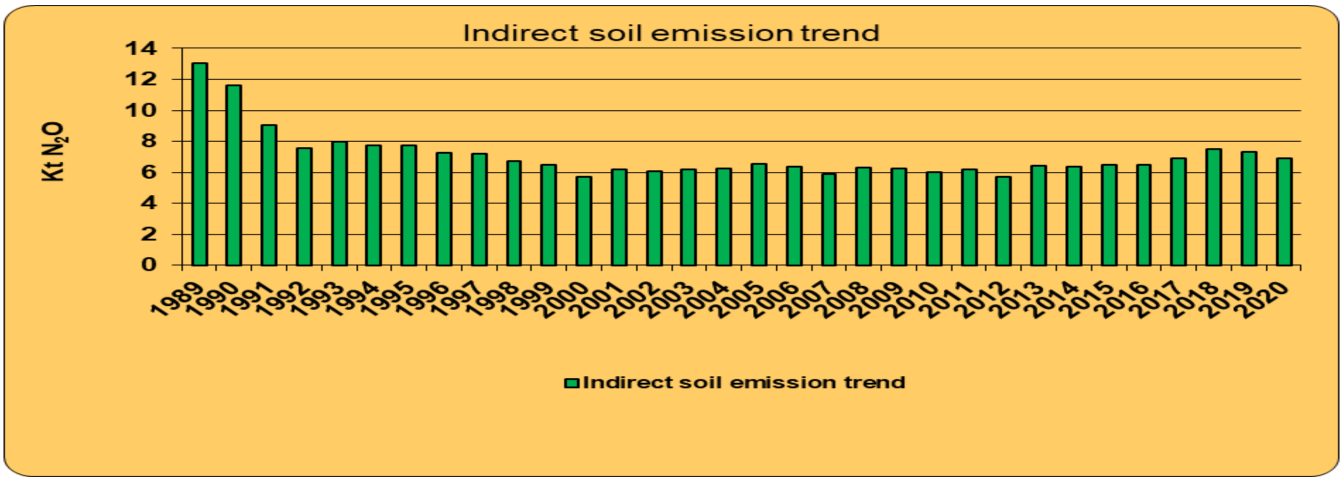
Microbial processes of nitrification and denitrification in agricultural soils produce indirect nitrous oxide emissions. Indirect soils emissions result from the following nitrogen input to soils:

- 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 2020, N_2O Indirect soil emissions represented 20.93 % of total N_2O emissions in the Agriculture sector;

- ❖ N_2O Indirect soil emissions as CO_2 equivalent in 2020 represented 11.18 % from Total Agriculture emissions;
- ❖ contributed with 1.80 % 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 Uncertainties 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 6.3.

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 1989-2020 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 1989-2020 is consistent.

5.5.4 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 *Waste sector*, the results of these being mentioned on the Checklists level.

In 2012 year, 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.

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 6.6.

5.5.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

Direct N_2O emissions

Were made recalculations on Direct N_2O emissions from Managed soils due to:

- transcription errors of the N bedding which is the 0 correct value use in the calculation amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes for pigs fattening for the year 2019 from F_{AM};
- due to of the update of the production and area for barley for the 2019 year from F_{CR};
- of the change the areas burned due to of the update the amount of biomass burned for the 1989-2019 period from F_{CR}.

The changes impact are presented in the table below:

Table 5.32 Implication of recalculations on emission estimates

Year	The changes impacts on estimating N_2O emissions from Managed soils		
	Direct N_2O emission from Managed soils		
	NGHGI 2021	NGHGI 2022	Difference
1989	41.04593835	41.04576079	-0.00017756
1990	35.63530721	35.63512247	-0.00018474
1995	24.94120914	24.94102912	-0.00018002
2000	18.34722434	18.36630298	0.01907864
2005	20.98330233	20.98312517	-0.00017716
2007	18.17147222	18.17125890	-0.00021332
2008	19.96630378	19.96612509	-0.00017869
2009	19.68459456	19.68441218	-0.00018238
2010	19.13066216	19.13048511	-0.00017705
2011	19.88505450	19.88488446	-0.00017004
2012	17.74223042	17.74204084	-0.00018958
2013	20.47099300	20.48481450	0.01382150
2014	20.46177567	20.47602085	0.01424518
2015	20.58553727	20.59230231	0.00676504
2016	20.72878234	20.72861035	-0.00017199
2017	22.37625004	22.37628523	0.00003519
2018	24.46049257	24.4552474	-0.00524517
2019	23.66639515	23.64008857	-0.02630658

Indirect N_2O emissions

Were made recalculations on Indirect N2O emissions from Managed soils due to:

- transcription errors of the N bedding which is the 0 correct value use in the calculation amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes for pigs fattening for the year 2019 from FAM;
- due to of the update of the production and area for barley for the 2019 year from FCR;
- of the change the areas burned due to of the update the amount of biomass burned for the 1989-2019 period from FCR .

The changes impact are presented in the table below:

Table 5.33 The changes impact on the N_2O emissions from Urine and dung deposited by grazing animals

Year	The changes impacts on estimating Indirect N_2O emissions from managed soils		
	Indirect N_2O emissions from managed soils		
	NGHGI 2021	NGHGI 2022	Difference
1989	13.04605793	13.046017978	-0.00003995
1990	11.59381162	11.593770059	-0.00004156
1995	7.747702519	7.7476620142	-0.00004050
2000	7.747702519	5.7071277858	-2.04057473
2005	5.702835093	6.5173944449	0.81455935
2007	6.086699162	5.8703075136	-0.21639165
2008	6.179556088	6.2964348210	0.11687873
2009	6.215254822	6.2436514550	0.02839663
2010	6.517434307	6.0146398500	-0.50279446
2011	6.33243471	6.2019273360	-0.13050737
2012	5.870355512	5.6797505400	-0.19060497
2013	6.296475026	6.4106069150	0.11413189
2014	6.243692488	6.3711308410	0.12743835
2015	6.014679687	6.4789754700	0.46429578
2016	6.201965594	6.4834956970	0.28153010
2017	5.679793194	6.904725094	1.22493190
2018	6.407497079	7.517213128	1.10971605
2019	6.367925676	7.300439878	0.93251420

5.5.6 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 (CRF 3.E)

Prescribed Burning of Savannas does not occur in Romania.

5.7 Field Burning of Agricultural Residues (CRF 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 2020 are lower than emissions in 1989 with 7.94%, due to the lower agricultural yields.

Figure 5.10 Cumulative emissions trend - Field Burning of Agricultural Residues

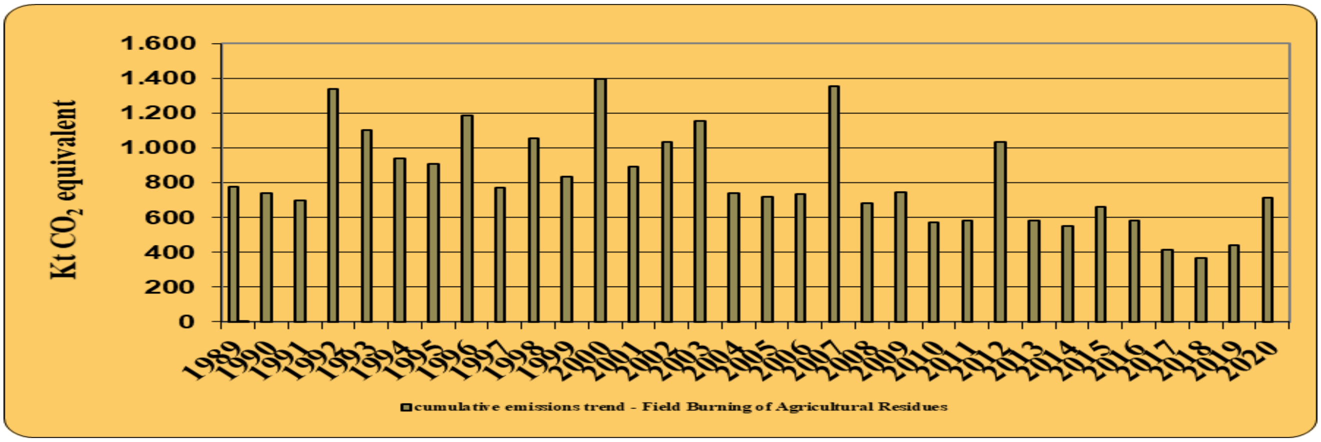


Table 5.34 Observations on source category 3F – "Field Burning of Agricultural Residues"

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, 1989-2020; 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.

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 5.35 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 Uncertainties 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 6.3.

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 6.3. 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 1989-2020 is consistent.

5.7.4 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 *Waste sector*, the results of these being mentioned on the Checklists level.

In 2012 year, 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.

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 6.6.

5.7.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

Were made recalculations due to of the update of the production and area for barley and of the change the areas burned due to of the update the amount of biomass burned.

The changes impact are presented in the table below:

Table 5.36 The changes impacts on estimating emissions from Field Burning of Agricultural Residues

Year	The changes impacts on estimating emissions from Field Burning of Agricultural Residues		
	Emissions from Field Burning of Agricultural Residues		
	NGHGI 2021	NGHGI 2022	Difference
1989	774.5402668	774.9579762	0.4177094
1990	737.9190363	738.3522144	0.0000000
1995	907.3564873	907.79746019	0.4331781
2000	1467.744815	1395.5550104	0.0000000
2005	719.7490865	720.15103781	0.4409729
2007	1356.185621	1357.085919	-72.1898046
2008	681.7345663	682.1526342	0.4019513
2009	744.7153698	745.1833413	0.0000000
2010	573.9036759	574.2931139	0.9002980
2011	580.7785396	581.1248633	0.4180679
2012	1033.121902	1033.711542	0.4679715
2013	611.8665778	583.6880211	0.3894380
2014	579.857506	552.1061564	0.3463237
2015	675.0953129	660.2430576	0.5896400
2016	582.3625566	582.7040632	-28.1785567
2017	412.7776301	412.7226835	-27.7513496
2018	360.6602625	367.9747439	-14.8522553
2019	402.4688307	442.8167287	0.3415066

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

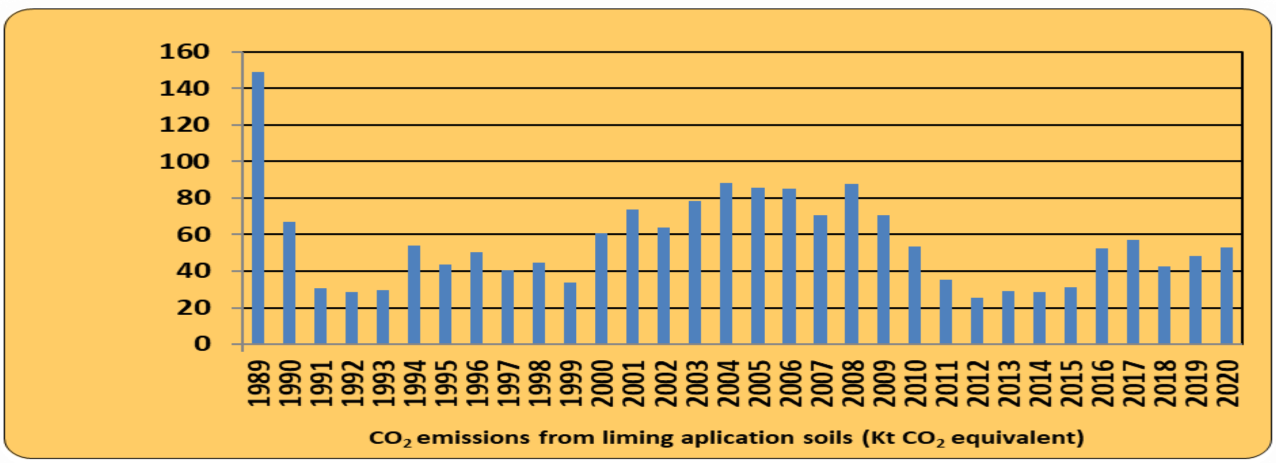
Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality, for to significant species, is envisaged.

5.8 Liming (CRF 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 Uncertainties 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.

5.8.4 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 *Waste sector*, the results of these being mentioned on the Checklists level. No unconformity has been noted following the UNFCCC review of the NGHGI.

5.8.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

Compared with last submission not made any recalculation.

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

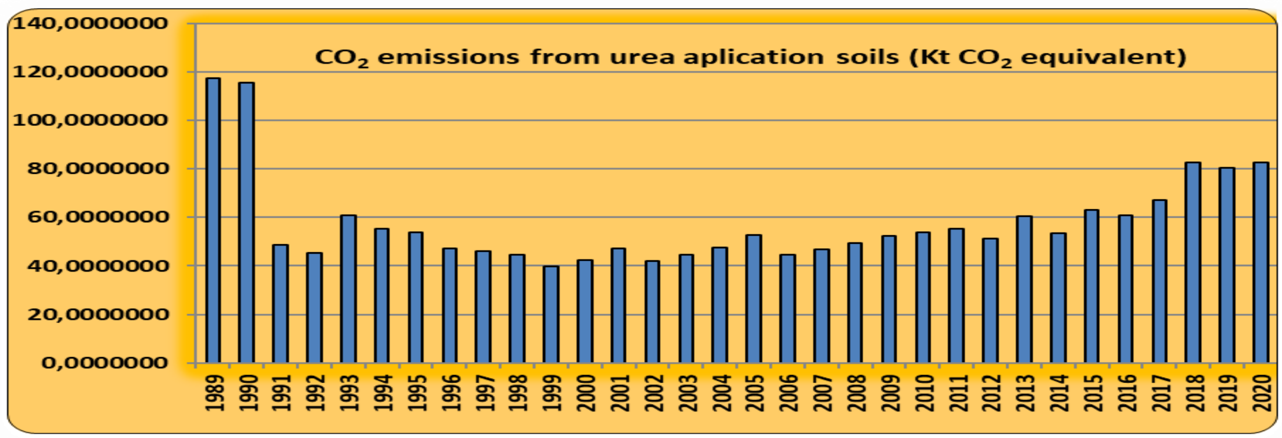
Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality.

5.9 Urea fertilization (CRF 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 Uncertainties 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.

5.9.4 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.

5.9.5 Category-specific recalculation, including change made in response to the review process and impact on emission trend

Compared with last submission not made any recalculation.

5.9.6 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 LULUCF (CRF Sector 4)

6.1 Overview of sector

For most researchers around the world, it is no longer a secret that climate change is caused by anthropogenic activities, and high levels of GHG emissions are only a consequence of them, which is a cause for concern. Also, among GHGs, CO_2 is found primarily responsible for the occurrence and acceleration of global climate change with all the devastating consequences for humanity, rising global temperatures, rising oceans and seas levels, floods, wildfires, droughts, etc. Currently, the CO_2 level has exceeded 415 ppm, and in the absence of major GHG reduction actions, the global temperature is about to increase by an average of 6 °C (10.8 °F), according to the latest estimates. Climate change and environmental degradation are an existential threat to the EU as well equally for the whole globe. To overcome these challenges, the EU needs a new growth strategy that will transform it into a modern, resource-efficient and competitive economy, where net GHG emissions will be *"ZERO"* in 2050. The European Green Deal is the plan to make the EU economy durable. This requires current GHG levels to drop substantially in the next decades. As an intermediate step towards climate neutrality, the EU has raised its 2030 climate ambition, committing to cutting emissions by at least 55 % by 2030 under the so-called *Fit for 55 package* in order to align current laws with the 2030 and 2050 ambitions. As the role of the LULUCF Sector in mittigating climate change for the next decades will be extremely important, a review of the regulation on GHG emissions and removals from LULUCF is underway at *Fit for 55 package*. The main aim of the Commission proposal is to strengthen the contribution of the LULUCF Sector to the EU's increased overall climate ambition for 2030 by setting an EU-level target of 310 million tonnes of CO_2 eq. in net GHG removals in the LULUCF Sector in 2030 by the ETS and the ESR. The right rules will ensure land use and forestry make a full contribution to emissions reduction targets, as well as supporting the EU's biodiversity goals. Also, from 2031 onwards, the EU want to merge agriculture non-CO_2 Sector emissions with the removals and emissions under the LULUCF Regulation scope to create a new single pillar covering AFOLU, with the aim of climate neutrality by 2035 at EU level in the combined Sector. Romania, through its Recovery and Resilience Facility, seeks to mitigate the economic and social impact of the coronavirus pandemic overlapping with the challenges of climate change and to create a more sustainable, resilient and better prepared economy and society for the challenges and opportunities of the green and digital transitions. In line with the objectives of the EU, EC and UNFCCC, the Government of Romania, adopted GD no. 590/2019, published in the Official Monitor No. 693, on the 22nd of August 2019, which establishes the legal, institutional and procedural framework for the administration of the LULUCF subdomain, as an active part of NGHGI. Therefore, it is mandatory to monitor, estimate and report GHG

E(+)/R(-) generated by specific activities to this subdomain, to the EC, the EEA and the UNFCCC Secretariat, at pre-established dates. Data flow of the activities carried out by applying the GD 590/2019 is highlighted in Figure 6.1.

Figure 6.1 Romania's LULUCF data flow

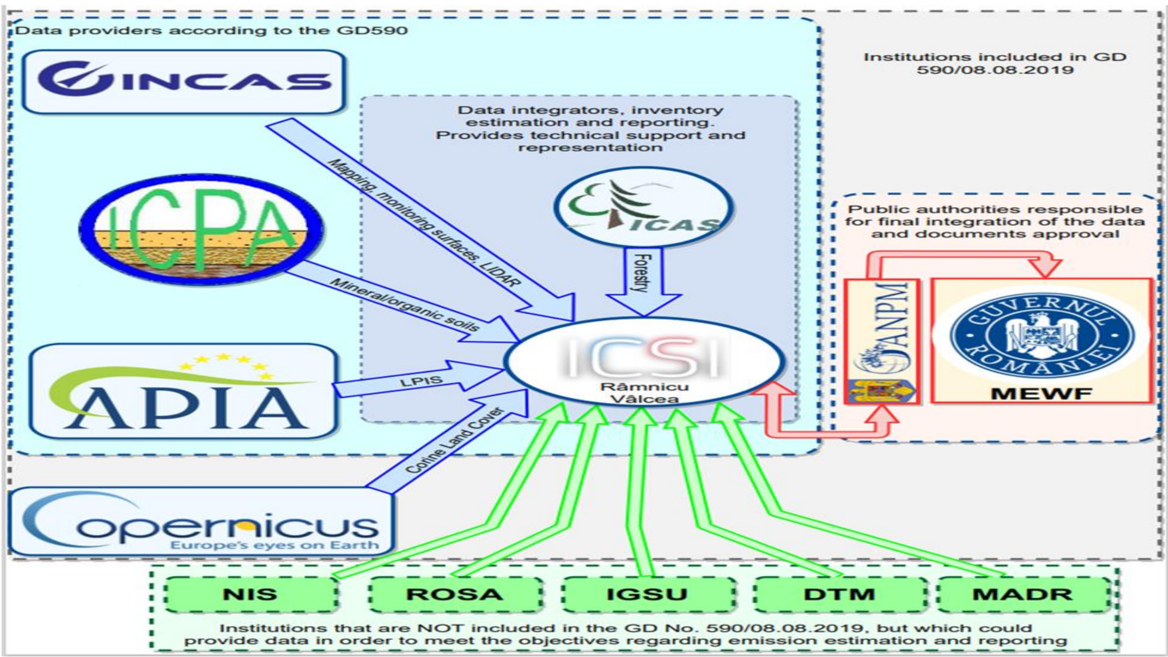


Figure 6.1, also indicates, on the right side, the final part of the data flow process, NEPA and MEWF, as public authorities responsible for final data QA/QC, aggregation and documents approval. The NGHGI of the LULUCF Sector covers all CO_2 E(+)/R(-) due to gains and losses in the relevant carbon pools of the predefined six land use categories, as well as non-CO_2 emissions from biomass burning and disturbance associated with land-use conversions. It should be noted that a number of factors used in the estimations of GHGs assume default values, recommended by the IPCC Guidelines. Those factors are considered to be modified on the basis of in-country analysis. The main issues addressed were in the interest of increasing the level of accuracy of reporting, ensuring quality information and objectives, as well as consistency in approaches to estimating GHGs E(+)/R(-). In preparing the NGHGI, Romania has followed the TACCC principles, as defined in 2006 IPCC. Table 6.1 shows the general definition and how Romania is fulfilling the TACCC principles:

Table 6.1 TACCC principles and their consideration in Romania´s LULUCF inventory

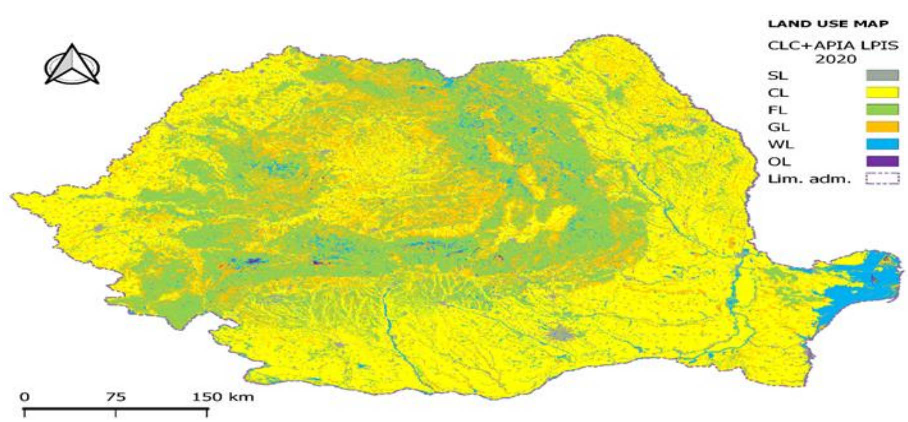
Transparency	
There is sufficient and clear documentation such that individuals or groups other than the inventory compilers can understand how the inventory was compiled and can assure themselves it meets the good practice requirements for national greenhouse gas emissions inventories.	*transparency of data/ information, respectively, traceability of data/information, (a) do I know what I will 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 greenhouse gas inventory are recommended in these Guidelines. Where elements are missing their absence should be clearly documented together with a justification for exclusion.	*complete character, the GHG E(+)/R(-) estimates were occurred for all land use categories. GHG emissions estimates are: CO_2, CH_4, 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.	*consistency, NGHGI 2022 will use new data and methods for the time period 1989-2020 into a hybrid way, combining mathematical modeling with explicit geospatial informations*
Comparability	
The national greenhouse gas inventory is reported in a way that allows it to be compared with national greenhouse gas inventories for 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 by correctly identifying/prioritizing resources, respectively the LULUCF key land use are: FL, CL, GL - but without neglecting the data and information for the other land use categories, like WL, SL, OL*
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 included in the NGHGI report respecting all the specific criteria, respectively, TACCC, which presuppose the assurance of the complete character and the characterization of all the surfaces at national level. These are officially statistical data, reported annually and represent the land use categories for Romania's entire territory since 1989. For Romania, GHG E(+)/R(-) estimates in the LULUCF Sector, were accounted using the *IPCC 2006 and IPCC 2019 Refinement* methodology.	

LULUCF results year 2020

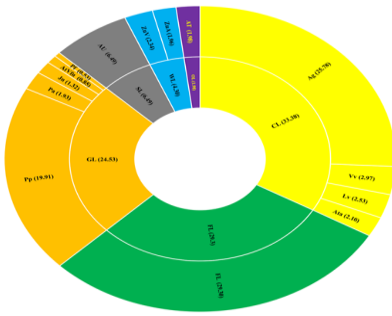
The LULUCF Sector, Figure 6.2, in year 2020, has become more influential, in terms of the level of removals from the total GHG emissions generated by the different sectors, following the trend of the EU/EC policies to increase/maximize the potential of this sink sector into detriment of other source sectors, in an attempt to mitigate the impact/effect generated by climate changes.

Figure 6.2 LULUCF 2020. EGM - explicit geospatial map



For 2020, in LULUCF Sector, land use categories have the following structure: (i) forests, (ii) cropland, (iii) grassland, (iv) wetlands, (v) built areas and roads/railways, (vi) other lands. The figure below shows the structure of subcategories in LULUCF, respectively their % distribution, according to their activity data (kha).

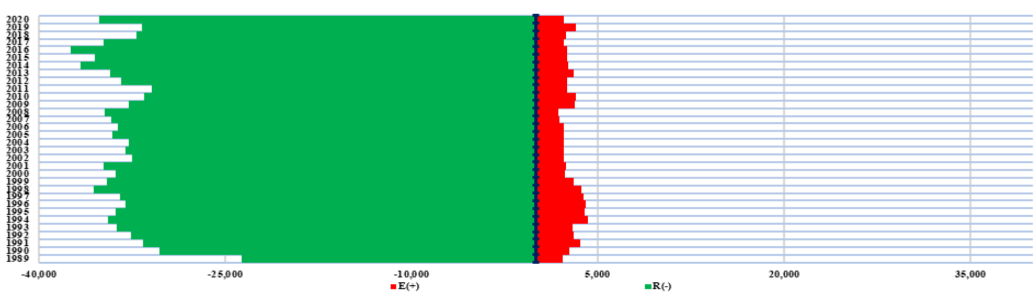
Figure 6.3 LULUCF Sector structure (%)



LU Romania code	LU category name	LU IPCC name	LU IPCC code	LU CRF code
Ag	CL - arable	Annual cropland	CL	4B
Pp	GL - pastures	Grassland grassy	GL	4C
Pf	GL - pasture with spare trees	Grassland grassy	GL	4C
Pa	GL - hayfields	Grassland grassy	GL	4C
Vv	CL - vineyards	Perennial cropland	CL	4B
Lv	CL - orchards	Perennial cropland	CL	4B
AtA	CL - shrub crops	Perennial cropland	CL	4B
Pd	FL - forests	Forestland	FL	4A
AtVF	GL - other land with forest vegetation	Grassland woody	GL	4C
Jn	GL - pinus migho scrubs (juniper trees)	Grassland woody	GL	4C
Tf	GL - shrubs	Grassland woody	GL	4C
AU	SL - construction + roads	Settlements	SL	4E
ZuV	WL - wet areas with vegetation	Wetlands	WL	4D
ZuA	WL - waters/ponds	Wetlands	WL	4D
AT	OL - other lands	Otherland	OL	4F

The GHG E(+)/R(-) estimates distribution in the LULUCF Sector are presented in Figure 6.4.

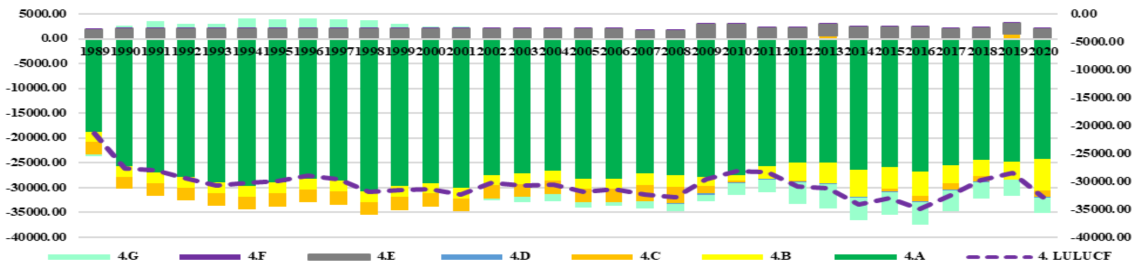
Figure 6.4 LULUCF Sector. GHG E(+)/R(-) estimates (kt CO_2 eq.)



Trend of LULUCF emissions/removals

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 a decreasing trend in the last 31 years, in the amount of 53.31%, CRF Table 10s1, Figure 6.5.

Figure 6.5 LULUCF Sector. Historical emission trend by land use categories (kt CO_2 eq.)



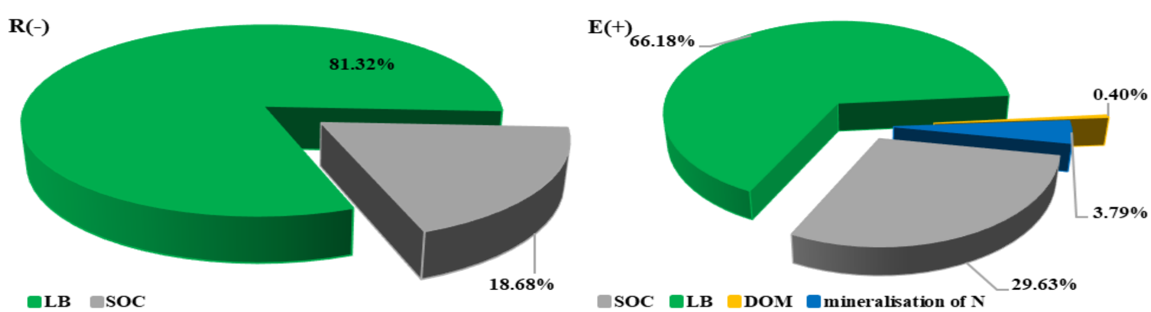
The FL category generates most of the negative emissions, removals of GHG in the LULUCF Sector. Table 6.2 shows the numerical differences in the historical chain for a period of 31 years, between 1989-2020 time period, in the LULUCF Sector. The changes depend on several factors, such as growing conditions, harvesting levels, management practices and changes of land use. These activities in 2020 altogether resulted in net R(-) estimated to be equal to -32893.96 kt CO_2 eq.

Table 6.2 LULUCF Sector. Numerical analysis of land use categories

LU	Evaluation	Time period	
		2020 - 1989	**2020 - 2019**
Forest land	average (kt CO_2 eq.)	-27038.66	-24603.42
	difference (kt CO_2 eq.)	-5503.02	523.57
	difference (%)	30.02	-2.11
Cropland	average (kt CO_2 eq.)	-2746.11	-4932.15
	difference (kt CO_2 eq.)	-4283.93	-2822.53
	difference (%)	208.01	82.18
Grassland	average (kt CO_2 eq.)	-1842.78	-135.10
	difference (kt CO_2 eq.)	1263.29	-2270.61
	difference (%)	-49.86	236.04
Wetlands	average (kt CO_2 eq.)	-47.90	-131.42
	difference (kt CO_2 eq.)	-211.92	-37.09
	difference (%)	-342.06	17.73
Settlements	average (kt CO_2 eq.)	2156.28	2156.26
	difference (kt CO_2 eq.)	236.21	9.96
	difference (%)	12.27	0.42
Other land	average (kt CO_2 eq.)	168.77	77.20
	difference (kt CO_2 eq.)	-118.29	-7.66
	difference (%)	-61.72	-8.35
HWP	average (kt CO_2 eq.)	-1213.98	-3205.22
	difference (kt CO_2 eq.)	-2820.12	125.24
	difference (%)	874.51	-3.88

Over time, in the LULUCF Sector, the largest contributor in the GHG pool, was occupied by CO_2, non-CO_2 GHGs, like CH_4 and N_2O, having insignificant contributions. The most important category recognized to be the main source of CO_2 removals is 4.A Forest land use category. This situation is, to some extent, related to the smaller annual harvest rates compared to annual forest growth in biomass, generating a significant amount of carbon stock change. The evolution of net emissions shows that the sector has functioned as a sink for the entire 1989-2020 time period. The main factor behind this trend was the category of FL. Forest biomass in forest land remaining forest and forest soils in land converted to forest land categories, are the predominant carbon pools in the category, contributed significant to the category sink function. The sink is mainly offset by emissions from the areas used in GL from the subcategories of land use Pa, Pf, Pp, AtVf, Jn, Tf. Over time, mineralization of N is a constant source of emissions. The distribution of GHG E(+)/R(-) according to the C pools is represented in Figure 6.6.

Figure 6.6 LULUCF Sector 2020. E(+)/R(-) distribution in carbon pools



All land use categories have been undergone significant improvements in the GHG E(+)/R(-) levels, more accurate estimates, compared to the previous report. The LULUCF Sector continuous sink, over the time series, being an important catalyst in mitigating the effects of climate changes, increasing the amount of CO_2 that is released from the atmosphere and stored in landscapes. This will continue to be done at the same time as restoring ecosystems to support and enhance the long-term viability of natural resources, ecosystem services, biodiversity and organic food production. The LULUCF Sector contribute to limit heating to 1.5 °C without significant overruns, as it is part of the solution in this current decade.

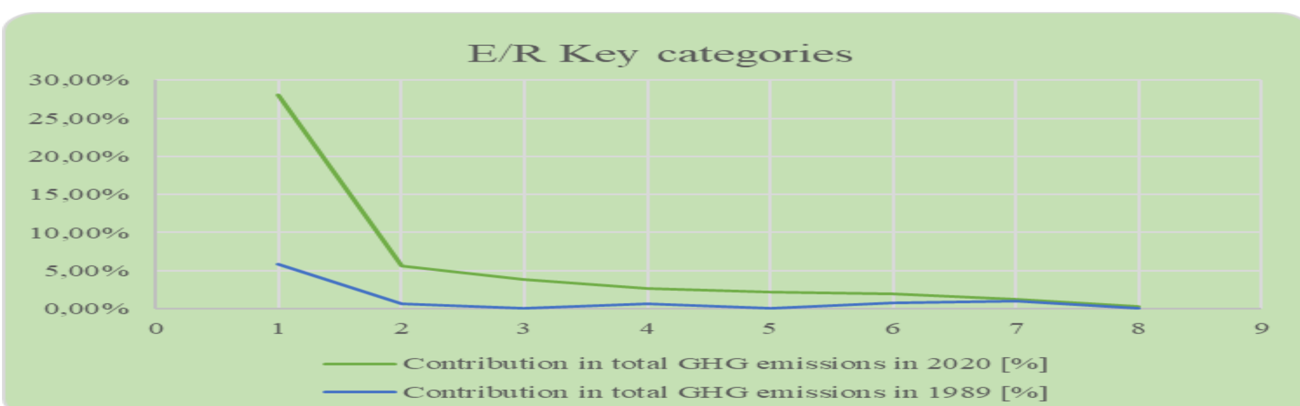
6.1.1 Key sources

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 NGHGI - 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 2020. 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	X	29,38%	T1, T2
4.B.1 Cropland Remaining Cropland	CO_2	X	X	5,95%	T1, T2
4.G Harvested Wood Products	CO_2	X	X	4,08%	T2
4.E.2 Land Converted to Settlements	CO_2	X	X	2,80%	T1, T2
4.B.2 Land Converted to Cropland	CO_2	X	X	2,29%	T1, T2
4.A.2 Land Converted to Forest Land	CO_2	X	X	2,08%	T2
4.C.1 Grassland Remaining Grassland	CO_2	X	X	1,33%	T1, T2
4.C.2 Land Converted to Grassland	CO_2		X	0,34%	T1, T2

Figure 6.7 LULUCF Sector 2020. Key categories, both by level and trend criteria



Drivers of recalculations

A series of drivers/variables contributed to the construction of NGHGI 2022, respectively of the GHG E(+)/R(-) estimates generated by the specific activities of the LULUCF Sector. In addition, there are:

(i) explicit geospatial approach 3, for the most accurate determination of AD(kha) for each land use category;

(ii) CS type parameters introduced through scientific studies;

(iii) revised C stock values for all carbon pools: LB, DOM and Soil. If approach 3 captured the dynamics of land use changes, the CS parameters brought the transition from Tier 1 to Tier 2, for more carbon pools.

All these new inputs compared to the previous inventory submission, led to a series of transformations in the level of GHG E(+)/R(-) estimates applied to 1989-2020 time series for the LULUCF Sector.

6.1.2 Land uses classification for representing LULUCF areas

For the reporting purposes under the UNFCCC and KP it is recommended to assign national land use categories, as specified in the GD 590/2019, 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 presented in NGHGI 2022, 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 lands not surrounded by trees, yet under forest management, including forest roads, water bodies, and administrative areas, are not included in the Forest land category;

(ii) Agricultural land associate 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 associate 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 ~ other land with forest vegetation; Tf ~ Shrubs; Jn ~ Pinus mugo shrubs, as Forest belts which are narrower than 20 m. Current assumption is that all Grasslands are assumed managed;

(iv) Water bodies and wet areas associate 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 associates 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 associates 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, Table 6.4:

Table 6.4 LULUCF Sector. Subcategories applied in GHG E(+)/R(-) estimates

IPCC category	National subcategories
4.A Forest land	*Pd ~ Forests*
4.B Cropland	*Ag ~ Arable; Vv ~ Vineyards; Lv ~ Orchards; AtA ~ Shrub crops*
4.C Grassland	*Pp ~ Pastures; Pf ~ Pasture with spares trees; Pa ~ Hayfields; AtVf ~ Other land with forest vegetation; Jn ~ Pinus mugo shrubs; Tf ~ Shrubs*
4.D Wetland	*ZuV ~ wet areas with vegetation; ZuA ~ Waters / ponds*
4.E Settlements	*AU ~ Construction + Roads*
4.F Other land	*AT ~ Other Land*

The land use matrix was completed with AD(kha), as follows:

(i) for the land use category FL the land use matrix is developed by interpolation between seven spatial assessments, on a point sampling, from both national and global geospatial datasets, for the 1976-2018 time period. Additional overlap was performed with forest area reported by NFI between 2012-2017 time period to set the reporting values. Outside the interval, extrapolation was used to report forest areas (see section 6.1.3);

(ii) for the land use categories CL and GL which are key categories in LULUCF Sector, were provided AD(kha), associated with the 2008-2020 time period, using explicit geospatial data, approach 3, from the use of LPIS/IACS technology - farmers in the payment program of APIA, about 70% of the total areas. For the rest of the areas were completed with maps from CLC [reference year 1990, 2000, 2006, 2012, 2018]. For the 1970-2006 time period, the *Matrix of land use changes*, used by Romania, contains a series of linear interpolations and extrapolations, with NIS as database source;

(iii) for land use categories WL, SL and OL for the 2008-2020 time period, differences between explicit geospatial maps developed for CL and GL (based on LPIS/IACS + farmers statements), CLC [reference year 1990, 2000, 2006, 2012, 2018] maps and NIS statistical data, approach 1 + approach 2 + approach 3, were used. For the 1970-2006 time period, the *Matrix of land use changes*, used by Romania, contains a series of linear interpolations and extrapolations.

The final area of annual cropland was significantly higher (1.5 times) in 2008 compared to 2006, and significantly lower for other non-forest land categories. Due to the large differences in the final areas in 2006 and 2008, it was decided that the non-forest land areas for 2007 could not be interpolated. Instead, the options to back calculate land remaining areas using the 2008 values, and to forward calculate land remaining areas using the 2006 values were considered. The estimates for the more recent part of the time series are considered to be more accurate, however, back calculating the land remaining areas would result in negative areas at the beginning on the time series. Therefore, the annual land remaining areas in 2006 were used, together with the land conversions for the subsequent years, to calculate the land remaining areas for the years 2007 to 2020. In the absence of any other information, the land use conversions for 2007 were assumed to be the same as the land use conversions that occurred in 2008. The adjusted land use matrices were then used to calculate the land use areas considering the 20 year transition from land converted to land remaining categories. All AD(kha) of the land use categories and the change of land use were normalized to the total area of the LULUCF Sector, also in accordance with the previous NGHGI reports of Romania, respectively to the total area of 23839.02 kha - according to ANCPI. The following table shows a summary of the 1989-2020 time series of the estimated areas in the NGHGI, differentiating the areas that remain as such in each use, compared to the previous year by the surfaces of changes in use, considering the default transition period of 20 years (IPCC 2006 Guideline, Table 6.5, CRF Tables 4.1):

Table 6.5 Annual land use change matrix for the 1989-2020 time period (kha)

LU category	1989	2000	2010	2019	2020
FL	**6864.23**	**6924.33**	**6969.40**	**6988.21**	**6989.47**
FL → FL	6856.81	6916.39	6961.38	6984.78	6986.03
LC → FL	7.42	7.94	8.02	3.43	3.44
CL → FL	3.05	2.70	2.64	0.52	0.53
GL → FL	3.70	4.53	4.98	2.74	2.74
WL → FL	0.30	0.31	0.24	0.00	0.00
SL → FL	0.37	0.32	0.16	0.17	0.17
OL → FL	0.00	0.08	0.00	0.00	0.00
CL	**9530.31**	**9115.73**	**8689.35**	**7851.21**	**7957.64**
CL → CL	9477.57	9062.80	8428.54	7639.04	7667.60
LC → CL	52.74	52.93	260.81	212.17	290.04
FL → CL	1.00	1.19	1.12	0.18	0.18
GL → CL	39.32	39.32	220.58	204.92	282.48
WL → CL	4.18	4.18	18.58	0.98	1.58
SL → CL	7.90	7.90	18.50	6.09	5.80
OL → CL	0.34	0.34	2.03	0.00	0.00
GL	**4989.89**	**5088.22**	**5276.41**	**5968.80**	**5848.53**
GL → GL	4916.81	5014.80	4853.58	5483.90	5670.68
LC → GL	73.08	73.42	422.83	484.90	177.85
FL → GL	1.22	1.56	1.68	1.35	1.35
CL → GL	63.43	63.43	364.30	478.58	172.00
WL → GL	3.12	3.12	15.97	3.05	2.39
SL → GL	4.62	4.62	40.52	1.76	2.07
OL → GL	0.70	0.70	0.36	0.16	0.04
WL	**759.21**	**859.99**	**986.47**	**1019.85**	**1024.61**
WL → WL	741.15	841.93	930.88	1014.48	1015.88
LC → WL	18.09	18.09	56.75	5.37	8.73
FL → WL	0.09	0.09	0.09	0.00	0.00
CL → WL	8.84	8.84	17.36	1.73	1.14

LU category	1989	2000	2010	2019	2020
GL → WL	7.78	7.78	34.27	3.64	7.59
SL → WL	0.77	0.77	2.52	0.00	0.00
OL → WL	0.58	0.58	1.35	0.00	0.00
SL	**1281.88**	**1409.36**	**1449.07**	**1539.33**	**1547.07**
SL → SL	1256.71	1384.23	1378.13	1526.81	1531.29
LC → SL	25.17	25.13	70.94	12.52	15.78
FL → SL	0.10	0.06	0.12	0.65	0.65
CL → SL	14.83	14.83	54.88	9.29	9.93
GL → SL	9.52	9.52	13.31	2.58	5.20
WL → SL	0.60	0.60	2.51	0.00	0.00
OL → SL	0.12	0.12	0.12	0.00	0.00
OL	**413.49**	**446.40**	**468.32**	**471.62**	**471.70**
OL → OL	408.76	441.64	461.77	471.49	471.58
LC → OL	4.74	4.77	6.55	0.13	0.12
FL → OL	0.00	0.03	0.00	0.00	0.00
CL → OL	0.77	0.77	0.31	0.01	0.01
GL → OL	3.04	3.04	3.47	0.12	0.11
WL → OL	0.77	0.77	2.72	0.00	0.00
SL → OL	0.15	0.15	0.05	0.00	0.00
Total areas LULUCF	**23839.02**	**23839.02**	**23839.02**	**23839.02**	**23839.02**

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 NGHGI, a new reporting system is being put in place starting with 2021 submission. This new approach intends to use of any explicit geospatial information existing in the country, either for land classification or for quality check classification. 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, 2008-2020, 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 6.6);

(v) statistical data from National Institute of Statistics (NIS).

Each of the IPCC land use category was addressed according to the national arrangements established by the GD 590/2019. In this new system, several Research and Development Institutes from Romania specialized on some of the activities designed to bring an obvious increase in the level of reporting, more detailed, with a high degree of complexity and also certainty, were co-opted, respectively:

(i) INCDS - covers the Forestland category in the NGHGI.

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. Aditional data sources and database (above desribed) used for forest area reporting forest land in the National GHGI, are described in Table 6.6.

(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 1990-2020 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 Juniperus 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 a 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 6.6 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	1990-2020	A/D, Rv

No.	Data name	Data Type	Temporal Coverage	AD were data is used
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
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 and Tier 3 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:

$$\boldsymbol{L\text{-}FLyr = (FL2 - FL1 + \Sigma FL\text{-}Lyr) / time;}$$

(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 classificatio and national land subcategories;

(ii) ICPA - establishes the methodology used to determine the C stock and EF's to estimates E(+)/R(-) from mineral and organic soils, respectively for Cropland and Grassland. ICPA provides monitoring mechanism for the purpose of accounting for the activities corresponding to the management of cultivated land, Cropland Management and Grassland, Grazing land Management;

(iii) INCAS - through specific activities of flying with an aircraft, supports the activities of the Research Institutes with data, information about the categories of land use of interest. Specifically, those areas, plots that are not easily identifiable with existing maps, or gaps in geosatellite data, LPIS/IACS, CLC, etc., are validated land uses or land conversions, etc., using the LiDAR and aero-photogrammetry technology. Studies performed until now by INCAS show that remote sensing and GIS technologies are very useful tools in accumulating important quantitative and qualitative information about the land surface, which can be successfully used for analysis in the deforestation/afforestation/reforestation, forest management and revegetation activities. The information resulting from the use of these methods can be of great importance for forest managers in the installation process of the forest and its subsequent management. Therefore, in 2021, INCAS had as main objective the acquisition of geospatial data using LiDAR technology and aerial photogrammetry, as well as data processing in order to achieve the main goal of the project: monitoring of the land use and land use change in the explicit space system, using aero-photogrammetry and air surveillance technologies at national level. In this regard, INCAS planned and performed flight missions that took approximately 200 hours, using the Hawker Beechcraft King Air C-90 GTx aircraft, equipped with a Riegl LMS-Q680i LiDAR system that operated at a wavelength of 1064 nm, respectively a DigiCAM-60 photogrammetric camera. These data sets are subsequently processed at quality standards in accordance with the requirements of NGHGI, using GIS techniques to highlight land use changes, at the local level, in the regions proposed by the partner institutions in this project. The integration of qualitative and quantitative information with sustainable assessment techniques can create a robust tool for monitoring the corresponding activities of deforestation, afforestation/reforestation, forest management and revegetation. Thus, in 2021, this activity was achieved by combining the data obtained from the scan with the LiDAR system and aerial images, as well as their spatial analysis based on a geographic information system (GIS) that combines qualitative and quantitative analysis. In addition to the previous years, topographic surveys consisting in Ground Control Points (GCPs) measurements were carried out in three pre-established areas (Arges, Brasov and Dobrogea). These ground control points can improve the global accuracy of LiDAR data, thus fulfilling the obligations assumed through the Government Decision no. 590/2019. In the first half of 2021, INCAS performed research flight over Constanța and Tulcea counties, using both the Riegl LMS-Q680i airborne LiDAR system and the DigiCAM-60 photogrammetric camera, resulting a number of approximately 43 flight hours. Also, in the second half of 2021, 155-hour research flights were performed over Brașov area. The reasons why these flights were made towards the end of the autumn season of 2021 were the conditioning by INCDS for obtaining data in a leaf-off season, respectively the aircraft maintenance that lasted form January to May 2021. Also, during this year, the processing of the geospatial database acquired in 2020 was successfully completed;

(iv) 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 1970-2020 hystorical time period.

6.1.4 Methodological issues

Most of the estimated CO_2 E(+)/R(-) in the LULUCF Sector come from the CSC. The CSC for each category is calculated in according with *IPCC 2006 Guidelines, V4, Ch. 2, Eq. 2.3,* as the sum of the CSCs of all the C deposits, AGB, BGB, DW, LT, SOC and HWP. In surfaces in transition between uses, the CSC is calculated as the difference between the stocks of C final, of the use of destination, and the initial ones, of the use of origin, divided between a period of 1 or 20 years, so that C's stocks reach equilibrium. The following table presents a summary of the methodology used in estimating the CSC of the deposits of the LULUCF Sector.

Table 6.7 LULUCF Sector 2020. Methodological summary of the estimation of the CSC of the deposits

From \ To		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	NA	D	T2	ICP,NFI	CS	T2	ICP,NFI	CS	T2	ICP,NFI	CS	T2	ICP,NFI	CS	T2	ICP,NFI	CS
	SOC	T1	NA	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

In the framework of the Romanian GHG inventory, E(+)/R(-) from the AGB and BGB pools are listed as in the Table 6.8. The biomass-stocks changes are calculated applying the gain-loss method, *IPCC 2006 Guidelines*. Losses are considered to happen in the year of conversions, gains of perennial CL happen along 20 years. Except for FL, CS of the different land use categories are kept constant over the time series. Depending on the land use category, the reporting on biomass is equivalent to a Tier 1 or Tier 2 method, as in the case of FL.

Table 6.8 LULUCF Sector 2020. 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	3.09/ 0.97	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	Pp	5.00	E	2.87	2.87	0.425	0.425	0.425	3.09/ 0.97	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	Pf	5.00	2.87	E	2.87	0.425	0.425	0.425	3.09/ 0.97	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	Pa	5.00	2.87	2.87	E	0.425	0.425	0.425	3.09/ 0.97	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	Vv	5.00	2.87	2.87	2.87	E	0.425	0.425	3.09/ 0.97	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	Lv	5.00	2.87	2.87	2.87	0.425	E	0.425	3.09/ 0.97	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	AtA	5.00	2.87	2.87	2.87	0.425	0.425	E	3.09/ 0.97	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	Pd	5.00	2.87	2.87	2.87	0.425	0.425	0.425	E	0.425	0.425	0.425	0.00	2.87	0.00	0.00
	AtVF	5.00	2.87	2.87	2.87	0.425	0.425	0.425	3.09/ 0.97	E	0.425	0.425	0.00	2.87	0.00	0.00
	Jn	5.00	2.87	2.87	2.87	0.425	0.425	0.425	3.09/ 0.97	0.425	E	0.425	0.00	2.87	0.00	0.00
	Tf	5.00	2.87	2.87	2.87	0.425	0.425	0.425	3.09/ 0.97	0.425	0.425	E	0.00	2.87	0.00	0.00
	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	0.00	0.00

ZuV	5.00	2.87	2.87	2.87	0.425	0.425	0.425	3.09/ 0.97	0.425	0.425	0.425	0.00	E	0.00	0.00
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	0.00	2.87	E	0.00
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	0.00	2.87	0.00	E

FROM (t-1)	To (t)															
	Loss (tC/ha/y)	**Ag**	**Pp**	**Pf**	**Pa**	**Vv**	**Lv**	**AtA**	**Pd**	**AtVF**	**Jn**	**Tf**	**AU**	**ZuV**	**ZuA**	**AT**
	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	95.92	95.92	95.92	95.92	95.92	95.92	95.92	E	95.92	95.92	95.92	95.92	95.92	95.92	95.92
	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	E	0.00	0.00	0.00
	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	2.87
	ZuA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	E	0.00
	AT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	E

** For L-FL (under Pd column), carbon stock change per year is estimated in AR sites and on natural established forest stands*

6.1.4.2 Change of C stock in dead organic matter carbon pool

The DOM changes are calculated in keeping with *IPCC 2006 Guidelines*. Depending on the land use category, the reporting on DOM is equivalent to a Tier 2 method as in the case of FL and for the rest of categories is Tier 1 method.

Table 6.9 LULUCF Sector 2020. 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	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pp	0.00	E	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pf	0.00	0.00	E	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pa	0.00	0.00	0.00	E	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vv	0.00	0.00	0.00	0.00	E	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lv	0.00	0.00	0.00	0.00	0.00	E	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	AtA	0.00	0.00	0.00	0.00	0.00	0.00	E	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pd	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18	E	0.00	0.00	0.00	-8.18	-8.18	-8.18	-8.18
	AtVF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	E	0.00	0.00	-8.18	-8.18	-8.18	-8.18
	Jn	-8.18	0.00	0.00	0.00	0.00	0.00	-8.18	0.00	0.00	E	0.00	0.00	0.00	0.00	0.00
	Tf	-8.18	0.00	0.00	0.00	0.00	0.00	-8.18	0.00	0.00	0.00	E	0.00	0.00	0.00	0.00
	AU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	E	0.00	0.00	0.00
	ZuV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	E	E	0.00
	ZuA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	E	E	0.00
	AT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	E

6.1.4.3 Change of C stock in soil carbon pool

The area of the mineral soils was calculated as the difference between the national total areas and the areas covered by organic soils. Changes in carbon and nitrogen stocks in mineral soils are calculated, pursuant to *IPCC 2006 Guidelines, Eq. 2.25*, as the difference between the stocks prior to relevant land-use changes and the stocks after the changes. The EFs have been derived on a CSs basis. The carbon stock of mineral soils in the various land-use categories, and the CSCs derived from those stocks and used as EFs, are shown for 2020 in Table 6.10:

Table 6.10 LULUCF Sector. Carbon stocks in mineral soils, by type of land-use change (tC/ha)

		To (t)														
FROM (t-1)	***Gain (tC/ha/y)***	**Ag**	**Pp**	**Pf**	**Pa**	**Vv**	**Lv**	**AtA**	**Pd**	**AtVF**	**Jn**	**Tf**	**AU**	**ZuV**	**ZuA**	**AT**
	Ag	E	0.10	0.10	0.10	see below	see below	see below	1.84	0.10	0.10	0.10	-0.80	0.10	0.10	-0.34
	Pp	-0.10	E	0.79	0.79	-0.10	-0.10	-0.10	1.74	0.79	0.79	0.79	-0.90	NA	NA	-0.44
	Pf	-0.10	0.79	E	0.79	-0.10	-0.10	-0.10	1.74	0.79	0.79	0.79	-0.90	NA	NA	-0.44
	Pa	-0.10	0.79	0.79	E	-0.10	-0.10	-0.10	1.74	0.79	0.79	0.79	-0.90	NA	NA	-0.44
	Vv	see below	0.10	0.10	0.10	E	see below	see below	1.84	0.10	0.10	0.10	-0.80	0.10	0.10	-0.34
	Lv	see below	0.10	0.10	0.10	see below	E	see below	1.84	0.10	0.10	0.10	-0.80	0.10	0.10	-0.34
	AtA	see below	0.10	0.10	0.10	see below	see below	E	1.84	0.10	0.10	0.10	-0.80	0.10	0.10	-0.34
	Pd	-1.84	-1.84	-1.84	-1.84	-1.84	-1.84	-1.84	E	0.00	0.00	0.00	-2.60	-2.20	-2.20	-2.15
	AtVF	-0.10	0.79	0.79	0.79	-0.10	-0.10	-0.10	0.00	E	0.79	0.79	-2.64	-1.74	-1.74	-2.20
	Jn	-0.10	0.79	0.79	0.79	-0.10	-0.10	-0.10	0.00	0.79	E	0.79	-0.90	NA	NA	-0.44
	Tf	-0.10	0.79	0.79	0.79	-0.10	-0.10	-0.10	0.00	0.79	0.79	E	-0.90	NA	NA	-0.44
	AU	0.80	0.90	0.90	0.90	0.80	0.80	0.80	2.64	0.90	0.90	0.90	E	0.90	0.90	-0.44
	ZuV	-0.10	0.00	0.00	0.00	-0.10	-0.10	-0.10	1.74	0.000	0.000	0.000	-0.90	E	E	-0.44
	ZuA	-0.10	0.00	0.00	0.00	-0.10	-0.10	-0.10	1.74	0.000	0.000	0.000	-0.90	E	E	-0.44
	AT	0.34	0.44	0.44	0.44	0.34	0.34	0.34	2.20	0.44	0.44	0.44	-0.44	0.44	0.44	E

From (t-1) \ To (t)			Cropland remaining cropland			
			CL_a	CL_p	CL_p	CL_p
			Ag	**Vv**	**Lv**	**AtA**
CL_a	1970-2013	**Ag**	0.04	0.63	0.63	0.04
	2013-2019	**Ag**	0.14	0.49	0.49	0.14
	2019-2020	**Ag**	0.37	0.49	0.49	0.37
CL_p	1970-2013	**Vv**	-0.63	NE	NE	NE
	2013-2019	**Vv**	-0.49	NE	NE	NE
	2019-2020	**Vv**	-0.49	NE	NE	NE
CL_p	1970-2013	**Lv**	-0.63	NE	NE	NE
	2013-2019	**Lv**	-0.49	NE	NE	NE
	2019-2020	**Lv**	-0.49	Ne	NE	NE
CL_p	1970-2013	**AtA**	0.04	NE	NE	0.04
	2013-2019	**AtA**	0.14	NE	NE	0.14
	2019-2020	**AtA**	0.37	NE	NE	0.37

From (t-1) \ To (t)			Grassland remaining grassland					
			GL_g	GL_g	GL_g	GL_w	GL_w	GL_w
			Pp	**Pf**	**Pa**	**AtVF**	**Jn**	**Tf**
GL_g	1970-2020	**Pp**	0.794	0.794	0.794	0.794	0.794	0.794
	1970-2020	**Pf**	0.794	0.794	0.794	0.794	0.794	0.794
	1970-2020	**Pa**	0.794	0.794	0.794	0.794	0.794	0.794
GL_w	1970-2020	**AtVF**	0.794	0.794	0.794	0.794	0.794	0.794
	1970-2020	**Jn**	0.794	0.794	0.794	0.794	0.794	0.794
	1970-2020	**Tf**	0.794	0.794	0.794	0.794	0.794	0.794

6.1.5 Uncertainties 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 NGHGI.

Activity data uncertainty

The AD(kha) uncertainty associated with the CL and GL, key categories, is related to the uncertainty of the associated land use data. It has been assumed that the uncertainty of the land use data is ± 10%, 95% confidence.

The uncertainty of the activity variable is determined by the uncertainty of the land use mapping and land use changes by explicit geospatial data, which in this case are represented by the: ***(i)*** information based on a periodically updated 1:5000 map connects the AD(kha) to other than the pure statistical calculus that we had previously. On one hand the LPIS/IACS, source of maps that covers most of the interest territory, brings accuracy and consistency to the areas reported, 0.5 ha minimum mapping unit. On the other hand, the degree of any kind of interpretation and error regarding AD(kha) is reduced, because in the LPIS/IACS there are some declarations of the farmers themselves that determine the land use categories, thus making this information more accurate also from this regard. ***(ii)*** The influence of still using part of CLC [reference year 1990; 2006; 2012; 2018] service and ***(iii)*** LiDAR and aero-photogrammetry technology to complete the scene with lower accuracy mapping was taken into consideration in the assumption of the uncertainty. For the land use categories, respectively for WL, SL and OL, Romania has assumed the use of the uncertainty as in NGHGI 2020, respectively 30%, 95% confidence.

Emission factor uncertainty

The uncertainty of the GHG E(+)/R(-) factors is, in general, greater than that of the activity variables, when in the estimation of these we start from the surface. Explicit geospatial data sets, approach 3 were used for the NGHGI 2022, respectively LPIS/IACS, CLC [reference year 1990; 2000; 2006; 2012; 2018], LiDAR and aero-photogrammetry technologies. Also, the associated EF uncertainty for the land use categories, CL and GL, was re-estimated from ±300% to ±100%, 95% confidence, benefiting from updates made with CS type parameters, SOC_{ref}, *FLU, FMG, FI*, thus facilitating switching from Tier 1 to Tier 2 information for the Soil carbon pool. For the land use categories, respectively for WL, SL and OL, Romania has assumed the use of the uncertainty as in NGHGI 2020, in the amount of 300%, 95% confidence. This represents the highest uncertainty factor that can be applied in an approach 1 propagation of errors uncertainty analysis, as symmetrical uncertainty is assumed. GWPs from *IPCC Fourth Assessment Report, AR4*, were used for GHG conversions. The values of GHG estimates generated by the specific activities in LULUCF Sector were centralized. Using the calculation equations from the 2006 IPCC Guidelines, the Uncertainties associated with the measurement, GHG E(+)/R(-) estimates, for each of land use change category were generated. For the calculation of uncertainty and trends, Romania used approach 1 - *Approach 1 Error Propagation, IPCC 2006 Guidelines for National Greenhouse Gas Inventories, V1, Ch. 3, Uncertainty*.

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

In the *IPCC 2006 Guidelines*, the steps for reporting of NGHGI are described. The activity plan includes all QA/QC activities and other activities that are required to be performed in terms of reaching and maintaining the appropriate quality in the tables and reports delivered. Important elements of QA/QC used in LULUCF Sector:

(i) *are correct values, 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) *check of calculation units;*

(v) *check of the plausibility of results, time-series, order of magnitude;*

(vi) *correct transformation/transcription into CRF tables;*

(vii) *where possible data should be checked with data from other sources;*

(viii) *check of order of magnitude;*

(ix) *are all references clearly made?*

(x) *are all of them well documented?*

(xi) *developing and implementing a QA/QC 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 6.11 together with a timeline, ensure that any identified errors can be resolved before the submission.* The objective of QA/QC in relation to specific steps and procedures is to ensure that the inventory is comparable, consistent, complete, transparent and accurate, as far as possible, considering the available resources and expertise level. The QA/QC's work is interrelated to the completion of essential points, which represent the QA/QC activities and the related procedures carried out in the process. In particular, some issues were regarding calculating the land use areas considering the 20 year transition period, ending up with some negative areas. Between the January and March submissions, experts found a solution to these inconsistencies. Planned improvements have been defined in order to prevent these errors in subsequent inventory cycles *(see section 6.1.9).*

Table 6.11 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	Confirms that the data path is correctly represented and that the necessary calculation steps are performed. Confirms 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	It follows whether all categories are fully represented and calculated
Checks whether units of measurement are properly labelled and transported correctly from the beginning to the end of the calculation	Sampling values for verifying the correctness of the units of the measurement unit from the beginning to the end of the calculation shall be chosen.
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 documents drawn up	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 NGHGI 2022, with its variables assessing, Table 6.12:

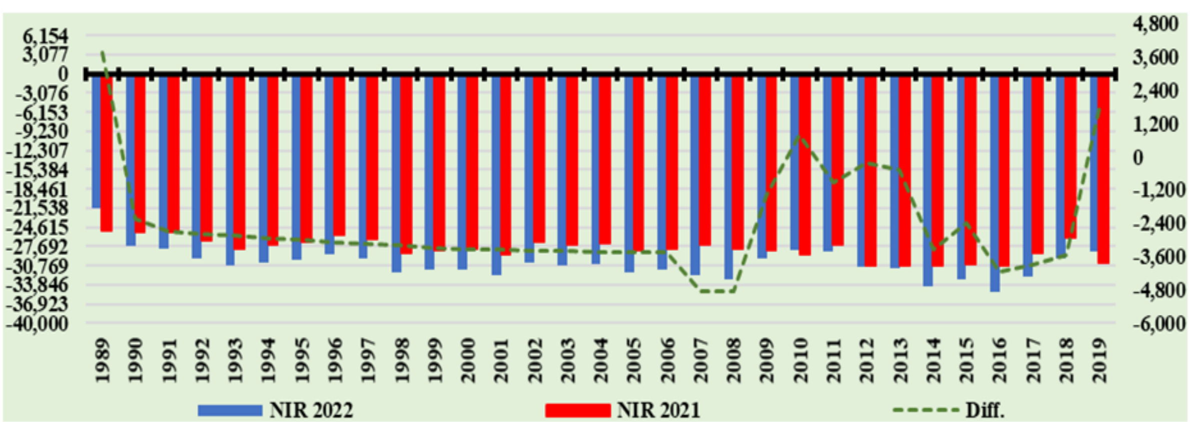
Table 6.12 LULUCF Sector, NGHGI 2022. SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
EGM (AD kha) update - LPIS/IACS [2007-2020] - 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 (1970-2020)		*R&D studies for the development of CS parameters*	

6.1.7 *Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend*

For the 2022 NGHGI, LULUCF Sector specific recalculations, are summarized in the following figure:

Figure 6.8 Quantification of recalculations performed in 1989-2019 time period (kt CO_2 eq.)



Direct and main reasons, associated with the evolution of the trend regarding GHG E(+)/R(-) levels for FL, CL, GL, WL, SL, OL are related to the following drivers/variables:

***(i)* 4.A FL**: for the 2020 inventory Romania recalculated the E(+)/R(-) estimates due to changes in the area and emission factors. The recalculation affected the 1970-2020 time period. The changes for the method of land identification are presented in 6.2 chapter and specific category changes on the emissions factors and recalculations are presented in 6.2.5 section;

(ii) **4.B CL**, *(a)* explicit geospatial maps, approach 3; *(b)* re-estimation of CS EFs [F_{LU}, F_{MG}, F_I, SOC_{ref}] for the soil carbon pool; *(c)* re-estimation of the parameters specific to carbon pools, LB, DOM and Soil; *(d) Land converted to cropland; N_2O; EF, Emissions*. For GL and WL land use categories converted to CL, N_2O emissions from mineralization were not related to CSC in mineral soils. Given the equation 11.8 (IPCC, 2006) which allows the estimation of direct N_2O emissions from the mineralization of organic carbon in the soil and the use of a C/N = 15 ratio, we had to reach an EF of about 1 kg N_2/tC lost by the mineral soil. The recalculation affected the 1970-2020 time period for the CL. The impact of the above changes on the temporal trend was to strengthen the ability to generate negative emissions/ removals;

(iii) **4.C GL**, *(a)* explicit geospatial maps, approach 3; *(b)* estimation of CS EFs [F_{LU}, F_{MG}, F_I, SOC_{ref}] for the soil carbon pool; *(c)* re-estimation of the parameters specific to carbon pools, LB, DOM and Soil; *(d) Land converted to cropland; N_2O; EF, Emissions*. For GL and WL categories converted to CL, N_2O emissions from mineralization were not related to CSC in mineral soils. Given the equation 11.8 (IPCC, 2006) which allows the estimation of direct N_2O emissions from the mineralization of organic carbon in the soil and the use of a C/N = 15 ratio, we had to reach an EF of about 1 kg N_2/tC lost by the mineral soil. The recalculation affected the 1970-2020 time period for the GL. The impact of the above changes on the time trend had the ability to generate negative emissions/removals, as opposed to the behavior in previous reports;

(iv) **4.D WL**, *(a)* explicit geospatial maps; *(b)* re-estimation of the parameters specific to carbon pools, LB, DOM and Soil; *(c) Land converted to cropland; N_2O; EF, Emissions*. For GL and WL categories converted to CL, N_2O emissions from mineralization were not related to CCS in mineral soils. Given the equation 11.8 (IPCC, 2006) which allows the estimation of direct N_2O emissions from the mineralization of organic carbon in the soil and the use of a C/N = 15 ratio, we had to reach an FE of about 1 kg N_2/tC lost by the mineral soil. The recalculation affected the 1970-2020 time period for the WL. The impact of the above changes on the time trend had the ability to generate negative emissions, removals, as opposed to the behavior in previous reports;

(v) **4.E SL**, *(a)* explicit geospatial maps; *(b) re-estimation of the parameters specific to carbon pools, LB, DOM and Soil*. The recalculation affected the 1970-2020 time period for the SL. The impact of the above changes on the time trend had the ability to generate emissions, at about 50% lower level as opposed to the behavior in previous reports;

(vi) **4.F OL**, *(a)* explicit geospatial maps; *(b) re-estimation of the parameters specific to carbon pools,* *LB, DOM and Soil*. The recalculation affected the 1970-2020 time period for the OL. The impact of the above changes on the time trend had the ability to generate emissions, at a lower level as opposed to the behavior in previous reports.

6.1.8 Completeness

Table 6.13 gives an overview of the new IPCC categories included in this chapter and the corresponding sub-divisions for which the calculations are made. It also provides information on the status of GHG E(+)/R(-) estimates for all subcategories. For completeness on C pools and GHG sources more information is available within the specific chapters in the NGHGI, *R - reported, NO - not occurred.*

Table 6.13 LULUCF Sector 2020. Status of E(+) estimates by sources and R(-) estimates by sinks

From \ To		FL			CL			GL			WL			SL			OL		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
FL	LB	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	R	R	NO	NO
	DW	NO	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	R	R	NO	NO
	LT	NO	NO	NO															
	SOC_{min}	NO	NO	NO	R	NO	R	R	NO	R	R	NO	R	R	NO	R	R	NO	NO
	SOM_{org}	R	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CL	LB	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO
	DW	R	NO	NO	R	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	R	NO	NO
	LT	NO	NO	NO															
	SOC_{min}	R	NO	NO	R	NO	NO	R	NO	R	R	NO	NO	R	NO	NO	R	NO	NO
	SOM_{org}	NO	NO	NO	R	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO	NO	NO
GL	LB	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO
	DW	R	NO	NO	R	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	LT	NO	NO	NO															
	SOC_{min}	R	NO	NO	R	NO	NO	NE	NO	NO	NO	NO	NO	R	NO	NO	R	NO	NO
	SOM_{org}	NO	NO	NO	NO	NO	NO	R	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO	NO	NO
WL	LB	R	NO	NO	R	NO	NO	NE	NO	NO	NE, NO	NE, NO	NE, NO	R	NO	NO	R	NO	NO
	DW	R	NO	NO	NE	NO	NO	NE	NO	NO	NE, NO	NE, NO	NE, NO	NO	NO	NO	NO	NO	NO
	LT	NO	NO	NO															
	SOC_{min}	R	NO	NO	R	NO	NO	NE	NO	NO	NO	NO	NO	R	NO	NO	R	NO	NO
	SOM_{org}	NO	NO	NO	NO	NO	NO	NE	NO	NO	NE, NO	NE, NO	NE, NO	NO	NO	NO	NO	NO	NO
SL	LB	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	NE, NO	NE, NO	NE, NO	NO	NO	NO
	DW	R	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO	NE, NO	NE, NO	NO	NO	NO
	LT	NO	NO	NO															
	SOC_{min}	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	NO	NO	NO	R	NO	NO
	SOM_{org}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO	NE, NO	NE, NO	NO	NO	NO
OL	LB	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	NO	NO	NO	NE, NO	NE, NO	NE, NO
	DW	R	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO	NE, NO	NE, NO
	LT	NO	NO	NO															
	SOC_{min}	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	R	NO	NO	NO	NO	NO
	SOM_{org}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO	NE, NO	NE, NO
HWP	CO_2	R																	

6.1.9 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 NGHGI submissions. These include:

(i) regarding the FL category, additional data checks and improvements of AD and EF are considered for the next NGHGI 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) interrogation of explicit geospatial maps, datasets, respectively using of CLC+ as a source of maps;

(iii) 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;

(iv) *Cropland improvements for mineral soils:* to improve the CS estimates for EFs, during the year of 2022 will be measured soil organic carbon in mineral soils, in selected survey areas. This will allow to refine the CS parameters developed in 2020-2021 years for CL;

(v) *Grassland improvements for mineral soils:* to improve the CS estimates for EFs, during the year 2022 will be measured soil organic carbon in mineral soils, in selected survey areas. This will allow to refine the country specific parameters developed in 2021 year for GL. Also, for estimation of the CS EFs (F_{Input}), the methodology for evaluation at the Territorial Administrative Unit level of the production and processing potential in agriculture will be used;

(vi) *Planned improvements for organic soils*: for estimation of the CS EFs for the soil carbon pool in organic soils, during 2022 year measured data for estimating the response ratio of the measured SOC values in comparison with the reference SOC values, will be used. The soil organic carbon content in organic soils, in selected survey areas under CL, GL and WL categories will be measured;

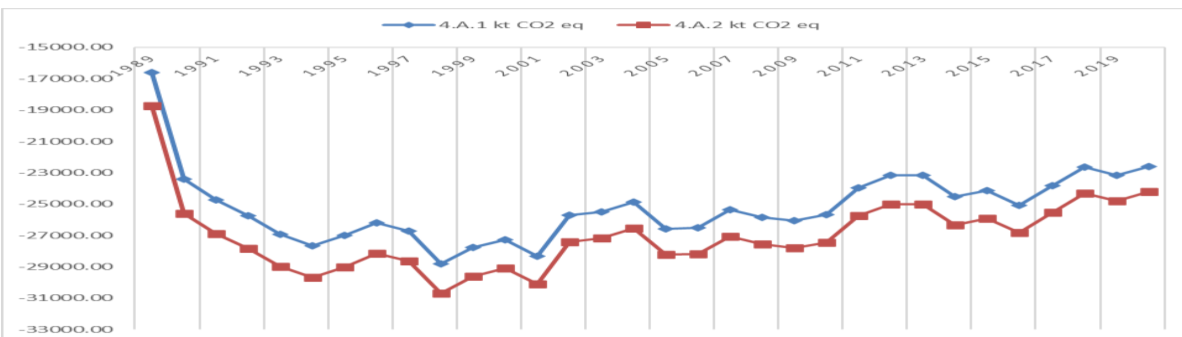
(vii) additional QA/QC elements to prevent issues like time series inconsistency that regard AD(kha), in compliance with 20 year transition period.

6.2 Forest Land (CRF 4.A)

6.2.1 Category description

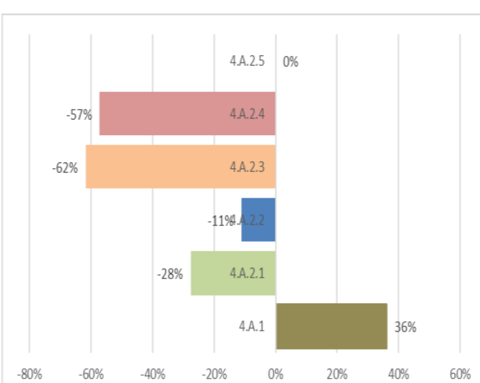
The GHG inventory for the Forest land (CRF 4.A) category includes emissions and removals of CO_2 associated with forest land and non-CO_2 estimates from wildfires (reported in section 6.10.5 below). The total removals from the FL category in the year 2020 is -24,222 kt CO_2 eq, from which the land converted to forestland accounts for 7%. Figure 6.9 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 decrease of 39% comparing average values for decades before and after 1989).

Figure 6.9 Summary of removals from FL category in 1989-2020 period (in kt CO_2 eq)



The CO_2 removals for each subcategory are presented in Figure 6.10.

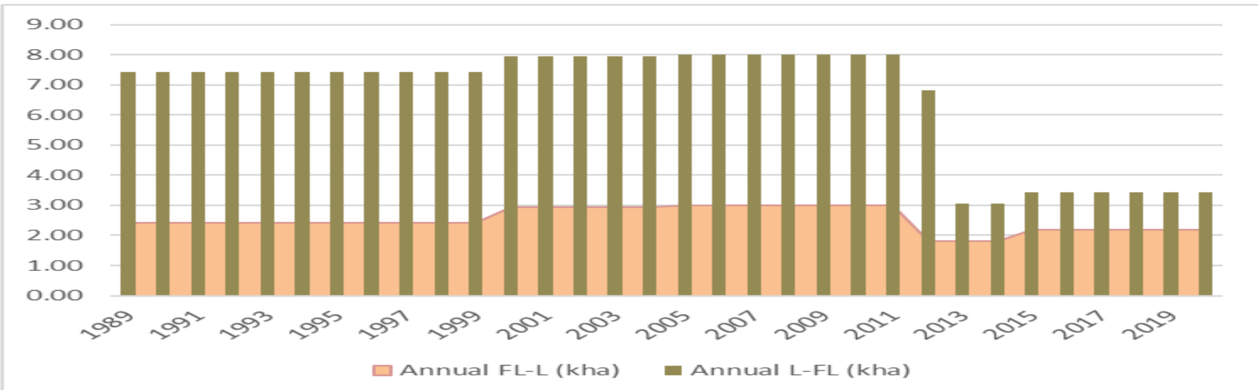
Figure 6.10 The comparison of CO_2 removals for 4.A sub-categories for the years 1989 and 2020



FL sub-category	1989 (kt CO_2 e)	2020 (kt CO_2 e)
4.A.1 FL-FL	-16,606	-22,621
4.A.2 CL-FL	-808	-586
4.A.2 GL-FL	-1001	-889
4.A.2 WL-FL	-93	-36
4.A.2 SL-FL	-211	-90
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, which resulted in the increase of total forest area by 2% between 1989 and 2020 (Figure 6.11).

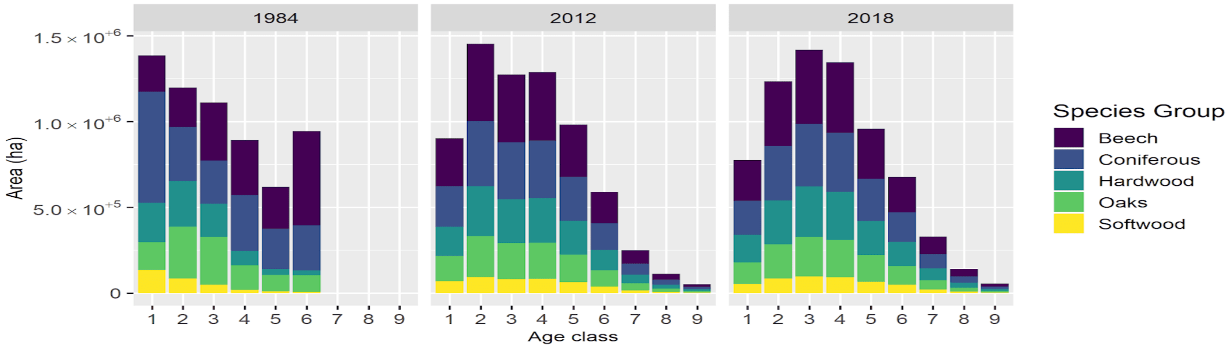
Figure 6.11 The area of forest-related land conversions



The Forest land category covers 6989.47 kha (4.A. 2020), equivalent to 29% of the country area.

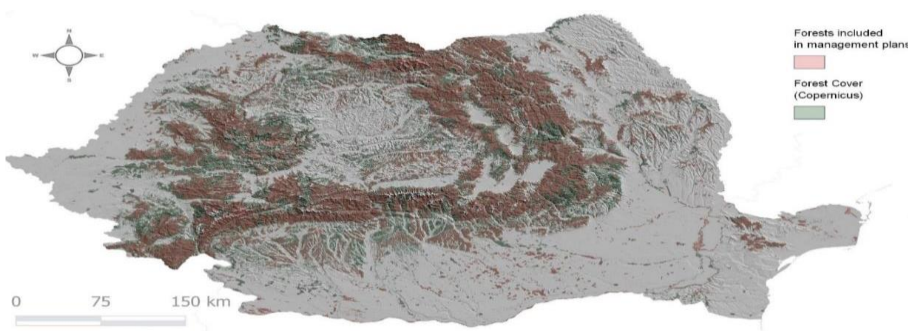
Between the first two NFI cycles (which ended in 2012 and 2018 respectively), the land covered by woody vegetation increased by 28 kha (5.6 kha/yr), while areas under regeneration decreased by 22 kha (4.4 kha/yr), resulting in a net increase of 6.28 kha of the Forest land category. During this time, the area with young forest stands showed a decreasing trend (the proportion of the area 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 6.12). 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 6.12 Forest area distribution in 20 year-age classes according to the NFFI (1984) and NFI (2012 and 2018)



The Romanian forests have a complex structure and high (bio)diversity; forest stands with two or more tree species that cover 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 unmixed forest of broadleaves species (67%), followed by forests of predominantly 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%). Despite the relatively equal proportions of the major landforms within the national territory, different forest types have different shares by area. 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 system where the application of forest management plans is obligatory, see Figure 6.13.

Figure 6.13 Area of forest land category stratified between included or not into forest management plans

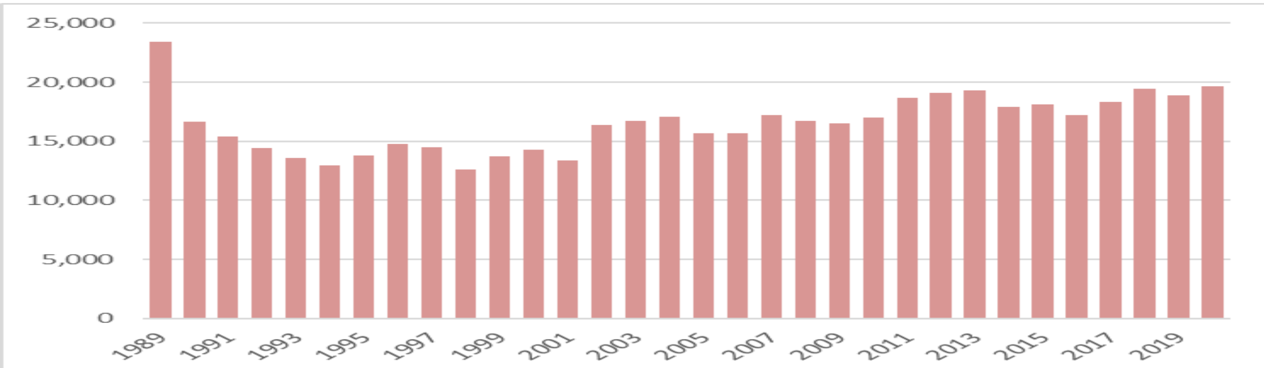


The forest area in Romania is managed under the provisions of the Forest Code (Law no. 46/2008) and is defined as follows:

- 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. Strict implementation of management practices was guided by governmental technical norms, long-term planning of wood harvesting, and consequent industrial processing. Since 1990, due to land property change, the Romanian forestry was registered under an inconsistent regulatory framework and under pressure from international wood markets, and 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 both environmental conditions and socio-economic requirements (State of Romanian Forests Report 2017). Since the year 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). Currently, 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 19 million m^3 per year in 2020 (NIS 2020). 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 level of the annual national harvest was lower than the allowable cut all over the reporting period; for instance, the total amount of allowable annual harvest in 2017 was estimated at 22.05 million m^3 (State of Romanian Forests Report 2017), out of which the total harvest was 18.32 million m^3. Figure 6.14 reports the annual harvest rate for the period 1990-2020.

Figure 6.14 Annual harvest (mil. m^3) for the period 1990 – 2020



The area of 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 (http://www.mmediu.ro/articol/ catalogul-padurilor-virgine-si-cvasivirgine-din-romania/ 4790). 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 groups of species (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.

6.2.2 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 6.14).

Table 6.14 Summary of the methodological approach for the 4.A. sub-categories

	4.A.1	**4.A.2**
method	Tier 1,2	Tier 2
approach	2,3	2,3
carbon pool estimated	LB; SOC (for organic soils)	LB; DOM; SOC
1989-2020 (kha)	Avg / Stdev	Avg / Stdev
	6,775.74 / 61.77	6.59 / 1.90
GHG pools and gases	CO_2, CH_4, N_2O	CO_2, CH_4, N_2O

6.2.2.1 Forest Land remaining Forest Land (CRF 4.A.1)

The estimation of CO_2 removals in the Forest Land remaining Forest Land (FL-FL) category follows the default "gain-loss" method (Tier 1) of the 2006 IPCC GL by using country-specific parameters. For this category, the C stock changes and emissions/removals were estimated for the following categories: living biomass (above and below ground) and organic soils. For the dead organic matter and mineral soil pools, it was assumed that the average transfer rates in and out of the respective are equal pools, so the annual net change is zero. The estimated emissions of the 4.A.1 category by gas are presented in Table 6.15.

Table 6.15 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	-16,605.88	0.01	0.00	**2005**	-26,569.46	0.01	0.00
1990	-23,399.19	0.03	0.00	**2006**	-26,516.22	0.06	0.00
1991	-24,740.57	0.02	0.00	**2007**	-25,385.32	0.16	0.01
1992	-25,738.86	0.05	0.00	**2008**	-25,853.26	0.02	0.00
1993	-26,917.18	0.03	0.00	**2009**	-26,077.34	0.06	0.00
1994	-27,651.17	0.02	0.00	**2010**	-25,687.31	0.01	0.00
1995	-27,012.34	0.01	0.00	**2011**	-23,964.92	0.14	0.01
1996	-26,208.07	0.01	0.00	**2012**	-23,190.12	0.42	0.02
1997	-26,708.89	0.00	0.00	**2013**	-23,160.83	0.03	0.00
1998	-28,824.25	0.01	0.00	**2014**	-24,519.73	0.01	0.00

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)
1999	-27,785.10	0.02	0.00	**2015**	-24,149.83	0.10	0.01
2000	-27,299.87	0.23	0.01	**2016**	-25,082.61	0.04	0.00
2001	-28,343.43	0.06	0.00	**2017**	-23,826.02	0.15	0.01
2002	-25,717.42	0.22	0.01	**2018**	-22,629.91	0.08	0.00
2003	-25,499.86	0.05	0.00	**2019**	-23,163.40	0.15	0.01
2004	-24,885.33	0.01	0.00	**2020**	-22,634.44	0.32	0.02

6.2.2.1.1 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. The FL-FL area provided in the land-use change matrix is obtained as the trend in FL's total area minus the annual area of the L-FL category, which is the accumulated area of annual conversions for the default 20 years. To achieve the highest accuracy possible, the activity data, i.e., forest area, was estimated for 225 forest structure classes (i.e., species group class x productivity class x age class) for which different growth rates were available.

For each year of the time series, the activity data is estimated through the following steps:

(1) in the inventory years 1984 (NFFI), 2012, and 2018 (NFI), the forest area for each class was estimated as a proportion of the total forest (i.e., FL) inventory area;

(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 the 2018 year and before the 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, 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 fraction 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* used in the *FL-FL* category, kha;

G_{TOTALi} = above-ground and below-ground biomass growth of class *i*, d.m. $ha^{-1}\ yr^{-1}$;

CF_i = carbon fraction of dry matter of class *i*, tonne C $(tonne\ d.m.)^{-1}$;

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 Annual 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} = annual area-specific above-ground and below-ground biomass growth rate, tonnes C $ha^{-1}yr^{-1}$;

I_{Vi} = net woody above-ground volume increment, 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 6.17);

R_i = ratio of below-ground biomass to above-ground biomass, dimensionless (Table 6.18);

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 6.16.

Table 6.16 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	**1995**	6.83	5.18	4.40	4.47
1995	**2000**	6.85	5.28	4.36	4.46

Year	Co	Be	Oak	Hw	Sw
	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$	$m^3ha^{-1}yr^{-1}$
2000	**2005**	6.86	5.38	4.33	4.45
2005	**2010**	6.87	5.48	4.29	4.44
2010	**2015**	6.89	5.53	4.24	4.40
2015	**2020**	6.90	5.54	4.17	4.34
2020	**1995**	6.83	5.18	4.40	4.47

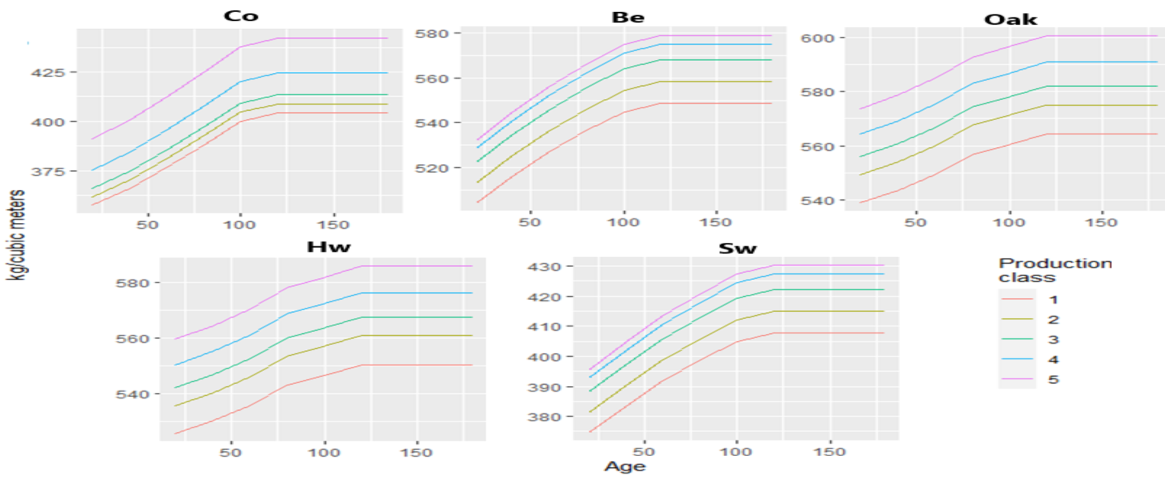
The NFI second cycle (2018) provides both estimates of the increment for each species group and actual loss due to harvest. These data are considerably different from the national statistics from the forest district's mandatory reporting concerning growth rates estimated based on the above yield tables 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). Additional NFI estimates are provided in the section below on wood removals.

The biomass expansion factor (BEF1) is used to estimate the whole 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 BEF1value is equal to one.

Concerning wood density (D), country-specific 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, Spruce, mean wood density values for each of the five species groups were computed for age and yield class (Figure 6.15).

Figure 6.15 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 (Dmean) 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 6.17:

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 6.17 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	0.39	0.55	0.57	0.55	0.40
1995	0.39	0.55	0.57	0.55	0.40
2000	0.39	0.55	0.57	0.55	0.40
2005	0.39	0.55	0.57	0.55	0.40
2010	0.39	0.55	0.57	0.55	0.40
2015	0.39	0.55	0.57	0.55	0.41
2020	0.39	0.55	0.57	0.55	0.41

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, tonne C (tC t.d.m)$^{-1}$.

The Root-to-shoot factor (R) was applied differently for specific species groups using country-specific factors (Giurgiu et al. 2004, Table 6.18).

Table 6.18 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 6.19.

Table 6.19 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 FL-FL ΔCG
	kha	$m^3\ ha^{-1}\ yr^{-1}$	t d.m. m^3	dimensionless	t C t^{-1} dm	Kt C yr^{-1}
1990	6,666.27	6.31	0.49	0.20	0.50	11,008.96
1995	6,709.51	6.47	0.50	0.20	0.50	11,160.90
2000	6,752.23	6.61	0.50	0.20	0.50	11,312.90
2005	6,792.79	6.74	0.50	0.20	0.50	11,462.15
2010	6,814.83	6.86	0.50	0.20	0.50	11,580.79
2015	6,841.34	6.95	0.50	0.20	0.50	11,610.26
2020	6,868.05	7.03	0.50	0.20	0.50	11,574.72

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-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 6.20) 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, it is not required in the case of conifers to apply a BEF (as in the C gain calculation) to estimate losses from harvest (Giurgiu et al. 2004).

Table 6.20 $H_{FL\text{-}harvest}$ 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
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

The loss of biomass due to the annual-harvest values was computed according to equation 2.12 of IPCC (2006) as follows:

Equation 6.8 Loss of carbon due to the annual-harvest values

$$C_L = H_{FLFL-harvest} \times D_i \times (1 + R_i) \times CF_i$$

where:

$H_{FLFL\text{-}harvest}$ = total annual volume of wood extracted [m^3 yr^{-1}] (Table 6.20);

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 6.21 and 6.22);

CF_j = 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);

k = 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 6.21.

Table 6.21 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	Annual C loss in FL-FL C_L
	1000 m^3/yr	1000 m^3/yr	t d.m. m^3	dimensionless	tC $d.m^{-1}$.	ktC yr^{-1}
1990	16,027.06	621.94	0.48	0.20	0.50	-4,796.52
1995	13,155.79	656.91	0.48	0.20	0.50	-3,974.19
2000	13,443.52	841.18	0.48	0.19	0.50	-4,079.11
2005	14,763.47	907.83	0.48	0.20	0.50	-4,465.83
2010	16,040.08	951.52	0.48	0.19	0.50	-4,836.87
2015	17,431.30	701.80	0.48	0.19	0.50	-5,208.77
2020	18,911.14	740.86	0.48	0.19	0.50	-5,575.21

The NFI produces estimates of the national drain between two cycles. As in the case of increment, the NFI estimates are considerably different from those provided by the national forest administration. The NFI estimates have led to a debate within the country and would have raised difficulties in reporting consistent estimates for the whole time series if applied. Therefore, until difficulties are resolved and time-series consistency established, Romania's approach for this GHG inventory is to rely on the values reported by forest districts regarding both the increment and harvest. Nevertheless, the two datasets were compared to grasp the gap between them fully. The analysis showed that both the increment and harvest estimates by the NFI are consistently higher by approximately the same margin compared to the NIS estimates. Therefore, applying the gain-loss method using growth and drain data pairs from NIS and NFI for the period with data from both systems, i.e., 2012-2018, and extrapolation until 2020, would produce similar carbon stock change estimates. The implied emissions factors, reported in Table 6.22 and the net C stock change factors demonstrate the above for both gains and losses.

Table 6.22 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 2012-2018 by applying NFI data instead of those by the NIS

Year	Implied C stock gains factor		Implied C stock losses factor		Implied C stock net change factor	
	t C ha yr^{-1}					
	NFI	NIS	NFI	NIS	NFI	NIS
2012 - 2017	2.6	1.7	-1.7	-0.7	0.9	1.0

The above estimations indicate an implied net C stock change difference of 10% for the 2012-2017 time series between the two datasets, which is well within the possible accuracy that is generally possible in the estimation of forest carbon stock changes. The NFI values validate the NIS estimates for the overlapping period to some degree. Nevertheless, as indicated before, the authorities have not accepted the initial data on wood drained reported by NFI, requiring further investigation of this estimate and the volume increment.

6.2.2.1.2 Change of C stocks in dead organic matter

Romania uses a Tier 1 approach to report the carbon stock change for the DOM pool, assuming that the transfer rates to and from C pools are equal, which means that the annual net change is zero. The Tier 1 approach is due to the lack of consistent information throughout the time series, but also because the changes are assumed to be relatively small, currently adding to the carbon stocks as argued below in section 11. This practice is consistently applied concerning E/R stock changes under the UNFCCC and the KP. Regarding the deadwood, between the 2012-and 2017 period, the AD is available for both standing and laying on the ground from the NFI. Data between the two NFI cycles (5 yr.) shows a significant increase in the standing DW and a significant decrease for the laying DW on the ground, with the overall estimates indicating a net increase in deadwood biomass. The increasing amount of DW in

Romania's forests may be related to several reasons, such as lower harvest rates in contrast to growth in biomass due to age-related structure, the sustainability of the Romanian forests management practices, and the effect of natural disturbance. Also, biodiversity conservation and improvement are achieved by conserving DW (both standing and lying) within the necessary ecological limits (Low no. 46/2008, art 26.4). Nevertheless, the relatively short period covered by the NFI measurements requires further studies to understand the NFI results better. The data from NFI may indicate that both DW and litter pools are not a source, assuming that changes in the litter pool are highly correlated with those of the DW as the input to both pools is from dead organic material, but litterfall is an additional source of input which has not been accounted for in the deadwood pool. Additional information is presented in Chapter 11.

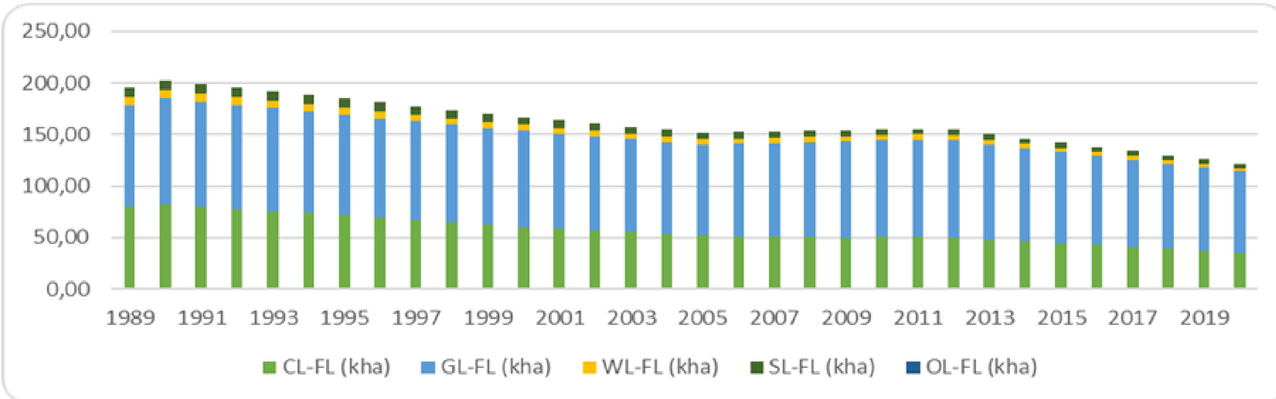
6.2.2.1.3 Change of C stocks in forest soils

The same approach, Tier 1, as in the above section, was considered for the C stock changes in mineral forest soils in the FL-FL category due to the lack of measurement throughout the time series. The C fluxes in forest mineral soils are considered in equilibrium, and therefore the C stock change is assumed to be zero. This assumption is supported by additional information presented in Chapter 11. Based on the above argumentation, one can suppose that the DOM C stocks increase, indicating that organic inputs into the soil increase. Furthermore, based on the NFI data, a published peer-reviewed research article justifies these assumptions (Blujdea V. N. et al., 2021) using two simulation models. This paper demonstrates that forest soils are no net source of emissions. Nevertheless, Romania needs more time to apply these estimates over the time series consistently. The area of forests on organic soils covers 2.546 kha in the country. The CO_2 emissions from organic soils have been estimated using the IPCC methodology applying the default EF given in Table 2.1 of the IPCC Wetlands Supplement for Drained Forest land, temperate zone.

6.2.2.2 Land converted to Forest Land (CRF 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 through 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.1
	kt C	kt C	kt C	kt CO_2
1989	188.95	17.41	370.06	-2,113.53
1990	198.75	16.87	384.01	-2,198.64
1995	181.56	13.52	349.15	-1,995.52
2000	160.95	12.67	315.30	-1,792.71
2005	149.59	12.82	285.63	-1,642.83
2010	177.88	13.29	290.33	-1,765.48
2015	209.37	12.50	266.24	-1,789.71
2020	200.83	8.07	227.72	-1,600.95

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 0-20 is used. By multiplying the Iv by the average wood density, root-to-shoot ratio, and carbon fraction (Table 6.16) the EF of 0.96 tC ha^{-1} yr^{-1} was estimated.

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

Land use categories		C stock ($tC\ ha^{-1}$) values in the diagonals, C stock changes ($tCha^{-1}yr^{-1}$) elsewhere from land use category					
		FL	**CL**	**GL**	**WL**	**SL**	**OL**
from	**FL**	84	1.84	1.84	1.84	2.60	2.15
	CL	-1.84	48	-0.1	-0.1	0.8	0.34
	GL	-1.84	0.1	40	0	0.9	0.44
	WL	-1.84	0.1	0	40	0.9	0.44
	SL	-2.60	-0.8	-0.9	-0.9	32	-0.44
	OL	-2.15	-0.34	-0.44	-0.44	0.44	41

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.

6.2.3 Uncertainties and time-series consistency

To estimate the C stock change in the 4.A. category, we used the same emission factors for the whole time series; thus, no bias is introduced. The land assessment methodology is obtained from two overlapping trends for the total FL area, which was harmonized considering the latest (NFI-based) inventory to develop accurate data (see section 6.8). The uncertainty associated with NFI's forest area, which is used for reporting the total FL area in the 2012 and 2018 time series, is 1.024%, whereas, for that associated with the forest area estimate up to the year 2011, 5% has been considered (by expert judgment and also by cross-checking on additional geospatial product for close years). The AD trend of 4.A.1 category in the time series is affected by the conversion rates estimated from the point sampling method and matching the overlapping trend. The combined uncertainty of the EF associated with the year 2020 was estimated at 30.7%. The overall combined uncertainty for the 2020 year of the 4.A.1 is shown in Table 6.27. The uncertainty regarding AD of 4.A.2 category is obtained in a way similar to 4.A.1 category, is also based on information from the point sampling area identification method (section 6.1.4) and it was quantified 10% for the conversion areas (by cross-check on additional geospatial product for close years). The combined uncertainty of the EF associated with the 2020 year was estimated at 17.32%.

Table 6.27 The results of the uncertainty analysis of the 4.A. category

IPCC category/Group	Gas	Base year emissions (+) or removals (-)	2020 emissions (+) or removals (-)	Activity data uncertainty (%1%)	Emission factor / estimation parameter uncertainty (unit ??)	Combined uncertainty
4A1 Forest Land remaining Forest Land	CO_2	-16,605.88	-22,634.44	1%	31%	31%
4A2 Land converted to Forest Land	CO_2	-1,876.21	-1,600.95	10%	17%	20%
4A1 Forest Land remaining Forest Land	CH_4	0.01	0.32	51%	99%	111%

IPCC category/Group	Gas	Base year emissions (+) or removals (-)	2020 emissions (+) or removals (-)	Activity data uncertainty (%1%)	Emission factor / estimation parameter uncertainty (unit ??)	Combined uncertainty
4A2 Land converted to Forest Land	CH_4	0.00	0.00	51%	99%	111%
4A1 Forest Land remaining Forest Land	N_2O	0.00	0.02	51%	99%	111%
4A2 Land converted to Forest Land	N_2O	0.00	0.00	51%	99%	111%

6.2.4 Category-specific QA/QC verification, if applicable

The national GHG inventory has three QA/QC levels implemented within the LULUCF Sector:
At the first level, the data providers conduct their first QC by applying official procedures to ensure and control the quality of data provided to the GHG inventory compilers.
Secondly, the LULUCF GHG inventory compilers perform (as part of QC or QA) a large number of necessary checks of various procedures to avoid errors associated with different data processing stages or calculations. The checks performed are*:*

- methods are established and followed step by step to avoid data management errors, especially by implementing complex excel spreadsheets;
- land use classification is verified by repeated assessment of sensitive cases (especially looking at forest conversions and forest/non-forest wood areas) and comparison against other data sources, and consulting with experts for specific issues (i.e., allocating land under conversions among various categories; land definitions; forest data parameters and testing various proxies);
- cross- checks of IEF's values against values reported by other EU countries;
- graphical check of the smoothness of the time series for each land use category and emissions from each C pool, check and fix any outlier and provide the explanation in the text for any extreme value;
- archiving of hard or digital copies, as appropriate, of the original data on all land use categories (i.e., statistical reports, databases with digital maps, and aerial photography);

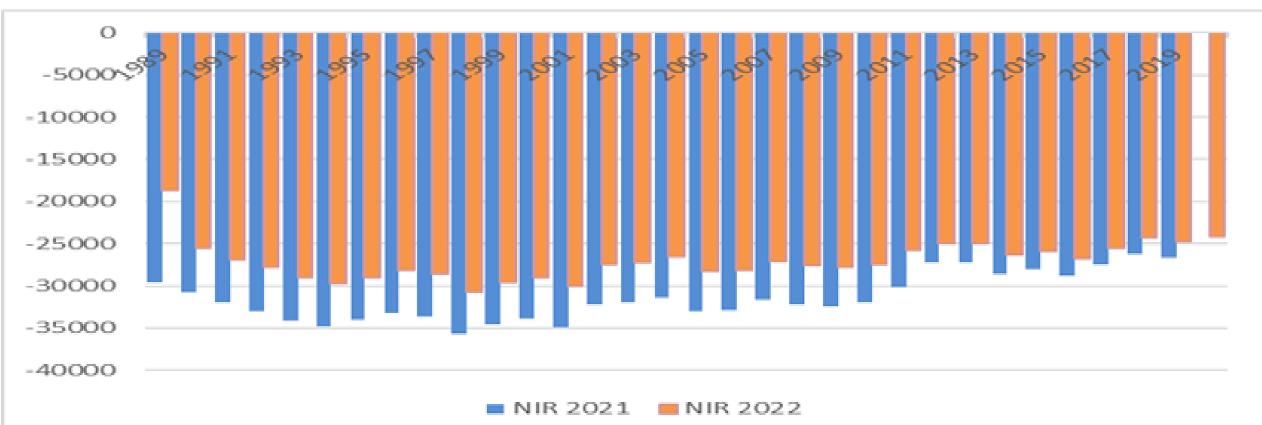
–the completion of the "List for Quality Control of the National Greenhouse Gas Inventory" following the quality assurance and quality control provisions. The list is completed and verified by different employees of the "Marin Drăcea" National Institute of Research and Development in Forestry Bucharest.

The third level, i.e., final QA, is implemented by the department of the Ministry of Environment, which is responsible for the National GHGI, consisting of checks related to both the CRF and all NIR chapters.

6.2.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

With the 2022 inventory, recalculations were applied to the entire time series for both 4.A.1 and 4.A.2 categories. Recalculations resulted from updating the activity data in 4.A.1 category and both AD and EF in 4.A.2. Overall, in the 4.A category, the removals of CO_2 decreased by an average of 14% per year (Figure 6.17).

Figure 6.17 Comparison of kt CO_2 removals from the 4A activity between 2020 and 2021 inventory submission



The differences resulting from applying the recalculations in percentages for each year compared with the previous submission are shown in Table 6.28.

Table 6.28 The difference in percentage for the two FL subcategories between the reported values of both the activity data and estimated removals for selected years in the present and the previous submission

Year	4.A.1 FL-FL category		4.A.2 L-FL category	
	Activity data (area)	CO_2 Gg removals	Activity data (area)	CO_2 Gg removals
1989	1.2%	-56.2%	-68.7%	-73.7%
1995	1.8%	-11.8%	-88.0%	-93.4%
2000	2.2%	-10.1%	-107.9%	-114.9%
2005	2.6%	-9.5%	-129.2%	-135.0%
2010	2.7%	-9.4%	-124.7%	-118.6%
2015	2.5%	-1.4%	-118.9%	-94.8%
2019	2.2%	-2.0%	-117.3%	-81.9%
Average 1989-2019	2.2%	-10.0%	-108.1%	-104.3%

Most differences in E(+)/R(-) estimates reported in this inventory compared to the previous one are triggered by updates in the annual conversion rates.

The improvement of the spatial approach by including a higher number of geospatial datasets reduced the AD values of both L-FL and FL-L.

The annual carbon stock in mineral soils was updated based on new values reported for GL and WL categories by ICPA. The L-FL category was divided between AR and naturally established stands, for which different EFs were used. In the 4.A.1 category, besides the AD, also EF was modified.

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

The concerted effort and collaboration between all parties involved in Romania's LULUCF sector have continuously progressed for the last year, starting from late 2019 with the new national inter-institutional agreements. The CO_2 estimation procedure was consistently improved and was followed by a continuous QA/QC process. The planned improvements on the land identification system are presented in the 6.1.9 Chapter. Considering the GHG estimation system, Romania will increase its efforts to harmonize with

NFI results and apply them consistently throughout the time series to adopt a higher tier for C stock change estimation, especially in the DOM and SOC pool. The planned improvements include:

- develop coherent and harmonized land identification between all land use and land-use change categories, including spatial information in the entire time series;
- uncertainty evaluation and checks regarding the land identification system;
- improve the uncertainty analysis of the emission factors;
- a detailed key category analysis, with the new estimates;
- harmonize the national statistical data reported each year with NFI estimates for the entire time series;
- improve cooperation with LPIS data providers and the Cadastral Office.

During the inventory preparation and based on the discussion and recommendations from the UNFCCC review (ARR 2020), the following improvement were adopted:

<u>4. General (LULUCF) (L.2, 2018) (L.12, 2016) (L.12, 2015) Transparency</u> "Improve the description and transparency of the land-use definition." Romania has considered the ERT recommendation and provided a comprehensive definition of the forest land category in the NIR 2022, section 6.2 and additional information on how forest land categories (FL-FL, L-FL and FL-L) are estimated. Romania starts from known total FL area (1974 - military maps based on orthophotos and beginning 2012, 2017 NFI based information applying cross-check methods between orthophotos and field validation; both datasets estimate and include forest areas under regeneration. The forest loss in the time series is spatially tracked through remote sensing and data from forest districts to differentiate between forest conversion and land temporarily under regeneration in forest land remaining forest land under regeneration. Moreover, the interpolation between three NFI forest structure data, allowed to stratify the FL-FL areas into five species groups, nine age classes, and five yield classes to a total of 225 categories.

<u>4. General (LULUCF) (L.3, 2018) (L.13, 2016) (L.13, 2015) Convention reporting adherence</u> "Ensure the consistency of the key categories between the LULUCF sector and KP-LULUCF." Romania has updated consistent information on the key categories following both UNFCCC and Kyoto protocol (see section 11.7.1).

<u>4.A Forest land – CO_2 (L.5, 2018) (L.16, 2016) (L.16, 2015) Accuracy</u> "Analyze the effect of not using species-specific carbon fractions for the estimates of emissions and removals to ensure that the estimates are accurate." Romania has used different carbon fraction values for estimating the LB carbon stock since the 2021 submission (i.e., 0.48 for conifers and 0.51 for broadleaves - IPCC 2006 GL table 43). See section 6.9.2.1.1.

<u>4.A.1 Forest land remaining forest land – CO_2 (L.6, 2018) (L.5, 2016) (L.5, 2015) (66, 2014) (61, 2013)</u>

(119, 2012) Accuracy "Provide estimates for the DOM and mineral soil pools using the tier 2 methodology." Romania still needs time to process the NFI data and make a transition later; the NFI only covers a short period in the time series raising consistency difficulties. Please see sections 6.2.2.1.2 and 11.2.1.2., the latter with some quantitative estimates.

4. General (LULUCF) – CO_2, CH_4 and N_2O "The ERT recommends that the Party explain the impacts of the recalculations of the annual net increment in volume on the overall trend for the five main groups of species in its next submission." Detailed information has been provided in the 6.9.5 section of the 2021 NIR on the overall trend affected by different applied emission factors.

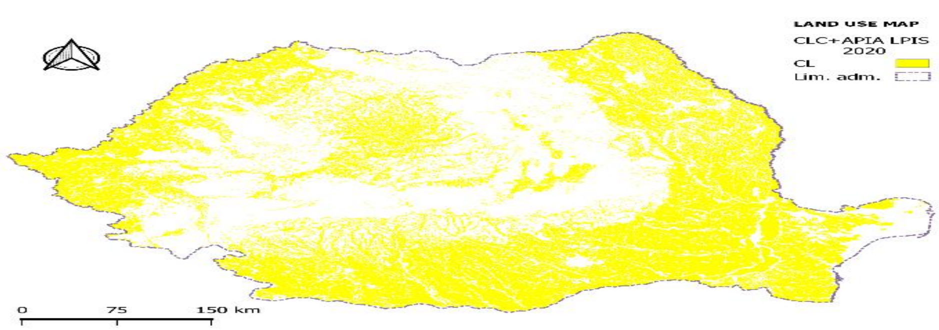
4.C.2.1 Forest land converted to grassland – CO_2 (L.18, 2018) Accuracy "Review the values of carbon stock changes in mineral soils for conversions of forest land to grassland and grassland with wooded land subcategories and, as appropriate, revise the reported estimates." Romania is considering the recommendation; nevertheless, CS data on carbon stock in mineral soil received from the data providers indicate the same values for grassland subcategories with or without tree cover, thus using the same carbon conversion factor. Note that the woody vegetation on grasslands is usually not considered. We consider using default factors to differentiate between GL national subcategories for further accuracy, in which no better data from national studies occur.

6.3 Cropland (CRF 4.B)

6.3.1 Category description

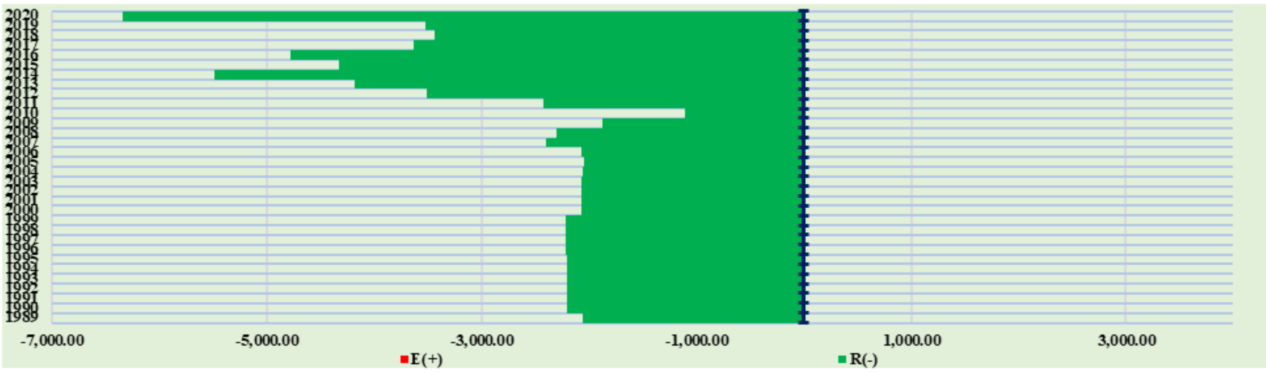
The 4.B land use category includes arable land, orchards, vineyards, shrub crops, Figure 6.18. The calculations of GHG E(+)/R(-) estimates were made for all individual years from 1989 to 2020, for the 4.B.1 and 4.B.2 and related sources/sinks.

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 for 1989-2020 time series:

Figure 6.19 4.B GHG E(+)/R(-) evolution in 1989-2020 time period (kt CO_2 eq.)



In 4.B land use category estimates were based on IPCC 2006 Guidelines, V4, 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. 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. Anthropic GHG E(+)/R(-) estimates in land use category 4.B are the result of changes in specific management practices 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. For the year 2020, 4.B land use category represents 7957.64 kha, from the total surface of LULUCF Sector, 23839.02 kha, Chapter 6.1, Figure 6.3.

Combining, processing and querying information

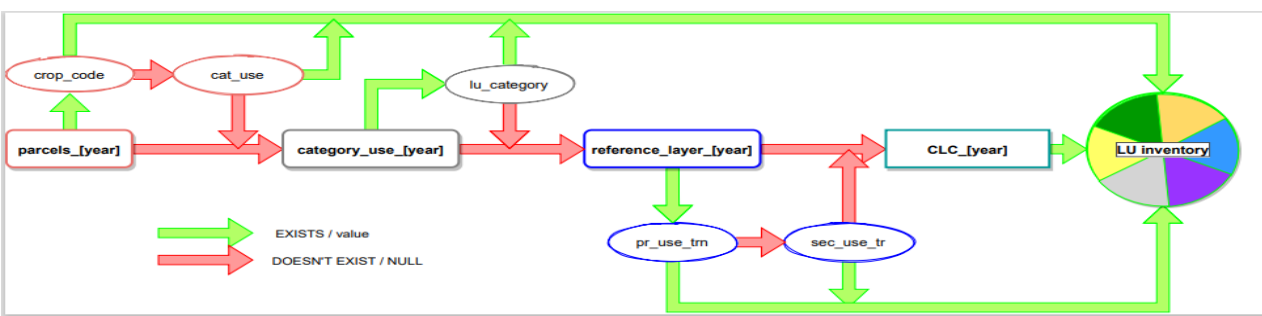
LULUCF surface management involved in this process for NGHGI 2022 reporting have undergone particularly important changes. The type 3 approach was initiated in 2020, continuing with the same model to build an explicit geospatial database of areas in key categories CL and GL, as well as in SL, WL, OL. The classification is now more detailed, according to the subcategories of land use, Chapter 6.1, Table 6.5. The main data sources used are:

(i) APIA, namely the LPIS parcel identification system, part of the IACS, which operates at the level of the reference parcel. The Romanian LPIS system uses aerial or satellite orthophoto images that comply with a uniform standard that guarantees an accuracy at least equivalent to that offered by mapping at a scale of 1: 5000. The pixel size of the images is 0.5 m, which ensures a submetric accuracy, covering most of the country's agricultural and pasture territory, about 70%. The source files are in ESRI shape file format, Stereo 70 projection system (EPSG 31700) and contain in the attached databases information of interest about land use. The data shall be updated annually by the named institution, the first occurrence covering the year 2007.

(ii) Corine Land Cover, a product of the Copernicus program, an inventory of land use categories classified into 44 land use classes, obtained by visual interpretation of high-resolution satellite images. These geospatial data are characterized by a minimum unit area of 5 ha to 25 ha. This GHG inventory started in 1985, 1990 reference year, with updates made in 2000, 2006, 2012 and 2018. The source files are in Geopackage SQLite Database format. The projection system is Lambert Azimuthal Equal-Area (ETRS-89 - LAEA, EPSG: 3035), used by the EU.

One of the objectives achieved for this submission was to extend the type 3 approach from 2012 (inclusively) from last year's report, to 2007 (inclusively), this time being coinciding with the period since the implementation of the information system for geospatial management of plots at APIA has started. Because of six-year limit for updating the CLC's graphical and alphanumeric databases has been exceeded for this submission, Romania have established a criterion for the validity of the data provided by Corine, which will lead to the best possible approximation of use of the plots during that period, so to a more accurate assessment of the changes made, given that the frequency of updating the data from the LPIS is much better (annual). Considering the fact that CLC data is updated once every six years and APIA sources are updated annually, Romania had to establish a rule in order to obtain the combination of data that could represent most accurately the situation in the field. If Romania use, for example the CLC instance from 2006 combined with APIA datasets from the year 2007 up to 2012 (when the new instance - CLC 2012 is available), then at one moment in time, enough changes in land use have happened in the field to render CLC 2006 data obsolete and very imprecise. Therefore, Romania considered that after the three years have passed, the changes in land use are already accumulated enough to dictate that the next instance from Corine Land Cover should be used. This instance best represents the situation from the year 2012, but in the year 2010 is already more accurate than the old 2006 instance. It should be noted that following the application of this rule, with the appearance of the CLC update for 2024, for example, the updates used for the last two years will be modified (the areas for 2022, 2023 years will be recalculated instead of CLC 2018 using the CLC 2024 update). A new revised version of CLC maps was used for NGHGI 2022. Starting with the release of CLC 2006 during the next update, a new version replaces the old updates, which are subject to more or less changes, as a by-product of the ongoing process. These revisions (correction of errors) are necessary due to the following factors: *availability of higher resolution satellite imagery; a new image or time series of satellite images adds new elements for the correct recognition of an element; improved availability or better quality of on-site data; the* *participation of experts with more expertise, for example in understanding and applying the CLC nomenclature; the decision to improve the product (in a given region) between two successive inventories.* Given that previously only one instance (update) of the land inventory was used for the 2012-2019 time period, namely CLC 2018 in version v2018, this year the Corine source maps were redone, using for CLC 2006, CLC 2012, CLC 2018 respectively the revisions v2020 already available last year on the Copernicus website. Covered areas for Romania have been separated from the total map (EU) leaving a margin at the limits to compensate for possible approximations caused by the transformation of the projection system. After performing the transformation from the projection system ETRS-89 - LAEA to Stereo 70, each map was cut according to the administrative limit that is used and the inventory of plots from APIA. As the data scheme from the APIA - LPIS source is quite complex and follows a series of laborious processing that involves a reclassification of the categories contained in the database, a centralization of its structure has been made. This includes important features for our processing: *edition (year); filename; data fields for classification; unique values that each of them contains.* A working diagram showing how to go through the data for each year, both graphical and alphanumeric from the two most important sources used to obtain the plots and their classification is shown in Figure 6.20:

Figure 6.20 Graphical and alphanumeric data filtering algorithm that are used from the two combined sources

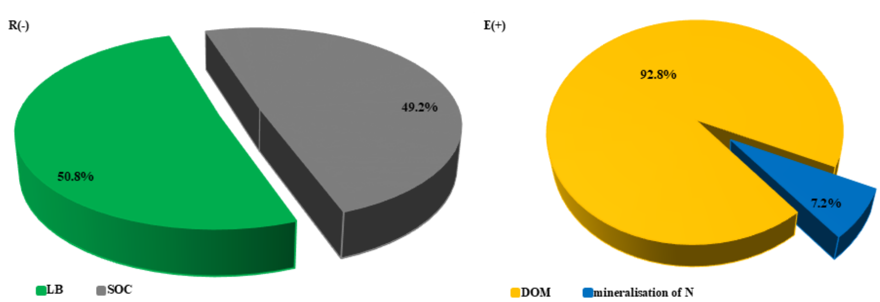


The next operation, applied to all the maps after they were brought and reduced to the coordinates of the area of interest, was a check on the integrity of the polygons and the elimination of any potential processing problems to be applied, removal of any nodes and/or duplicate lines, or self-intersecting 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 NGHGI on the years approached (2012-2019). 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 use 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.*

6.3.2 Methodological issues

The following figure shows the C stock changes by carbon pools:

Figure 6.21 4.B 2020. E(+)/R(-) distribution in carbon pools



6.3.2.1 Cropland remaining Cropland (CRF sector 4.B.1)

Since there have been various updates in this GHG inventory, Romania included them at subcategory level, a summary of recalculations is included in Chapter 6.3.5. Romania also identified here the next improvements for the GHG E(+)/R(-) estimates, a summary of these are in Chapter 6.3.6. The C stock in LB and DOM of Cropland remaining in the same subcategory for more than 20 years is assumed 0. These GHG E(+)/R(-) estimates are explained below:

6.3.2.1.1 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), 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, Tabel 5.3)* are loss in the first year. In the year of conversion and over the next 19 years, there is a growth in LB in the new perennial crop, i.e. 8.5/20 = 0.425 tC/ha/year *(IPCC 2019 Refinement, V4, Ch. 5, Tabel 5.3),* are gained along 20 years. In previous submissions, the mature LB was assumed to be 4.43 tC/ha, which is lower than the assumed LB in annual cropland. This has been updated in the current submission, the number of years until maturity has also been updated from 15 to 20 years to align with IPCC defaults. In addition, the CSC in the conversion from Ata to Lv and Vv was previously considered 0 (NA) and the gains in the conversion Vv and Lv to Ata were not reported in previous submissions. These assumptions have been updated. 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, Tabel 5.9),* are lost in the year of conversion. It is assumed that there is a gain of LB in the perennial cropland along 20 years, i.e. 8.5/20 = 0.425 tC/ha/year, are gained along 20 years. However, in previous years, there was an error in the sign of the EF, and the conversion from annual cropland to perennial cropland was reported as a loss and not a gain. The loss of LB of the previous annual cropland was not included in the estimates of previous submissions. These have been updated.

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, are lost in the year of conversion. It is assumed that there is a gain of LB in the annual cropland in the year of conversion, i.e. 5 tC/ha. However, in previous years, there was an error in the sign of the EF, and the conversion from annual cropland to perennial cropland was reported as a loss and not as a gain. This has been corrected in the current submission. 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 have been updated to the values for orchards in *IPCC Refinement, Table 5.2*, previously, values based on Hungary NIR were used. In Hungary NIR this value is 4.43 tC/ha, and smaller than for annual crops. The value 4.43 is of the same order of magnitude as the *2019 IPCC Refinement, Table 5.2, V4, Ch. 5*. 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.

6.3.2.1.2 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.

6.3.2.1.3 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 in *IPCC 2006, V4, Ch. 5, 4.2.3 Soil carbon*. Romania has collected information for 1990, 2013 and 2019 years that allows for the estimates of CSC in SOC.

Table 6.29 4.B.1 parameters developed for the soil carbon pool

	SOC_{ref} tC/ha	**F_{LU}**	**F_{MG}**	**F_I**	**SOC tC/ha**
1990 value	**45**	**0.69**	**1.02**	**0.95**	**30.09**
1990 assumption	CS (under native vegetation) soil organic C stocks (SOC_{ref}) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	IPCC 2006 Long temp cultivated -temperate	IPCC 2006 Reduced tillage - temperate dry	IPCC 2006 temperate dry - low	$SOC_{ref}*F_{LU}-F_{MG}*F_I$

	SOC_{ref} tC/ha	F_{LU}	F_{MG}	F_I	SOC tC/ha
2013 value	**45**	**0.71**	**1.02**	**0.95**	**30.96**
2013 assumption	(under native vegetation) soil organic C stocks (SOC_{ref}) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	IPCC inland wetland mineral soils 2013, relative stock change factors for land-use (F_{LU}) for long term cultivation on cropland, table 5.3, V4, Ch. 5 default	IPCC 2006 Reduced tillage - temperate dry	IPCC 2006 temperate dry - low	SOC_{ref}*F_{LU}-F_{MG}*F_I
2019 value	**45**	**0.76**	**1.04**	**0.95**	**32.79**
2019 assumption	CS (under native vegetation) soil organic C stocks (SOC_{ref}) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	CS	CS	IPCC 2006 temperate dry - low	SOC_{ref}*F_{LU}-F_{MG}*F_I

Information regarding the parameters for soil carbon pool - CL

The method for estimating the CS EFs for CL was selected considering the official data available in our country, statistical data provided by NIS, as well as the information obtained by analysing other reports on the national inventory of GHG emissions/removals of other countries on obtaining EFs for estimating the annual change in soil organic carbon stock. Romania has collected information for 20 years that allows the calculation of estimates for CSC in SOC, in Cropland and Grassland categories. Romania has collected information on soil chemical and physical properties for 10 years (1986-1996) to develop the *Profisol geodata base* (around 6000 soil profiles throughout the entire country) and information on soil chemical and physical properties for 10 years (1992-2002) to develop the *Monitoring geodata base* (670 soil profiles located on agricultural land throughout the entire country). The value of 45 tC/ha for SOC_{ref} obtained for mineral soils is based on estimations from the above mentioned geodata bases. Experiments carried out in the past at Fundulea Research Institute showed that the humus content and, consequently the organic carbon content, has the tendency in the soil system to reach an equilibrium state over the time. Also, the results from the experiments illustrated that the decrease over time, 50 years time period, of humus content under conditions of balanced fertilization was not significant, only 8 % decrease, when compared with not fertilized control variants, where the decrease over time was of around 25 %. General notes on the factors are in the Table 6.29:

(i) the climate zone is warm temperate dry;

(ii) SOC_{ref} 1990, 2013, 2019: is constant along the time series as the type of soil and the climate in the area under conversion do not change;

(iii) F_{LU} for 2019: for the calculation of F_{LU}, we used the data from the NIS regarding the areas classified under different uses and considering that the respective areas kept the same use in the long run. For the calculation we used the series of data provided by NIS for the years 1990-2020

(iv) F_{MG} 2019: *CS* for the calculation of F_{MG} we used the data from the survey on agricultural production methods 2010, which was conducted at the same time as the 2010 general agricultural census. We used data from the last agricultural census, which was the basis for the development of agricultural production methods 2010, it is the only official source in which we found data on agricultural management systems. The value refers to all management systems because 90 % of the country's agricultural area is cultivated in a conventional system (full)

(v) F_I 2019: *CS* for the F_I calculation we used the data from the NIS regarding the surfaces on which fertilizers were applied. As in the case of F_{LU}, we used the string of data provided by NIS for the years 1990-2019. The entire agricultural area of the country was classified as having a single level of inputs and we obtained a single F_I value specific to Romania.

SOC changes have been calculated for conversions from perennial cropland to annual cropland, as well as from annual cropland to perennial cropland. Changes in SOC for conversions between perennial cropland subcategories have not been estimated. SOC changes have been calculated for the perennial cropland subcategory of Ata remaining Ata cropland based upon the accumulated area of remaining Ata cropland. Changes in SOC have also been calculated for annual cropland remaining annual cropland. When calculating this for the annual cropland, the area of organic soil has been substracted from the accumulated area of remaining annual cropland to avoid double counting. It is assumed that SOC in CLperennial remaining in the same subcategory (Vv remaining, Lv remaining) or in conversions between Vv and Lv do not change as the land use is still CLperennial and the management practices have not changed along the time series. It is also assumed that in the conversions between Ata and Lv or Vv there is no change in management, and therefore the CSC in SOC in these areas is not applicable (NA).

Table 6.30 4.B.1 Carbon stock change estimates in SOC

Land use to →	**Ag**	**Ata**	**Lv**	**Vv**
Land use from ↓				
Ag	E	E	E	E
Ata	E	E	NA	NA
Lv	E	NA	NA	NA
Vv	E	NA	NA	NA

E estimated, NA not applicable

In order to determine the AD(kha) corresponding to organic soils, the vector calculation methodology was used. EGM 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 1989-2020, thus generating recalculations for the entire 1970-2020 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*.

6.3.2.1.4 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, CRF 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.

6.3.2.2 Land converted to Cropland (CRF sector 4.B.2)

6.3.2.2.1 Changes of carbon stock in biomass carbon pool

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, aboveground and underground, 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. In previous submissions, a value of 0.85 tC/ha was used for LB in GLgrassy (Pa, Pf, Pp). This has now been corrected in line with IPCC default values.

Woody GL to CLannual (AtVf, Tf, Jn to Ag)

It is assumed a loss of the mean LB in GLwoody in the year of conversion, i.e. 6.4 tC/ha; and a gain of LB in CLannual (Ag) in the year of conversion. Afterwards, C stock in LB is assumed in equilibrium, in line with IPCC 2006.

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) in for 20 years, until maturity is reached, equal to 0.425 tC/ha/year. Afterwards, C stock in LB is assumed in equilibrium. In previous submissions, the gain of LB in CLperennial (Lv, Vv, Ata) was assumed to occur only in the year of conversion. This has been corrected in the current submission. In previous submissions, the CSC in LB in conversions from GLgrassy to Ata were estimated as those of conversions to Ag.

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 in for 20 years, until maturity is reached, equal to 0.425 tC/ha/year. Afterwards, C stock in LB is assumed in equilibrium. In previous submissions, the gain of LB in CLperennial was assumed to occur only in the year of conversion. This has been corrected in the current submission. In previous submissions, the CSC in LB in conversions from Tf or Jn to Ata were assumed to produce a loss of 4.7 tC/ha in the year of conversion. This has been corrected in the current submission and are estimated as described above. In addition, in previous submissions, the same LB was considered for all grassland types, 0.85 tC/ha, this has now been updated to differentiate between grassy and woody grassland.

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 to annual 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 for the next 20 years when the crop will reach maturity. In previous submissions, these estimates - Lv, Vv and Ata to WL - were reported under OL to CL. This has been corrected in the current submission.

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 the LB in the new perennial cropland occurs until it reaches maturity, 20 years, equal to 0.425 tC/ha/year. It is assumed that LB in settlements is 0, so there is not loss of LB. In previous submissions, the gain of LB in perennial cropland was assumed equal to that in annual cropland. This has been corrected in the current submission.

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 the LB in the new perennial cropland occuring until it reaches maturity, 20 years, equal to 0.425 tC/ha/year. It is assumed that LB in Other land is 0, so there is not loss of LB. In previous submissions, the gain of LB in perennial cropland was assumed equal to that in annual cropland. This has been corrected in the current submission.

6.3.2.2.2 Changes of carbon stock in dead organic matter carbon pool

CSC in dead organic matter is only estimated for the conversions of Tf and Jn to Ag or Ata. It is considered all DOM is loss in the year of conversion, and no C is gain afterwards. It is assumed a loss in the year of conversion of -8.175 tC/ha.

6.3.2.2.3 Changes of carbon stock in soil carbon pool

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 (2006)*. The C stock changes are assumed to occur during the IPCC default 20 - year period. 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).

6.3.2.2.4 Biomass burning

Romania chose to use the NO notation key, because this kind of activities doesn’t happen in Cropland remaining or and land converted to Cropland.

6.3.3 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 activity data uncertainty associated with the 4.B.1 and 4.B.2 land use categories are related to the uncertainty of the associated land use data. It has been assumed that the uncertainty of the land use data is ±10% and this assumption is based on expert judgement as a consequence of the reduction from the previous uncertainty value of ±30%. The use of spatial information based on a periodically updated 1:5000 map connects the activity data to other than the pure statistical calculus that we had previously. On one hand, the source of LPIS/IACS maps covering most of the territory of interest and brings accuracy and consistency to the reported areas (0.5 ha minimum mapping unit), and the influence of the CLC service completes the scene with high-precision mapping, in assuming uncertainty. It should be noted that the accuracy of the information is increased, as the activity data generated by LPIS/IACS technology are validated by statements of farmers who assume the categories of land use.

Emission factor uncertainty

The emission factor uncertainty associated with 4.B land use category is related to the uncertainty of the applied carbon stock and stock change factors. The associated uncertainty for biomass in 4.B land use category has been assumed to be ±75% based on the default IPCC value *(IPCC 2006, V4, Ch. 2, Section 5.2.1.5)*. Additional analysis is required in order to assess the uncertainty of the applied country-specific factors. Therefore, as a temporary measure, an uncertainty factor of ±100% has been assumed. This represents the highest uncertainty factor that can be applied in approach 1 propagation of errors uncertainty analysis, as symmetrical uncertainty is assumed.

Table 6.31 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**	1.005	0.020	0.107	0.015	0.000
4B2	**CO_2**	1.005	0.003	0.041	0.006	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**	1.005	0.000	0.000	0.000	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	N_2O	1.005	0.000	0.000	0.000	0.000

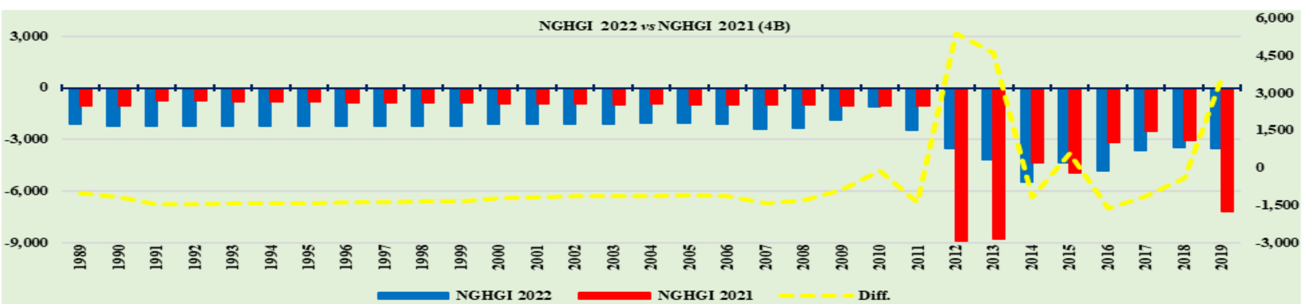
6.3.4 *Source specific QA/QC and verification, if applicable*

(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 CRF tables and NIR chapters.

6.3.5 *Category-specific recalculations, including changes made in response to the review process and impact on emission trend*

The specific recalculations in the CL land use categories are summarized in the following figure:

Figure 6.22 Quantification of recalculations performed in 1989-2019 time period (kt CO_2 eq.)



The changes in absolute values of the GHG emission/removal levels, Figure 6.22, are due to a basket of variables/drivers, respectively: ***(i)*** explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies, detailed in Chapter 6.3.1., paragraph *Combining, processing and querying information*; ***(ii)*** estimation of EF, soil carbon pool, detailed in Table 6.29; ***(iii)*** re-estimation of the parameters specific to carbon pools, LB and DOM, detailed in Chapters 6.3.2.1 and 6.3.2.2; ***(iv)*** re-estimation of direct N_2O emissions from the mineralization of organic carbon in the soil, *Land converted to cropland*. For GL and WL land use categories converted to CL, N_2O emissions from mineralization were not related to CSC in mineral soils.

Given the equation 11.8 *(IPCC 2006)* which allows the estimation of direct N_2O emissions from the mineralization of organic carbon in the soil and the use of a C/N = 15 ratio, we had to reach an EF of about 1 kg N_2/tC lost by the mineral soil. The recalculation affected 1970-2020 time period for the CL. The impact of the above changes on the time trend has generated negative emissions, removals. All these methodological changes have resulted in reduced emissions for the entire time period, 1989-2019, compared with the previous submission. The reasons and justifications for the category-specific recalculations are to mainly improve accuracy and consistency.

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

As part of the improvement plan of NGHGI, Romania will continue its efforts to improve GHG E(+)/R(-) estimation associated with CL to complete adaptation to the latest methodologies. Further investigation is planned into the:

(i) interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period;

(ii) methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete;

(iii) review of SOC parameters in CL; not all transitions are estimated and the values used for the land use Ata were not transparent; update and revise calculations in the SOC carbon pool, where necessary. To improve the country specific estimates for emission factors, during 2022 year will be measured soil organic carbon in mineral soils in selected survey areas. This will allow to refine the CS parameters developed in 2020-2021 years;

(iv) estimation of the country specific emission factors for the soil carbon pool in organic soils, during 2022 year, will use measured data by estimating the response ratio of the measured SOC values in comparison with the reference SOC values. The soil organic carbon content in organic soils in selected survey areas will be measured*;*

(v) additional QA/QC elements to prevent issues like time series inconsistency that regard AD(kha), in compliance with 20 year transition period.

6.4 Grassland (CRF 4.C)

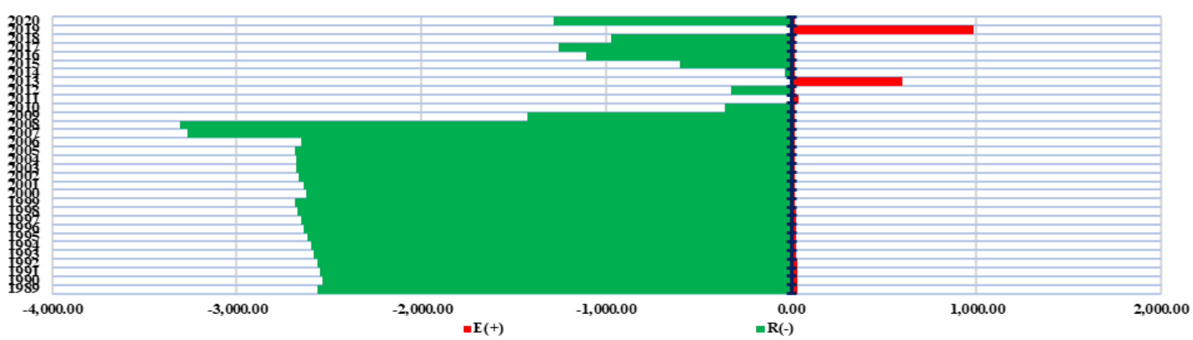
6.4.1 Category description

The 4.C land use category includes pastures, pasture with spares trees, hayfields, other land with forest vegetation; pinus mugo shrubs; shrubs, Figure 6.23. The calculations of GHG E(+)/R(-) estimates were made for all individual years from 1989 to 2020, for the 4.C.1 and 4.C.2 and related sources/sinks.

Figure 6.23 4.C land use category. EGM - explicit geospatial map

The following figure include a 4.C summary of the 1989-2020 time series GHG E(+)/R(-) estimates:

Figure 6.24 4.C GHG E(+)/R(-) evolution in 1989-2020 time period (kt CO_2 eq.)

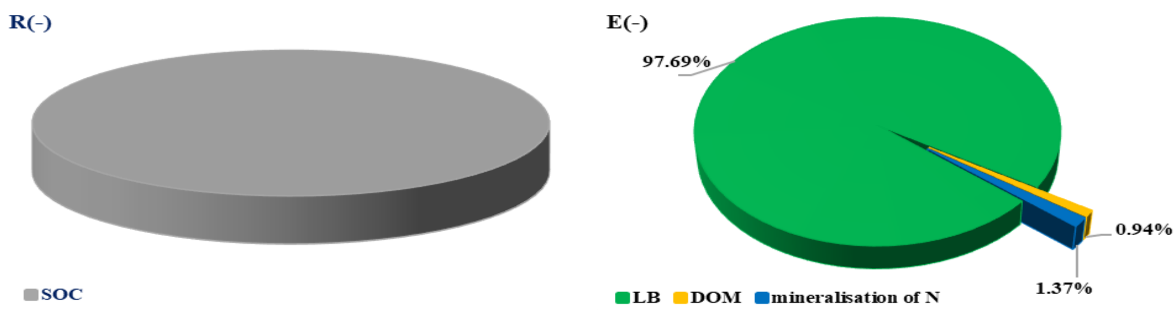


Under this category, CO_2 emissions from LB, soils and DOM have been reported. Grassland category is responsible for -1,270.41 kt of CO_2 net removals in 2020, sharing 3.40 % of total GHG E(+)/R(-) estimates from grassland remaining grassland and land converted to grassland as key categories. As in the 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*.

6.4.2 Methodological issues

The following figure shows the C stock changes by carbon pools:

Figure 6.25 4.C 2020. E(+)/R(-) distribution in carbon pools



6.4.2.1 Grassland remaining Grassland (CRF sector 4.C.1)

The C stock in LB and DOM of Grassland remaining in the same subcategory for more than 20 years is assumed 0. The GHG E(+)/R(-) estimates are explained below:

6.4.2.1.1 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 a gain of LB in the conversion from grassy to woody grassland along 20 years, *IPCC default period*, equal to 0.425 tC/ha/year. It is assumed a loss of the LB in the grassy grassland in the year of conversion equal to 2.87 tC/ha. In previous years, a difference in C stock of 3.58 tC/ha (4.43-0.85) was applied to the accumulated areas. This has been updated in the current submission, with the LB on the annual area converted, lost in the year of conversion and the same assumptions for perennial cropland are applied to woody grassland.

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 are lost in the year of conversion). 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. In previous years, a difference in C stock of -3.58 tC/ha (-4.43+0.85) was applied. This has been updated in the current submission.

6.4.2.1.2 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*.

6.4.2.1.3 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. So apply 45 tC/ha to GL as well, also for grassy and for woody; EFs are for GL as a whole. SOC in GL remaining was not estimated in previous submissions.

Table 6.32 4.C.1 parameters developed for the soil carbon pool

	SOC_{ref} tC/ha	**F_{LU}**	**F_{MG}**	**F_I**	**SOC tC/ha**
1990 value	**45**	**0.70**	**0.95**	**0.92**	**27.53**
1990 assumption	CS, (under native vegetation) soil organic C stocks (SOC_{ref}) for mineral soils (tC/ha^{-1} in 0-30 cm depth) instead of IPCC 2006 Table 2.3.	ICPA: Technical-scientific Report prepared for the National Authorities of Romania, NEPA and MEWF: Methodology for estimating emission factors used in the calculation of the annual change in the stock of organic carbon in mineral soils under the Grassland category - ICPA Technical Report, November 2021.	IPCC 2006 Table 6.2 moderately degraded grassland - temperate	ICPA: Technical-scientific Report prepared for the National Authorities of Romania, NEPA and MEWF: Methodology for estimating emission factors used in the calculation of the annual change in the stock of organic carbon in mineral soils under the Grassland category - ICPA Technical Report, November 2021.	$SOC_{ref}*F_{LU}-F_{MG}*F_I$
2020 value	**45**	**0.70**	**1.14**	**0.92**	**33.04**

	SOC_{ref} tC/ha	F_{LU}	F_{MG}	F_I	SOC tC/ha
2020 assumption	CS, (under native vegetation) soil organic C stocks (SOC_{ref}) for mineral soils (tC/ha^{-1} in 0-30 cm depth) instead of IPCC 2006 Table 2.3.	Technical-scientific Report prepared for the National Authorities of Romania, NEPA and MEWF: Methodology for estimating emission factors used in the calculation of the annual change in the stock of organic carbon in mineral soils under the Grassland category - ICPA Technical Report, November 2021	IPCC 2006 Table 6.2 improved grassland - temperate	ICPA: Technical-scientific Report prepared for the National Authorities of Romania, NEPA and MEWF: Methodology for estimating emission factors used in the calculation of the annual change in the stock of organic carbon in mineral soils under the Grassland category- ICPA Technical Report, November 2021.	$SOC_{ref}*F_{LU}-F_{MG}*F_I$

The overlapping explicit geospatial maps with the polygons that delimit the types of soils in Romania, led to the evaluation of AD(kha) 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 6.3.2.1.3. 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*.

6.4.2.1.4 Biomass burning

The burning of Grassland residues occurs to some minor extent in Romania. 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. Non-CO_2 emissions from biomass burning are included in Agriculture sector - 3F category.

6.4.2.2 Land converted to Grassland (CRF sector 4.C.2)

6.4.2.2.1 Changes of carbon stock in biomass carbon pool

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)

In the case of annual cropland to woody grassland (*AtVf, Jn and Tf*), it is assumed a loss of the LB in the annual cropland, 5 tC/ha, and an accumulation of the LB in grassland for the next 20 years, 0.425 tC/ha/year. In previous submissions, both the loss and the total gain was considered for a 20 years period, by using the accumulated areas for the calculation. This has been corrected in the current submission, and just 0.425 tC/ha is gained each year for a 20 years period; the loss of LB in the annual cropland only occurs in the year of transition.

Perennial cropland to grassy grassland (Vv, Lv, Ata to Pp, Pf, Pa)

In the case of Ata, Lv and Vv it is assumed a loss of the mean LB in the perennial cropland and a gain of the LB in the new grassland, in the year of conversion, -6.4 tC/ha + 2.87 tC/ha. Afterwards, the C in LB is assumed in equilibrium. In the previous submissions, in the case of Ata it was assumed a loss of the LB in the annual cropland and a gain of the LB in grassland, in the year of conversion. This has been corrected in the current submission.

Perennial cropland to woody grassland (Vv, Lv, Ata to Jn, Tf, AtVf)

For Lv, Ata and Vv to AtVf, Jn and Tf it is assumed that 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 for a 20 years period, 8.5 tC/ha/20 years = 0.425 tC/ha/year. In previous submissions, it was assumed no change in LB due to the conversion, as the LB in previous and new land use is the same. However, it needs to be considered that the loss is due to an abrupt change that happens in the year of conversion, while the gain is due to a continuous gain for a 20 years period. In addition, as part of the current submission, new CSC factors have been applied for the gain and loss of perennial cropland and woody grassland based on the IPCC 2019 Refinement. In previous years, there was an inconsistency between the LB for AtVf considered in conversions from AtVf to CL, where a loss of 0.85 tC/ha is considered, and the LB considered for conversions from CL to AtVf, where a gain of 4.43 tC/ha is considered. This has been corrected in the current submission.

Wetlands converted to grassland

In previous years, it was assumed that there was no change in C stock in LB due to conversion from Wetlands to Grasslands, since the LB in Wetlands was considered equal to the LB in Grasslands, 0.85 tC/ha, and any loss and gain of this LB was assumed to happen in the year of conversion. These assumptions have now been reviewed.

Wetlands to grassy grassland (ZuA, ZuV to Pp, Pf, Pa)

In previous years, it was assumed that there was no change in C stock in LB due to conversion from Wetlands to Grasslands, since the LB in Grassland was considered equal to the LB in Wetlands and any loss and gain of this LB was assumed to happen in the year of conversion. This has now been corrected for conversions of ZuA to grassy grassland where 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. The LB in the new woody grassland is gained along a 20 years period, 8.5 tC/ha / 20 years = 0.425 tC/ha/year.

Settlements converted to grassland

Settlements to grassy grassland (AU to Pp, Pf, Pa)

It is assumed that there is no LB in settlements and that the gain in LB in grassy grassland occurs in the year of conversion only, i.e. 2.87 tC/ha.

Settlements to woody grassland (AU to Jn, Tf, AtVf)

It is assumed that there is no LB in settlements and that the gain in LB in woody grassland occurs along a 20 years period, 8.5 tC/ha / 20 years = 0.425 tC/ha/year. In previous years it was assumed that the LB in grassland was 0.85 tC/ha, this being inconsistent with the estimates of other conversion to woody grasslands; it was also considered that any loss or gain occured in the year of conversion only. This has been corrected for the current submission, using 8.5 tC/ha as the value for LB in woody grassland and assuming a gain along years.

Other lands converted to grassland

Other lands to grassy grassland (AT to Pp, Pf, Pa)

It is assumed a gain of C in LB, in the new grassy grassland, in the year of conversion equal to 2.87 tC/ha. It is assumed that there is no LB in Other lands and therefore this conversion will result in no loss in LB.

Other lands to woody grassland (AT to Jn, Tf, AtVf)

It is assumed that there is no LB in other lands and that the gain in LB in woody grassland occurs along a 20 years period, 8.5 tC/ha / 20 years = 0.425 tC/ha/year. In previous submissions it was assumed that the LB in grassland was 0.85 tC/ha, this being inconsistent with the estimates of other conversion to woody grasslands; it was also considered that any loss or gain occurs in the year of conversion. This has been corrected in the current submission, using 8.5 tC/ha as the value for LB in woody grassland and assuming a gain along a 20 years period.

6.4.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in dead organic matter is only estimated for the conversions of Tf and Jn to Ag or Ata; and for the conversions of AtVf to ZuV, AU and AT. It is considered that all DOM is loss in the year of conversion, and no C is gain afterwards. It is assumed a loss in the year of conversion of -8.175 tC/ha.

6.4.2.2.3 Change of carbon stock in soil carbon pool

Romania developed in a research-development project, *Monitoring soil quality in Romania*, 2006, national reference of C stocks in mineral soils, assuming 20 years transition period. The area of the mineral soils was calculated as the difference between the national total areas and the areas covered by organic soils. The C stocks and the C stock changes of mineral soils in land converted to GL categories are detailed in Chapter 6.1.4.3, Table 6.10.

6.4.2.2.4 Biomass burning

Romania chose to use the NO notation key, because this kind of activities doesn’t happen in Grassland remaining or and land converted to Grassland.

6.4.3 Uncertainties 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 6.1.5 and 6.3.3.

Table 6.33 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**	1.005	0.001	0.024	0.003	0.000
4C2	**CO_2**	1.005	0.000	0.006	0.001	0.000
4C1	**CH_4**	0.000	0.000	0.000	0.000	0.000
4C2	**CH_4**	0.000	0.000	0.000	0.000	0.000
4C1	**N_2O**	1.005	0.000	0.000	0.000	0.000
4C2	**N_2O**	1.005	0.000	0.000	0.000	0.000

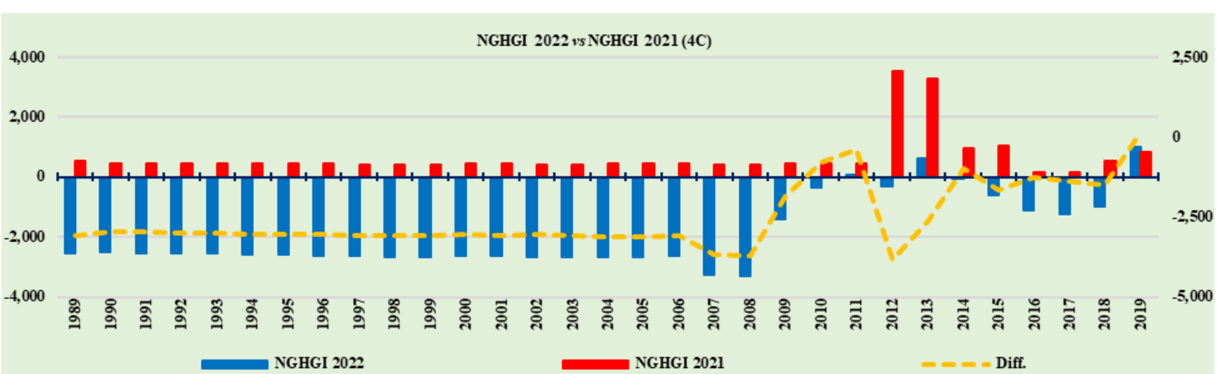
6.4.4 Source specific QA/QC and verification, if applicable

(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 CRF tables and NIR chapters.

6.4.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

The specific recalculations in the GL land use categories are summarized in the following figure:

Figure 6.26 Quantification of recalculations performed in 1989-2019 time period (kt CO_2 eq.)



The changes in absolute values of the GHG emission/removal levels, Figure 6.26, are due to a basket of variables/drivers, respectively: ***(i)*** explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies, detailed in Chapter 6.3.1., paragraph *Combining, processing and querying information*; ***(ii)*** for soil carbon pool, estimation of EF as country specific parameters, detailed in Table 6.32; ***(iii)*** re-estimation of the parameters specific to carbon pools, LB and DOM, detailed in *Chapters 6.4.2.1 and 6.4.2.2*. The impact of the above changes on the time trend has generated negative emissions, removals. All these methodological changes have resulted in reduced emissions for the entire time period, 1989-2019, compared with the previous submission. The reasons and justifications for the category-specific recalculations are to mainly improve accuracy and consistency.

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

As part of the improvement plan of NGHGI, Romania will continue its efforts to improve GHG E(+)/R(-) estimation associated with GL to complete adaptation to the latest methodologies. Further investigation is planned into the:

(i) interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period;

(ii) methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete;

(iii) Update and revise calculations in the SOC pool, where necessary. To improve the country specific estimates for emission factors, during 2022 year will be measured soil organic carbon in mineral soils for Grassland category in selected survey areas. This will allow to refine the CS parameters developed in 2021 year. Also, for estimation of the country specific emission factors (FInput), the methodology for evaluation at the Territorial Administrative Unit level of the production and processing potential in agriculture will be used;

(iv) estimation of the country specific emission factors for the soil carbon pool in organic soils, during 2022 year will use measured data by estimating the response ratio of the measured SOC values in comparison with the reference SOC values. Will be measured the soil organic carbon content in organic soils, in selected survey areas;

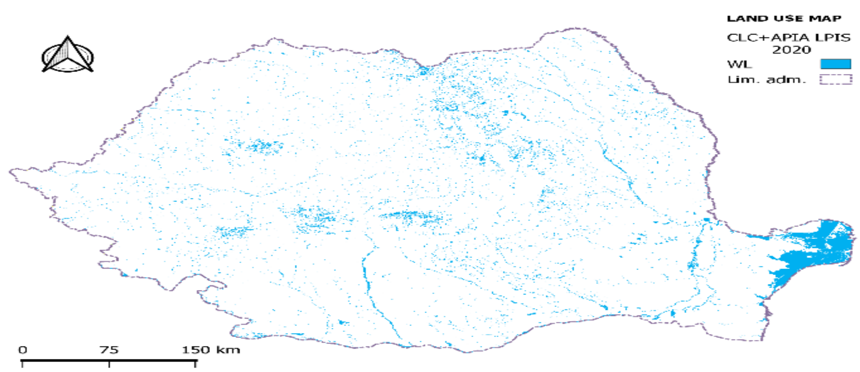
(v) additional QA/QC elements to prevent issues like time series inconsistency that regard AD(kha), in compliance with a 20 years transition period.

6.5 Wetlands (CRF 4.D)

6.5.1 Category description

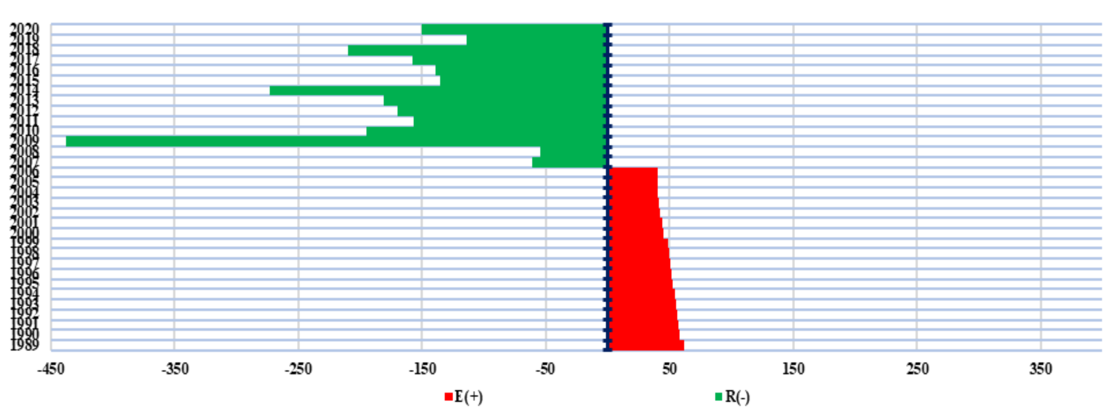
The 4.D category includes wet areas with vegetation, waters / ponds, Figure 6.27, and GHG E(+)/R(-) estimates are reported. The calculations were made for all individual years from 1989 to 2020 years for the subcategories and related sources/sinks. Under this category, GHG E(+)/R(-) from living biomass, soil and dead organic matter have been reported. Due to the use of 3 approach type, taken into account for GHG E(+)/R(-) estimates, the methodology detailed in Chapter 6.3.1, paragraph *Combining, processing and querying information*, the Wetlands category has changed its source behavior in sink, being responsible for -149.96 kt CO_2 in 2020, representing 0.40 % of total GHG E(+)/R(-) estimates.

Figure 6.27 4.D land use category. EGM - explicit geospatial map



The following figure include a 4.D summary of the 1989-2020 time series GHG E(+)/R(-) estimates:

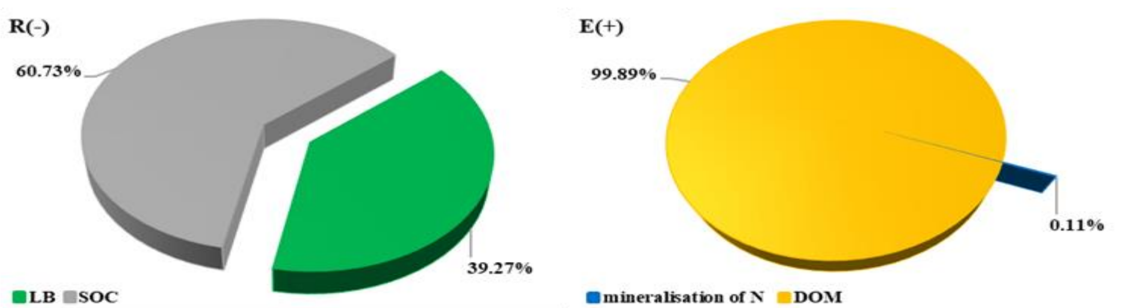
Figure 6.28 4.D GHG E(+)/R(-) evolution in 1989-2020 time period (kt CO_2 eq.)



6.5.2 Methodological issues

The following figure shows the C stock changes by carbon pools:

Figure 6.29 4.D 2020. E(+)/R(-) distribution in carbon pools



6.5.2.1 Wetland remaining Wetland (CRF 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 is assumed to purely be a loss equal to 2.87 tC/ha in the year of conversion only. In previous submissions, it was assumed that there is no CSC in LB conversions between different types of WL or in WL remaining in the same subcategory. 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.

6.5.2.2 Land converted to Wetland (CRF sector 4.D.2)

6.5.2.2.1 Changes of carbon stock in biomass carbon pool

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 but for conversions to ZuV, a gain in LB equal to 2.87 tC/ha is assumed in the year of conversion only. In previous submissions the LB loss was assumed 4.43 tC/ha.

This has been updated in the current submission to 5 tC/ha, so it is consistent with estimates of other conversions.

Perennial cropland to wetlands (Vv, Lv, Ata to ZuA, ZuV)

It is assumed that the mean LB in cropland is lost, 6.4 tC/ha, and that the LB in grassy wetland is gained, 2.87 tC/ha, in the year of conversion only. There is no gain in C associated with ZuA. In previous submissions, gain was not estimated in the conversion form Ata to WL. This has been updated in the current submission to treat Ata as perennial cropland.

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 2.87 tC/ha. For conversions to grassy wetlands, a gain in LB is assumed in the first 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 only a loss in LB of 2.87 tC/ha. Previously, it was assumed CSC in LB in conversions of grassy grassland to wetlands is 0, consistently with the assumption of CSC in conversions from wetlands to grassy grasslands.

Woody grasslands to wetlands (Jn, Tf, AtVf to ZuA, ZuV)

For AtVf, Tf and Jn, it is assumed a loss of the mean LB in previous grassland, 6.4 tC/ha, and a gain of LB in grassy wetlands, 2.87 tC/ha, in the year of conversion. No gain in LB is assumed to occur for conversions to ZuA. In previous submissions for AtVf, it is assumed a loss of LB in the previous grassland, -314*0.52*0.5*1.18, and a gain of the LB in the new wetland, 0.85 tC/ha, in the year of conversion. This has been corrected in this submission and treat AtVf the same as other woody grassland subcategories.

Settlements converted to wetlands (AU to ZuA, ZuV)

It is assumed a gain of the LB in ZuV wetlands 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)

For ZuV, it is assumed a gain of the LB in the new wetlands in the year of conversion (2.87 tC/ha). For ZuA, no gain in LB is assumed. No loss in LB is associated with conversions from Other land.

6.5.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in dead organic matter is only estimated for the conversion of AtVf to ZuV.

It is considered all DOM is loss in the year of conversion, and no C is gain afterwards. It is assumed a loss in the year of conversion of -8.175 tC/ha.

6.5.2.2.3 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 for Wetlands mineral soils is 40 tC/ha, Chapter 6.2, Table 6.26. The area of the mineral soils was calculated as the difference between the national total areas and the areas covered by organic soils. Because the majority of Wetlands in Romania occur on mineral soils, similar C stock was assumed as for Grassland. The C stocks and the C stock changes of mineral soils in land converted to WL categories are detailed in Chapter 6.1.4.3, Table 6.10. The level of the organic soil surface, AD(kha), 98.42 kha, was evaluated according to the methodology described in the Chapter 6.3.2.1.3 and represents the most important area of organic soil among all the land use categories in the LULUCF Sector.

6.5.2.2.4 Biomass burning

The Party chose to use the notation key NO, because this kind of activities doesn’t happen in Wetlands remaining or land converted to Wetlands.

6.5.3 Uncertainties 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 6.1.5.

Table 6.34 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**	0.300	0.000	0.000	0.000	0.000
4D2	**CO_2**	0.300	0.000	0.004	0.002	0.000

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	**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**	3.015	0.000	0.000	0.000	0.000
4D2	**N_2O**	3.015	0.000	0.000	0.000	0.000

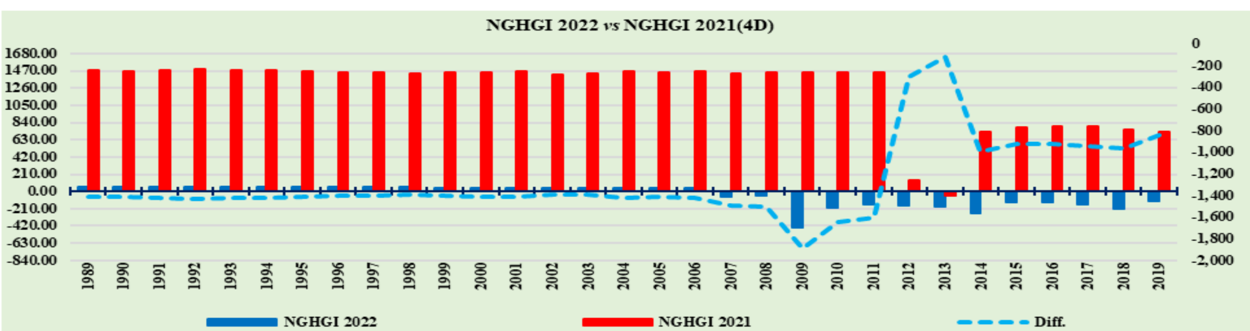
6.5.4 Source specific QA/QC and verification, if applicable

(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 CRF tables and NIR chapters.

6.5.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

The specific recalculations in the WL categories are summarized in the following figure:

Figure 6.30 Quantification of recalculations performed in 1989-2019 time period (kt CO_2 eq.)



The changes in absolute values of the GHG emission/removal levels, Figure 6.30, are due to a basket of variables/drivers, respectively: ***(i)*** explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2007-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies, detailed in Chapter 6.3.1, paragraph *Combining, processing and querying information*; ***(ii)*** re-estimation of the parameters specific to carbon pools, LB and DOM, detailed in Chapters 6.5.2.1 and 6.5.2.2. The impact of the above changes on the time trend has generated negative emissions, removals. All these methodological changes have resulted in reduced emissions for the entire time period, 1989-2019, compared with the previous submission. The reasons and justifications for the category-specific recalculations are to mainly improve accuracy and consistency.

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

As part of the improvement plan of NGHGI, Romania will continue its efforts to improve GHG E(+)/R(-) estimation associated with WL to complete adaptation to the latest methodologies. Further investigation is planned into the:

(i) interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period;

(ii) methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete;

(iii) update and revise calculations in the SOC carbon pool, where necessary;

(iv) estimation of the country specific emission factors for the soil carbon pool in organic soils, during 2022 year will use measured data by estimating the response ratio of the measured SOC values in comparison with the reference SOC values. Will be measured the soil organic carbon content in organic soils, in selected survey areas;

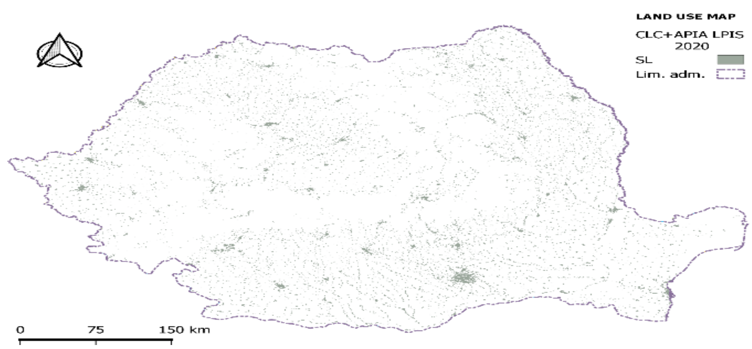
(v) additional QA/QC elements to prevent issues like time series inconsistency that regard AD(kha), in compliance with a 20 year transition period.

6.6 Settlements (CRF 4.E)

6.6.1 Category description

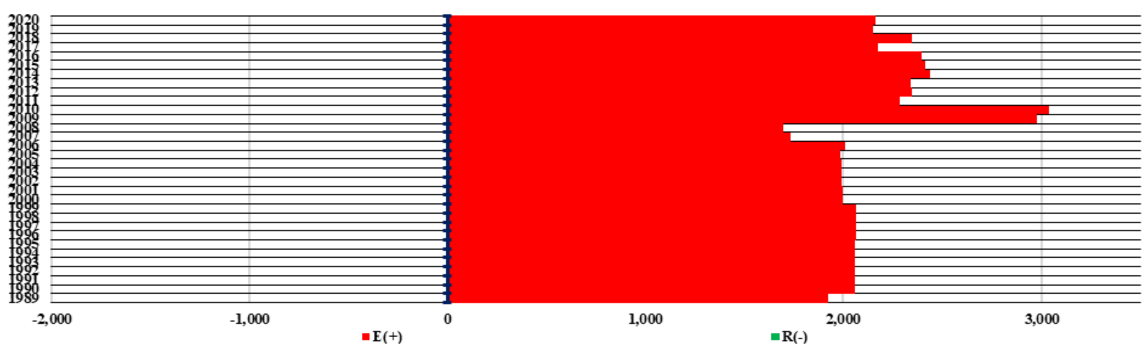
The calculations of the GHG E(+)/R(-) estimates were made for all individual years from 1989 to 2020, for the subcategories and related sources/sinks. Under this category, GHG E(+)/R(-) estimates from LB, Soil and DOM have been reported. The type 3 approach was considered for GHG E(+)/R(-) estimates, according to the methodology detailed in Chapter 6.3.1, paragraph *Combining, Processing and Querying Information*. The Settlements category, Figure 6.31, mentains its source behavior, being responsible for 2161.24 kt CO_2 in 2020 year, representing 5.78 % of total GHG E(+)/R(-) estimates.

Figure 6.31 4.E land use category. EGM - explicit geospatial map



The following figure include a 4.E summary of the 1989-2020 time series GHG E(+)/R(-) estimates:

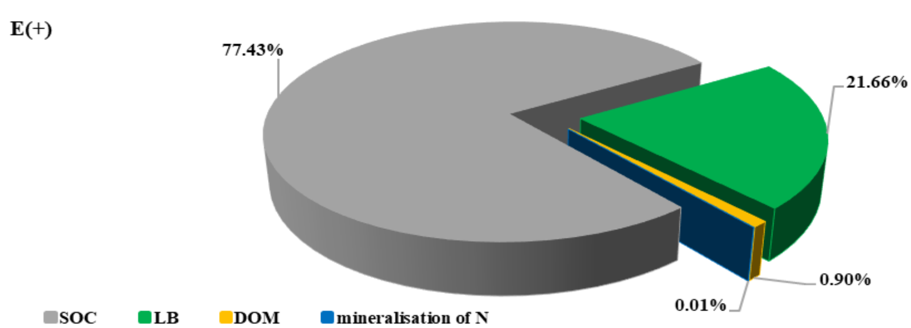
Figure 6.32 4.E GHG E(+)/R(-) evolution in 1989-2020 time period (kt CO_2 eq.)



6.6.2 Methodological issues

The following figure shows the C stock changes by carbon pools:

Figure 6.33 4.E 2020. E(+)/R(-) distribution in carbon pools



6.6.2.1 Settlements remaining Settlements (CRF sector 4.E.1)

It is assumed no CSC in LB, DOM or SOC in Settlements remaining.

6.6.2.2 Land converted to Settlement (CRF sector 4.E.2)

6.6.2.2.1 Changes of carbon stock in biomass carbon pool

Cropland converted to settlements

Annual cropland to settlements (Ag to AU)

It is assumed that the loss of LB in cropland annual in the year of conversion, 5 tC/ha. No gain in LB is associated with conversion to settlements.

Perennial cropland to settlements (Vv, Lv, Ata to AU)

For Ata, Vv and Lv, it is assumed that the loss of LB in cropland perennial in the year of conversion is equal to the mean LB for perennial cropland, 6.4 tC/ha. No gain in LB is associated with conversion to settlements.

Grassland converted to settlements

Grassy grasslands to settlements (Pp, Pf, Pa to AU)

It is assumed the loss of LB in grassland grassy in the year of conversion, 2.87 tC/ha. Previously, the loss in LB was assumed to be 0.85 tC/ha. No gain in LB is associated with conversion to settlements.

Woody grasslands to settlements (Jn, Tf, AtVf to AU)

For Jn, Tf and AtVf it is assumed that the loss of LB in grassland, in the year of conversion is equal to the mean LB for perennial cropland, 6.4 tC/ha. No gain in LB is associated with conversion to settlements.

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 only, equal to 2.87 tC/ha. No gain in LB is associated with conversion to settlements. It is assumed no gain or loss in LB for wetlands - waters/ponds, ZuA.

Other lands converted to settlements *(AT to AU)*

It is assumed no C in LB in SL, therefore there is no CSC in LB in conversion from OL to SL.

6.6.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in dead organic matter it is not estimated for the land use conversions to the SL.

It is considered that DOM is loss in the year of conversion, and no C is gain afterwards, detailed in Chapter 6.1.4.2, Table 6.9.

6.6.2.2.3 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. C stock in Settlements was estimated to be 32 tC/ha, Chapter 6.2, Table 6.26, assuming that the top 10 cm of the mineral soil of cropland has been removed; and assuming that the SOC is distributed uniformly in the top 10 cm of the mineral soil. The C stocks and the C stock changes of mineral soils in land converted to SL categories are detailed in Chapter 6.1.4.3, Table 6.10. The level of the organic soil surface, AD(kha), 0.50 kha, was evaluated according to the methodology described in the Chapter 6.3.2.1.3.

6.6.2.2.4 Biomass burning

Romania chose to use the NO notation key, because this kind of activities doesn't happen in Settlements remaining or land converted to Settlements.

6.6.3 Uncertainties 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 6.1.5.

Table 6.35 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**	0.300	0.000	0.000	0.000	0.000
4E2	**CO_2**	0.300	0.000	0.050	0.021	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

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	**N_2O**	3.015	0.000	0.000	0.000	0.000
4E2	**N_2O**	3.015	0.000	0.000	0.000	0.000

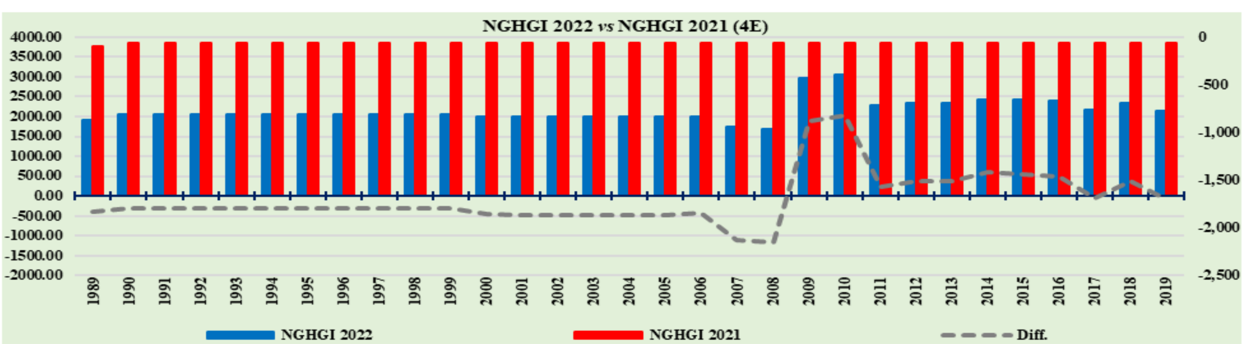
6.6.4 Source specific QA/QC and verification, if applicable

(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 CRF tables and NIR chapters.

6.6.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

The specific recalculations in the SL categories are summarized in the following figure:

Figure 6.34 Quantification of recalculations performed in 1989-2019 time period (kt CO_2 eq.)



The changes in absolute values of the GHG E(+)/R(-) levels, Figure 6.34, are due to a basket of variables/drivers, respectively: ***(i)*** explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies, detailed in Chapter 6.3.1., paragraph *Combining, processing and querying information*; ***(ii)*** re-estimation of the parameters specific to carbon pools, LB and DOM, detailed in Chapters 6.6.2.1 and 6.6.2.2. The impact of the above changes on the time trend has resulted in a 45% lower emission level compared to the previous submission. The reasons and justifications for the category-specific recalculations are to mainly improve accuracy and consistency.

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

As part of the improvement plan of NGHGI, Romania will continue its efforts to improve GHG E(+)/R(-) estimation associated with SL to complete adaptation to the latest methodologies. Further investigation is planned into the:

(i) interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period;

(ii) methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete;

(iii) update and revise calculations in the SOC pool, where necessary;

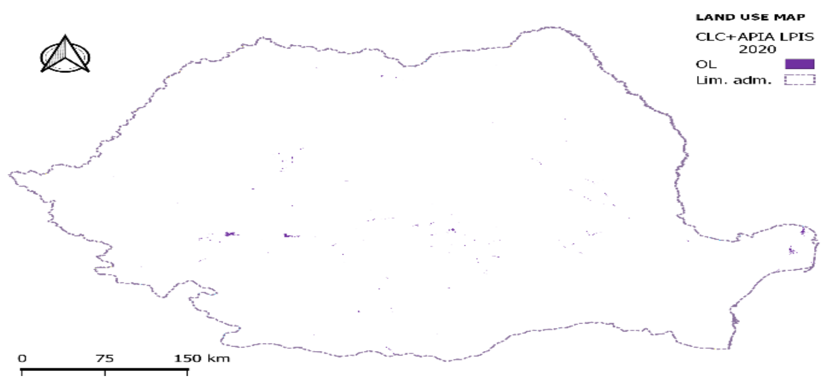
(iv) additional QA/QC elements to prevent issues like time series inconsistency that regard AD(kha), in compliance with a 20 year transition period.

6.7 Other lands (CRF 4.F)

6.7.1 *Catgory description*

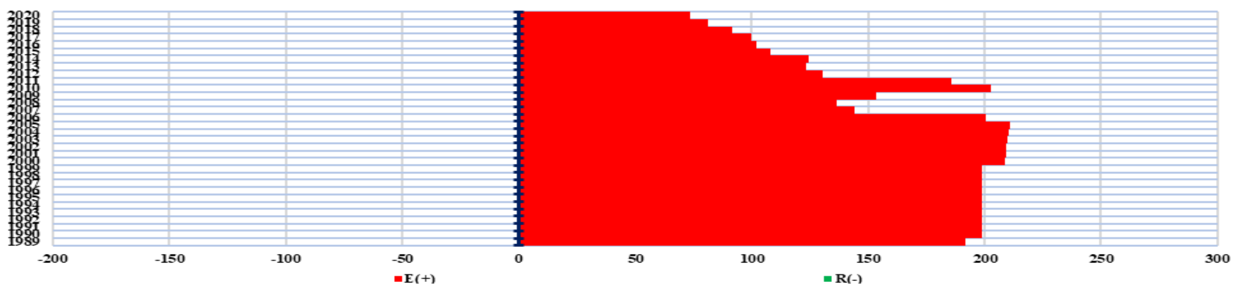
In the 4.F category, Figure 6.35, GHG E(+)/R(-) estimates are reported. The calculations were made for all individual years from 1989 to 2020 for the subcategories and related sources/sinks. Under this category, CO_2 emissions from living biomass, soil and dead organic matter have been reported. The 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 Other land use category mentains its source behavior, being responsible for 73.37 kt CO_2 in 2020 year, representing 0.20 % of total GHG E(+)/R(-) estimates.

Figure 6.35 4.F land use category. EGM - explicit geospatial map



The following figure include a 4.F summary of the 1989-2020 time series GHG E(+)/R(-) estimates:

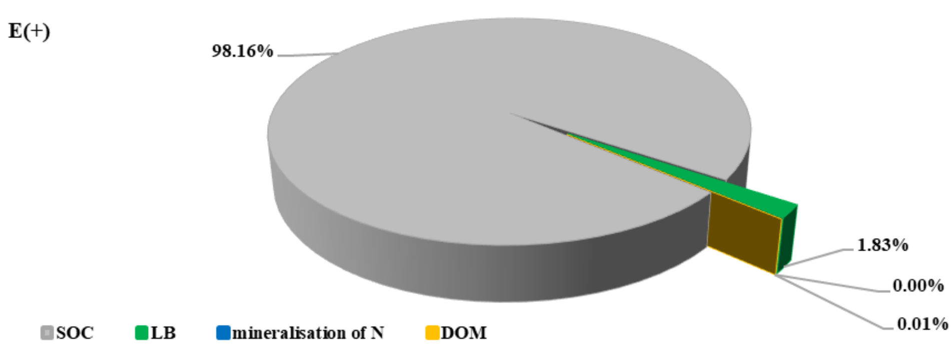
Figure 6.36 4.F GHG E(+)/R(-) evolution in 1989-2020 time period (kt CO_2 eq.)



6.7.2 Methodological issues

The following figure shows the C stock changes by carbon pools:

Figure 6.37 4.F 2020. E(+)/R(-) distribution in carbon pools



6.7.2.1 Other land remaining Other land (CRF sector 4.F.1)

It is assumed no CSC in LB, DOM or SOC in Other land remaining.

6.7.2.2 Land converted to Other land (CRF sector 4.F.2)

6.7.2.2.1 Changes of carbon stock in biomass carbon pool

Cropland converted to Other land

Annual cropland to Other land (Ag to AT)

For Ag it is assumed the loss of all C stock, -5 tC/ha, in the year of conversion only, annual area is used. No gain in LB is associated with conversions to Other land.

Perennial cropland to Other land (Vv, Lv, Ata to AT)

For Lv, Vv and Ata it is assumed the loss of the mean C stock, -6.4 tC/ha, in the year of conversion only, annual area is used. No gain in LB is associated with conversions to Other land.

Grassland converted to Other land

Grassy grasslands to Other land (Pp, Pf, Pa to AT)

For Pa, Pp, Pf all LB is lost in the year of conversion only, 2.87 tC/ha. In the previous submission, this value was assumed to be 0.85 tC/ha. No gain in LB is associated with conversions to Other land.

Woody grasslands to Other land (Jn, Tf, AtVf to AT)

For Jn, Tf, and AtVf the mean LB is lost in the year of conversion only, 6.4 tC/ha. No gain in LB is associated with conversions to Other land.

Wetlands converted to Other land *(ZuA, ZuV to AT)*

For ZuV all LB is lost in the year of conversion only , 2.87 tC/ha. No gain in LB is associated with conversions to Other land. For ZuA conversion to Other land, no CSC is assumed in LB.

Settlements converted to Other land *(AU to AT)*

It is assumed not LB in SL or OL, and therefore is no CSC.

6.7.2.2.2 Change of carbon stock in dead organic matter carbon pool

CSC in dead organic matter it is not estimated for the land use 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 6.9.

6.7.2.2.3 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, Chapter 6.2, Table 6.26. 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 C stocks and the C stock changes of mineral soils in land converted to OL categories are detailed in Chapter 6.1.4.3, Table 6.10. The level of the organic soil surface, AD(kha), 0.40 kha, was evaluated according to the methodology described in the Chapter 6.3.2.1.3.

6.7.2.2.4 Biomass burning

Romania chose to use the notation key NO, because this kind of activities does not happen.

6.7.3 Uncertainties 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 6.1.5.

Table 6.36 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**	0.300	0.000	0.000	0.000	0.000
4F2	**CO_2**	0.300	0.000	0.002	0.001	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**	0.300	0.000	0.000	0.000	0.000
4F2	**N_2O**	0.300	0.000	0.000	0.000	0.000

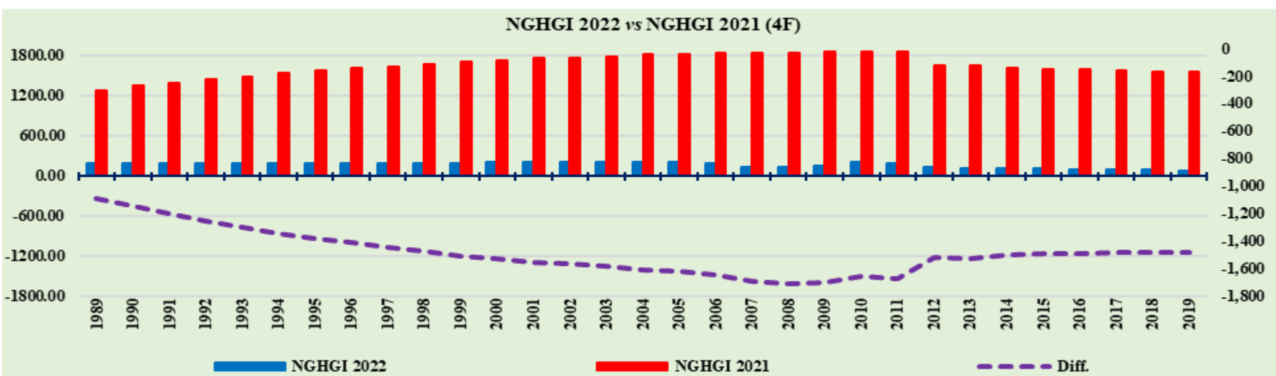
6.7.4 *Source specific QA/QC and verification, if applicable*

(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 CRF tables and NIR chapters.

6.7.5 *Category-specific recalculations, including changes made in response to the review process and impact on emission trend*

The specific recalculations in the OL categories are summarized in the following figure:

Figure 6.38 Quantification of recalculations performed in 1989-2019 time period (kt CO_2 eq.)



The changes in absolute values of the GHG emission/removal levels, Figure 6.38, are due to a basket of variables/drivers, respectively: ***(i)*** explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies, detailed in Chapter 6.3.1., paragraph *Combining, processing and querying information*; ***(ii)*** re-estimation of the parameters specific to carbon pools, LB and DOM, detailed in Chapters 6.7.2.1 and 6.7.2.2. The impact of the above changes on the time trend has significantly contributed to the major reduction in emissions/removals levels compared to the previous submission. The reasons and justifications for the category-specific recalculations are to improve accuracy.

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

As part of the improvement plan of NGHGI, Romania will continue its efforts to improve GHG E(+)/R(-) estimation associated with OL to complete adaptation to the latest methodologies. Further investigation is planned into the:

(i) interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period;

(ii) methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete;

(iii) update and revise calculations in the SOC pool, where necessary;

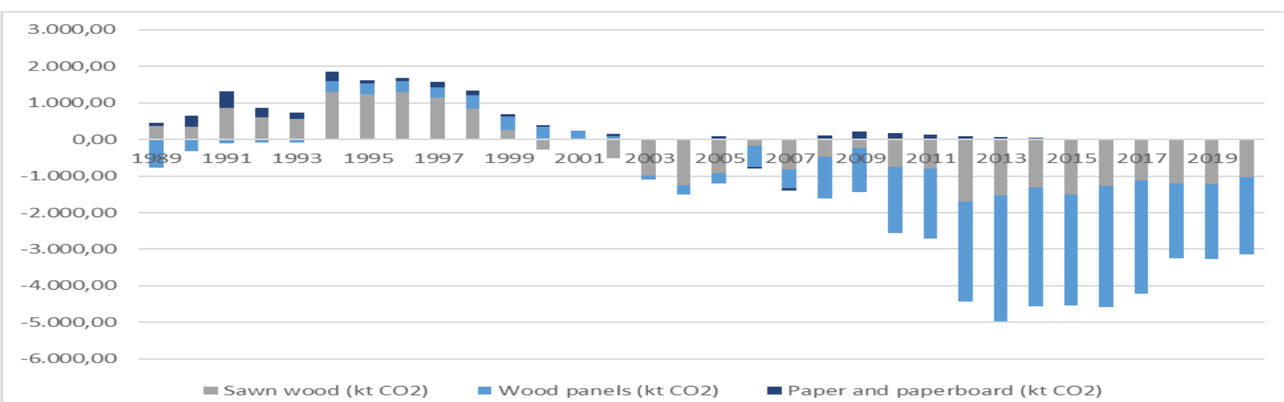
(iv) additional QA/QC elements to prevent issues like time series inconsistency that regard AD(kha), in compliance with a 20 year transition period.

6.8 Harvested wood products (CRF 4G)

6.8.1 Category description

The C stock change in the HWP pool is estimated based on the domestic consumption of wood products (i.e., production approach) and the application of the first-order decay function using equation 12.1 from the 2006 IPCC GL together with default half lifetime values as required by Equation 2.8.5 from the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol. The annual E(+)/ R(-) from the HWP for the 1989-2020 period is shown in Figure 6.39.

Figure 6.39 Net annual E(+)/ R(-) from the HWP for each product subcategory's 1989-2020 period



6.8.2 Methodological issues

The international database of Forestry Production and Trade of the Food and Agriculture Organization of the United Nations (FAOSTAT) was used to get AD to estimate the carbon stock change in the HWP pool: https://www.fao.org/faostat/en/#data/FO, interrogated in December 2021. Queried quantitative data from the database was retrieved regarding the internal production, exports, and imports from 1961, as shown in Table 6.37. 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 6.37 HWP values for volume or mass by category and type used to estimate the carbon stock

Type	*FAO code*	*Sub-category*	*Unit*	*1990*	*2000*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Production	**1866**	**Industrial Roundwood (Con)**	1000 m^3	3801	4587	4947	5632	5007	4550	4420	4869	4360	5571
	1867	**Industrial Roundwood (Broad)**	1000 m^3	6924	5530	5144	4839	5229	5402	5158	5568	5826	5376
	1632	**Sawn wood (Con)**	1000 m^3	1357	2077	3739	3704	4600	4339	4088	4067	3999	3980
	1633	**Sawn wood (Broad)**	1000 m^3	1554	1319	1793	1700	1700	1700	1600	1600	1600	1615
	1873	**Wood-based panel**	1000 m^3	1044	287	4810	4781	4991	5421	5181	3888	3904	4221
	1876	**Paper and paperboard**	m t	547	340	355	424	390	426	492	587	561	500
	1875	**Wood-PULP**	m t	481	293	0	0	0	0	0	0	0	0

Type	*FAO code*	*Sub-category*	*Unit*	*1990*	*2000*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Import	**1866**	**Industrial Roundwood (Con)**	1000 m^3	205	11	667	917	1644	1617	1169	1151	908	1600
	1867	**Industrial Roundwood (Broad)**	1000 m^3	215	10	68	91	149	152	309	113	81	43
	1875	**Wood-PULP**	m t	71	4	99	116	122	167	152	156	133	141
Export	**1866**	**Industrial Roundwood (Con)**	1000 m^3	0	234	373	214	73	28	20	8	10	21
	1867	**Industrial Roundwood (Broad)**	1000 m^3	2	297	108	112	96	57	98	83	97	98
	1875	**Wood-PULP**	m t	3	31	0	2	0	0	2	1	14	16

The annual volumes or mass of wood products were converted to carbon using Tier 2, i.e., applying first-order decay functions. The default conversion factor used (Table 6.38) to estimate the AD of carbon stock at the beginning of each year (C(i)) and the inflow of the HWP during each year (Inflow (i)) were taken from Table 2.8.1. of the 2013 KP Supplement. Finally, to estimate the carbon stock change during a year for Equation 2.8.5 from the 2013 KP Supplement, the half lifetime values were used from Table 2.8.2 from the same document (see Table 6.38).

Table 6.38 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 HWP C pools include products generated by wood production in the FL-FL category, whereas instant oxidation is assumed for the harvest in the FL-L category. Instant oxidation is also assumed for wood in solid waste disposal sites.

6.8.3 Uncertainties and time-series consistency

FAO data is used to estimate the AD series, for which a 15% uncertainty is assumed, and for calculating carbon conversion factors, a 50% uncertainty is considered. The total combined uncertainty is 52% for the HWP category.

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

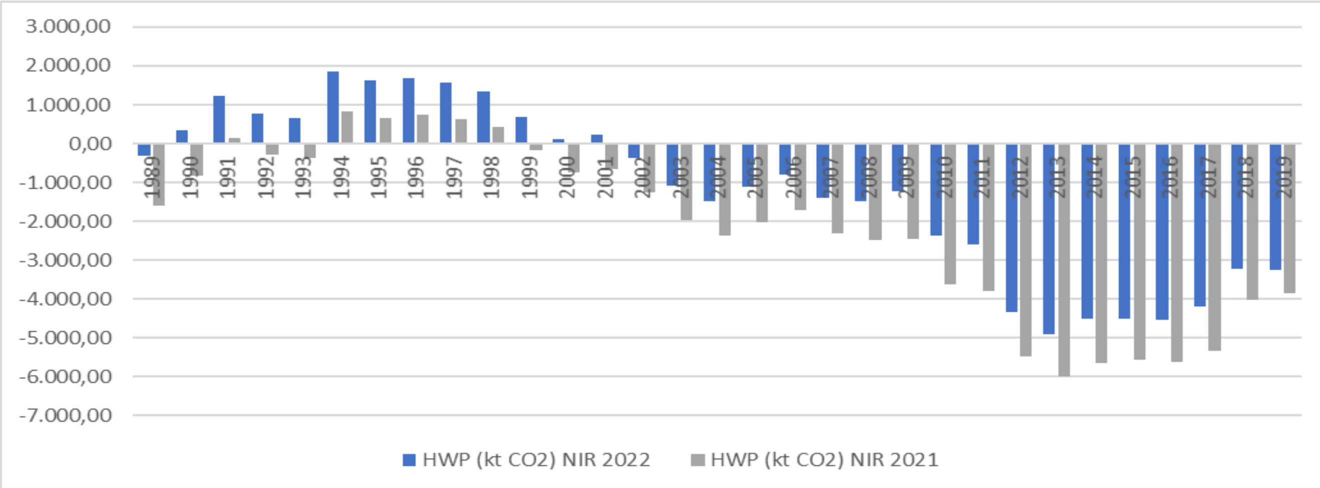
The CO_2 emissions from the HWP category were analyzed at the sector level by cross-check of various procedures to avoid errors associated with different data processing stages or calculations.

6.8.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

The methodology has been updated for the 2022 GHG inventory (i.e., the 2006 IPCC GL is applied in combination with emission factors from the 2013 KP Supplement. The AD data from FAO has been updated, and the annual fraction of feedstock for paper and paperboard was modified by applying Equation 2.8.2 of the 2013 KP Supplement. The default C conversion factor from the 2013 KP Supplement was different for sawn wood conifers and broadleaves.

The impact of the changes is reflected in Figure 6.40.

Figure 6.40 Comparison between net annual E(+)/ R(-) from the HWP for each product subcategory's 1989-2020 period



6.8.6 Category-specific planned improvements, if applicable (i.e., methodologies, activity data, emission factors, etc.), including those in response to the review process

During the inventory preparation and based on the discussion and recommendations from the UNFCCC review (ARR 2020), the following improvement were adopted:

4.G HWP - CO_2 (L.22, 2018) Accuracy "Use different carbon conversion factors for coniferous and non-coniferous species in order to more accurately estimate CO_2 emissions from the HWP pool and revise the reported estimates." In this submission, different conversion factors on sawn wood conifers and broadleaves have been used from Table 2.8.1 of the KP Supplement (i.e., 0.225 for conifers and 0.28 for broadleaves).

6.9 Nitrous oxide emissions from runoff associated to land conversions

6.9.1 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 CRF tables. Organic soils area is very small, thus leaching there is also negligible.

6.9.2 Methodological issues

Default factors from Tier 1 and Equation 11.10 are tested. The amount of N_2O emissions from runoff/leaching is negligible.

6.9.3 Uncertainties and time-series consistency

Not applicable.

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

Not applicable.

6.9.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

Not applicable.

6.9.6 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.

6.10 GHG emissions from LULUCF sources

6.10.1 Direct N_2O emissions from N fertilization of Forest Land and Other (CRF 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 CRF Table 4(I).

6.10.2 Non-CO_2 emissions from drainage of soils and Wetlands (CRF Table 4(II))

Since 1989 there has been no activity in the drainage of Forest lands in Romania. An area of 2.55 kha is reported as drained organic soils under Forest land, with CO_2 emissions reported under 4A1 and N_2O emissions in Table 4(II). Peatland area and related activities are insignificant. Flooding is also considered negligible.

6.10.3 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 (CRF 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 2020 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).

6.10.4 Indirect N_2O emissions from managed soils (CRF 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.

6.10.5 Biomass Burning (CRF 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 6.39). 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 CRF 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 6.39 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}	**Gg CO2 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
1994	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

Year	4.A.1			
	Area burned	CO_2 Emissions	CH_4 emissions	N_2O emissions
	ha ha^{-1}	Gg CO2 yr^{-1}	tonnes yr^{-1}	tonnes yr^{-1}
2003	762.00	16.13	48.32	2.67
2004	124.00	2.63	7.86	0.43
2004	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
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

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.

6.10.6 Category-specific planned improvements, including those in response to the review process

No planned improvements.

6.10.7 Recalculations of non-CO_2 emissions from sources

Activity data of forest areas affected by fires was updated on new data reported.

7 WASTE (CRF Sector 5)

7.1 Overview of the sector

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

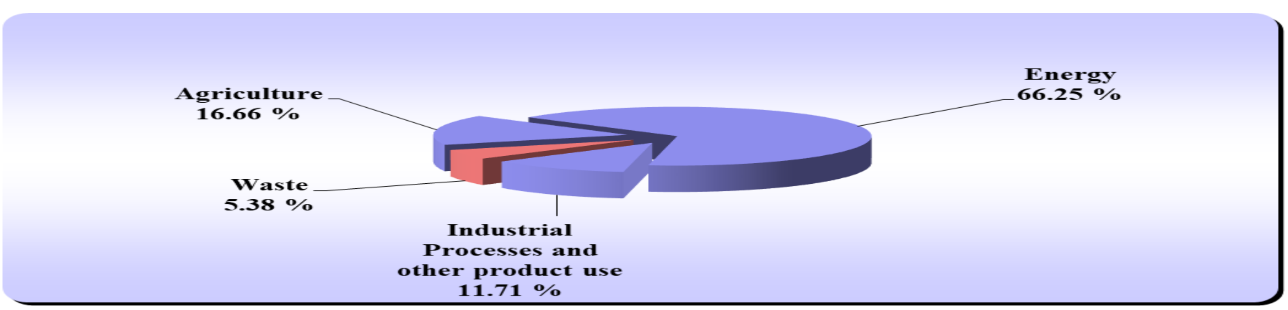
IPCC category	Emissions estimation status		
	CO_2	CH_4	N_2O
5.A Solid Waste Disposal			
5.A.1 Managed Waste Disposal	✓	✓	NA
5.A.2 Unmanaged Waste Disposal	✓	✓	NA
5.A.2.1 deep (>5m)	✓	✓	NA
5.A.2.2 shallow (<5 m)	✓	✓	NA
5.A.3 Other	NA	NA	NA
5.B Biological Treatment of Solid Waste			
5.B.1 Composting	NA	✓	✓
5.B.1 Anaerobic Digestion at Biogas Facilities	NO	✓	NO
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	✓	✓
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 2020 GHG emissions from the Waste Sector accounted for 5,916.18 kt CO_2 equivalent, which represent 5.35 % of the total national GHG emissions in this year (Figure 7.1).

Figure 7.1 The contribution of Waste Sector to the total GHG emissions in Romania, 2020



In the base year (1989), the total GHG emissions from the waste sector amounted to 5197.85 kt CO_2 equivalent, which accounted for 1.69% of the total national GHG emissions in this year. Compared with the other sectors, emissions from the waste sector showed a significant increase from the base year, with 13.82%, due to increasing of incineration activities and waste generation rate in parallel with increasing of living standards (Table 7.2, Figure 7.2).

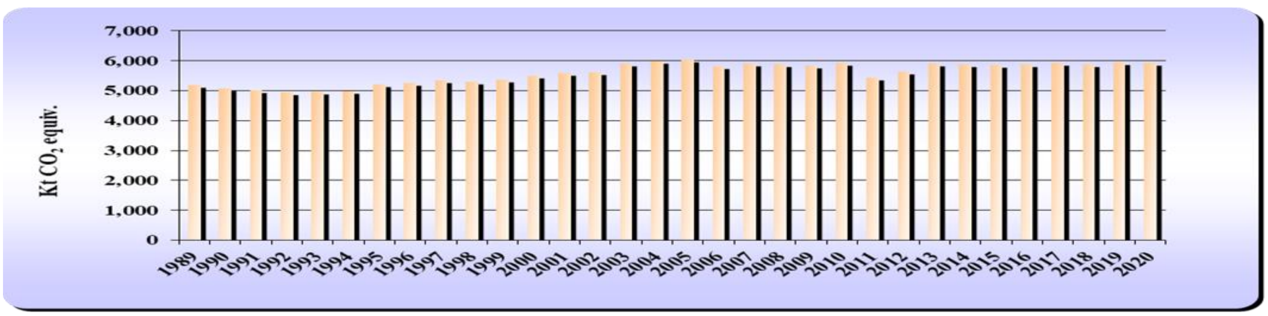
Table 7.2 The contribution of Waste Sector to the total GHG emissions in Romania, for 1989–2020 period

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	307,045.72	5,197.85	1.69
1990	249,696.53	5,086.99	2.04
1991	205,870.96	5,004.41	2.43
1992	190,518.23	4,941.28	2.59
1993	180,396.62	4,955.65	2.75
1994	177,810.78	4,989.89	2.81
1995	184,936.24	5,208.04	2.82
1996	187,826.01	5,267.90	2.80
1997	180,668.05	5,339.05	2.96
1998	163,592.71	5,300.44	3.24
1999	145,577.48	5,371.35	3.69
2000	138,979.50	5,498.80	3.96
2001	142,647.77	5,583.48	3.91
2002	144,186.01	5,620.29	3.90
2003	149,901.26	5,897.72	3.93
2004	148,139.99	5,985.01	4.04
2005	146,902.60	6,039.25	4.11
2006	148,403.92	5,819.20	3.92
2007	151,887.14	5,913.67	3.89
2008	147,982.51	5,873.96	3.97
2009	127,058.67	5,847.49	4.60
2010	122,862.63	5,920.03	4.82
2011	129,627.15	5,430.01	4.19
2012	127,537.24	5,640.41	4.42
2013	116,059.32	5,893.88	5.08
2014	115,292.89	5,874.13	5.09
2015	114,817.69	5,867.27	5.11

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 [%]
2016	113,456.38	5,887.04	5.19
2017	116,701.16	5,930.84	5.08
2018	117,597.48	5,892.72	5.01
2019	113,939.38	5,941.45	5.21
2020	109,934.33	5,916.18	5.38

* Preliminary data

Figure 7.2 Total GHG emissions trend from Waste Sector for 1989–2020 period



The most important contribution to GHG emissions from Waste Sector, in 2020 year, has Solid Waste Disposal Subsector, contributing with 65.45% in the total (Figure 7.3), Biological treatment accounts for 1.41 %; Incineration and Open Burning of Waste Subsector accounts for only 0.20% and Wastewater Treatment and Discharge Subsector contribute with 32.94%. Wastewater Treatment and Discharge and Solid Waste Disposal Subsectors are key category sources both by level and trend (Table 7.3 and Figure 7.4).

Figure 7.3 Contribution of the sub-sectors in the total GHG emissions from Waste Sector in 2020

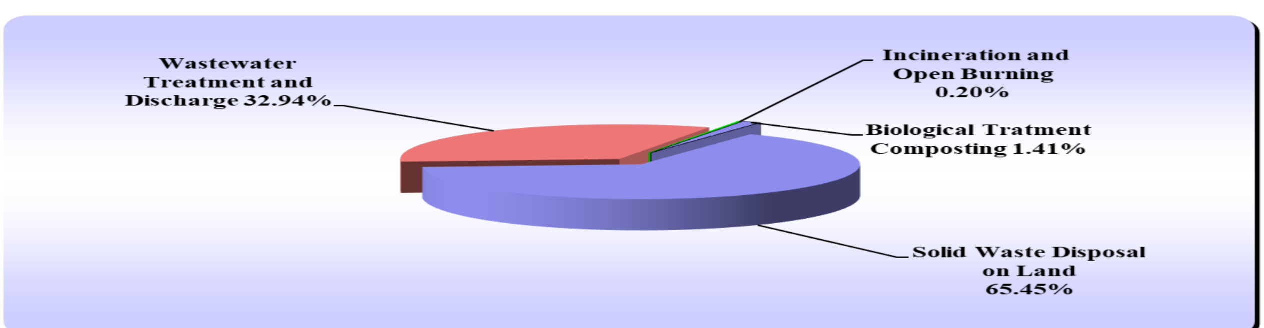
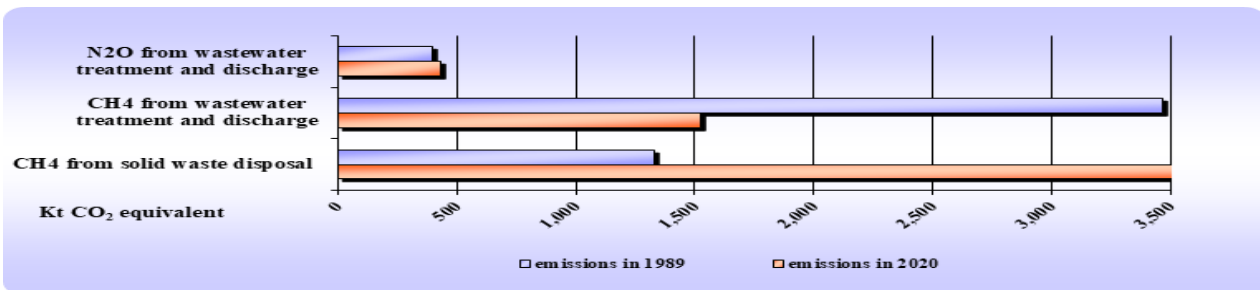


Table 7.3 Key categories in Waste Sector based on the level and trend assessment in 2020

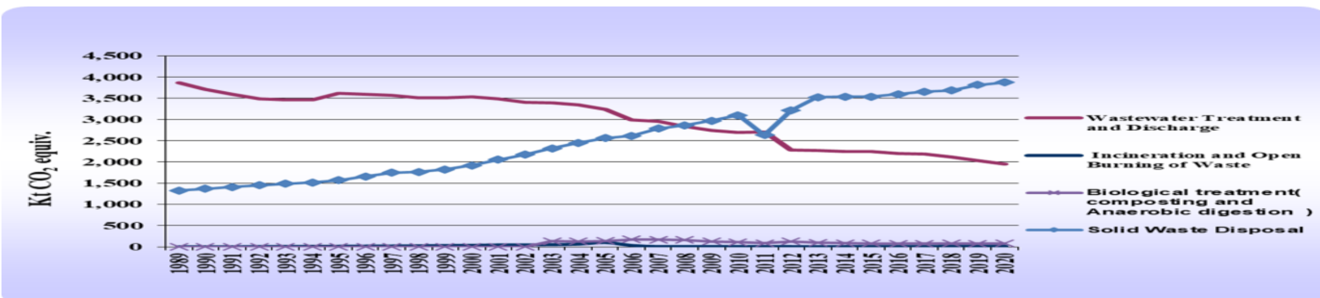
Key categories	GHG	Criteria (L and/or T)	Contribution in total GHG emissions [%]	Methodological tier used
5.A Solid waste disposal	CH_4	L,T	3.4	T2
5.D Wastewater Treatment and Discharge	CH_4	L,T	1.4	T2
	N_2O	LT	0.4	T2

Figure 7.4 Key categories in Waste Sector both by level and trend criteria, in 2020



Methane represents the major greenhouse gas from Waste sector with a contribution of 23.96% to the total methane emissions in Romania, in 2020. In the same year, nitrous protoxide has a contribution of 4.15% 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 2020 year comparing with the level in the base year, with a percentage of 190.94 % (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 -49.59 % in 2020 compared to 1989. This decrease is due to the decreasing number of population and the increase number of inhabitants connected to sewerage, and to the decreasing level of industrial production. GHG emissions trend from Biological treatment (composting and anaerobic digestion) decreased in 2020 year comparing with the level in the base year, with a percentage of 38.13 %. 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", finished in 2013, in Waste Incineration category were described also the N_2O emissions, the various type of incinerated waste and in this context the GHG emissions trend increase in 2020 year comparing with the level in 1989 year, with a percentage of 961.13 % (Figure 7.5). In Waste Incineration Subsector the emissions trend has remained almost constant in 2020 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 7.5 GHG emissions trend from Waste Sector, by sub-sectors for 1989–2020 period



7.2 Solid Waste Disposal (CRF 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) and waste from construction and demolition activities. 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 2015-2019 (final data for 2020 will be provided after statistical survey of the end of this year)

Indicator	2015	2016	2017	2018	2019
Amount of municipal waste generated (tons)	4,903,535	5,142,542	5,333,171	5,296,239	5,430,341
From which:					
Household waste collected from the population and assimilated from economic operators (tons)	3,685,250	3,894,853	4,162,921	4,249,988	4,632,802
Municipal waste (tonnes)	429,286	454,170	400,228	430,097	419,429
Waste generated and uncollected (tonnes)	600,345	523,670	419,444	314,022	178,470
Recyclable waste from the population, collected through authorized economic operators, others than sanitation operators (tonnes)	188,654	269,849	350,578	302,132	199,640
Specific information on municipal waste in the period 2015-2019					
Indicator	**2015**	**2016**	**2017**	**2018**	**2019**
Degree of connection to the sanitation service (%)	83.57	85.55	88.12	88.09	93.07
urban	93.67	94.50	95.90	95.58	97.67
rural	71.79	75.10	79.15	79.38	87.70
The amount of municipal waste collected separately (tone)	430,305	580,602	696,742	634,536	576,816
The quantity of recycled municipal waste* (tons)	649,591	689,443	745,427	586,406	623,214

Indicator	2015	2016	2017	2018	2019
Degree of recycling achieved for municipal waste (%)	13.25	13.41	13.98	11.07	11.48
The amount of municipal waste recovered (tons)	116,296	219,608	227,280	241,445	251,277
The amount of biodegradable waste from municipal waste deposited (tons)	1,856,416	1,913,329	2,159,103	2,068,288	2,120,022

Source: Waste Directorate of National Agency for Environmental Protection

For 2020 year data regarding the amount of MSW generated are 5,533,706 tons and the amount of MSW collected 5,386,834 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 2020 year municipal solid waste are deposited in managed SWDS. In accordance with European regulations, the unmanaged SWDS storage activity was stopped. (Table 7.5).

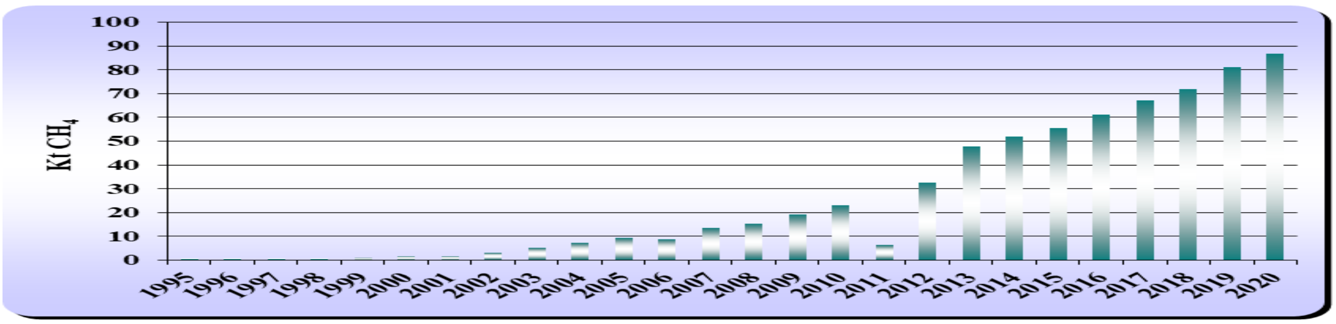
Table 7.5 Number of Solid waste Disposal Sites (Source Waste Directorate of NEPA)

Type of SWDS/Year	2013	2014	2015	2016	2017	2018	2019	2020
Managed	34	34	35	37	42	43	44	46
Unmanaged deep / **Unmanaged shallow**	48	33	25	19	7	-		

CH_4 emissions from SWDS

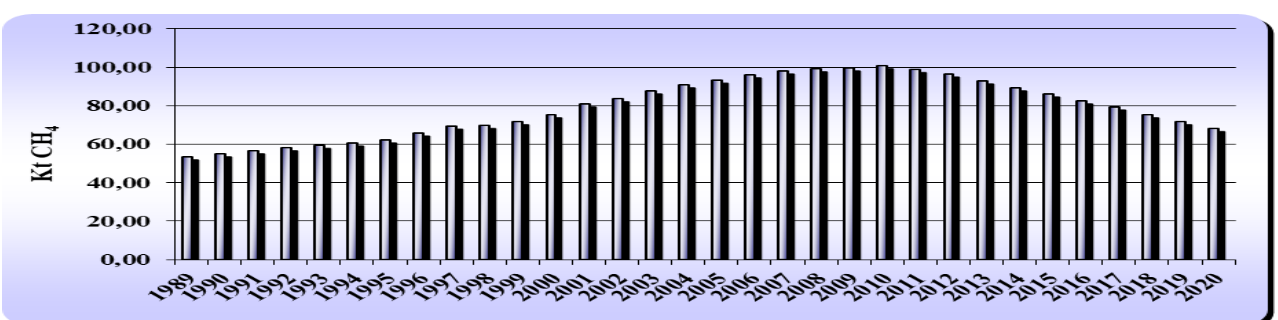
The methane emissions from Solid Waste Disposal Sites to managed landfills were estimated for the period 1995-2020, because in 1995 year was opened the first managed SWDS. The methane emissions from managed SWDS have an increasing trend between 1995 – 2010 period. The significant difference between the 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. Comparing with 2019 year, in 2020 year, CH_4 emissions register an increase due to the amount of generated waste, which has increased from 5,430,341 t in 2019 to 5,533,706 t in 2020 year.

Figure 7.6 CH_4 emissions trend from waste disposed to managed sites for 1995–2020 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 7.7), 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 7.7 CH_4 emissions trend from waste disposed to unmanaged sites for 1989–2020 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 1950-2020 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 1950-2002 period and data provided by NEPA Waste Directorate for period 2003-2020 (see the Table 7.6).

Table 7.6 The percentage composition of municipal solid waste

Years	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	26.80	0.67
1995	11.92	14.25	36.55	0.91
2000	13.68	16.36	41.96	1.04
2005	12.76	14.50	38.60	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	44.40	1.97
2010	9.88	20.31	32.19	2.11
2011	8.81	20.54	31.55	1.64
2012	11.06	20.70	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

Years	Paper and textiles [%]	Garden & park waste/ other non-food organic	Food waste [%]	Wood/straw [%]
2017	10.30	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

* 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

Type of site	MCF	DOC	DOC_F	F	k	OX
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 2003-2020 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 2020 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	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	1132.44
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

Year	managed	unmanaged deep sites	unmanaged shallow sites
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	58.234	3.99
2018	4,918.28	0	
2019	5,072.67		
2020	4,811.81		

*Preliminary data (final data for 2020 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 2006-2020 were considered in the emission estimation. Taking into account that the statistical survey on waste has not yet finalized for 2020 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 1989-2020.

Table 7.10 Total annual sewage sludge disposed to Solid Waste Disposal Sites (1989–2020 period)

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	1186.75	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
2016	305.88	20.36	1.45
2017	428.76	5.60	0.38
2018	380.04	0.00	
2019	345.02		
2020	338.32		

* Preliminary data (final data for 2020 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 16 managed SWDS and the amount of CH_4 for energy purposes is reported by 4 managed SWDS. For the 2020 year, according to the questionnaire completed by the operators, data on CH_4 recovered are both measured, 4.78 kt, and estimated, 1.65. 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

Year	Amount of CH_4 flared kt/year	Amount of CH_4 for energy recovery kt/year
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	3.90
2018	6.41	3.08
2019	3.40	2.67
2020	3.22	3.01

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	42.59	40
1990	54.86	50	43.89	40
1995	62.83	50	50.26	40
2000	76.87	50	61.50	40
2005	102.60	50	82.08	40
2007	111.38	50	89.10	40
2008	114.53	50	91.62	40
2009	118.82	50	95.06	40
2010	124.09	50	99.27	40
2011	105.33	50	84.26	40
2012	128.83	50	103.06	40
2013	140.91	50	112.73	40
2014	141.39	50	113.11	40
2015	141.52	50	113.22	40
2016	143.78	50	115.02	40
2017	146.19	50	116.95	40

Year	Greenhouse Gas			
	CH_4		CO_2	
	kt	%	kt	%
2018	147.39	50	117.91	40
2019	152.72	50	122.17	40
2020*	154.88	50	123.90	40

* Preliminary data

7.2.3 Uncertainties 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 6.3. 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	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CH_4 from managed and unmanaged solid waste disposal	CH_4	30.00	36.06	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 1989-2020 is consistent.

7.2.4 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 *Agriculture Sector,* the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Decision 166/2005/EC of the European Commission and in accordance with the Regulation 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.

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 2003-2020 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.

7.2.5 Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend

For this category no recalculations have been performed.

7.2.6 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 (CRF 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 2020 year level, 38 municipal waste composting facilities reported activity data.

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
2019	38
2020	38

Figure 7.8 CH_4 emissions trend from composting, for 2003–2020 period

Figure 7.9 N_2O emissions trend from composting , for 2003–2020 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 2003-2020 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 4.1.5 Energy Balance 1990_2020_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	**CH_4**	**N_2O**	**Source**	**Biogas**	**CH_4**	**Source**
	kt	**kt**	**kt**		**(TJ)**	**kt**	
2002	NO	NO	NO	NEPA	30.00	0.03	Annex 4.1.5 Energy Balance 1990_2020_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	0.05	
2008	378.17	3.78	0.23		25.00	0.02	
2009	302.72	3.03	0.18		45.00	0.04	
2010	259.82	2.60	0.16		129.00	0.13	
2011	174.45	1.74	0.10		547.00	0.54	
2012	231.97	2.32	0.14		1143.00	1.13	
2013	181.90	1.82	0.11		822.00	0.82	
2014	156.59	1.57	0.09		810.00	0.80	
2015	146.05	1.46	0.09		767.00	0.76	
2016	140.96	1.41	0.08		739.00	0.73	
2017	141.03	1.41	0.08		755.47	0.75	
2018	135.09	1.35	0.08		864.94	0.86	
2019	131.42	1.31	0.08		794.29	0.79	
2020*	149.83	1.50	0.09		772.08	0.77	

7.3.3 Uncertainties 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
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. Uncertainty estimate associated with CH_4 emission factor for composting amounts 100 percent, according to *2006 IPCC Guidelines.* Uncertainty estimate associated with N_2O emission factor for composting of organic waste amounts 110 percent, according to *2006 IPCC Guidelines.*

7.3.4 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 *Agriculture Sector,* the results of these being mentioned on the Checklists level.

7.3.5 Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend

CH_4 emissions from anaerobic digestion at biogas plants have been estimated for the first time.

7.3.6 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 (CRF 5.C)

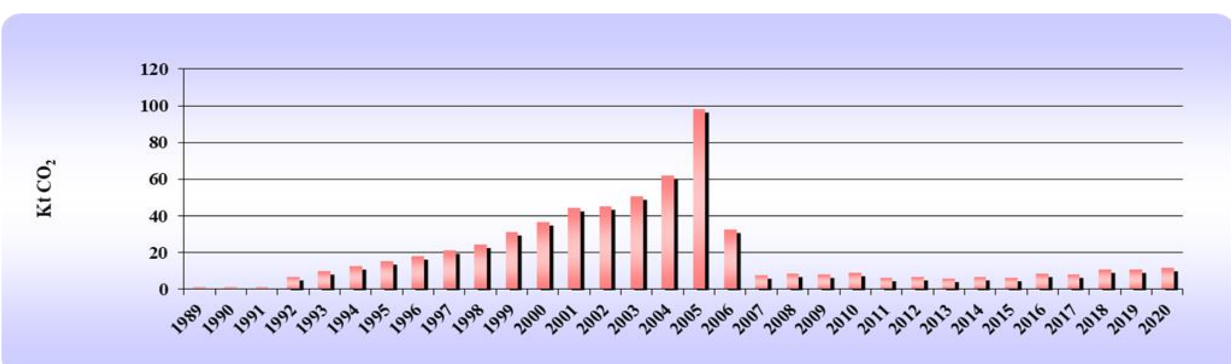
7.4.1 Category description

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 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 7.10 CO_2 emissions trend from waste incineration, for 1989–2020 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 provided by National Institute for Public Health. Clinical waste are incinerated since 1996, but more accurate data became available after 2000. It can observe a period of increasing activity between 1999 and 2007. Since 2008 in Romania were closed all health units crematoria used to burn hazardous medical waste, in according with European regulations. Based on the quantities of hazardous waste incinerated reported by NEPA (which include both with heat recovery and incineration without heat 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 7.11 CO_2 emissions trend from clinical waste incineration, for 1989–2020 period

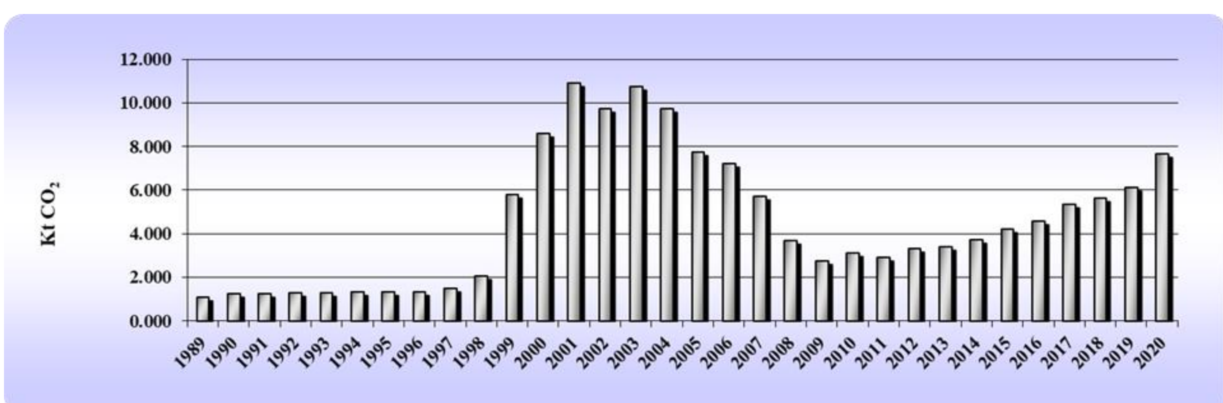


Figure 7.12 CO_2 emissions trend from hazardous waste incineration, for 1992–2020 period

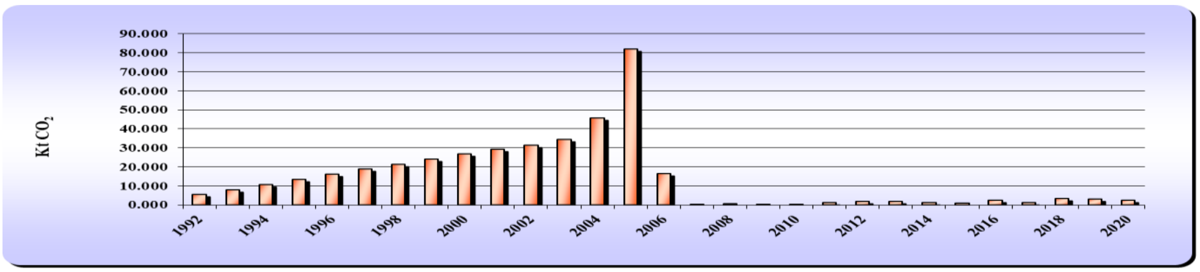


Figure 7.13 CO_2 emissions trend from biogenic waste incineration, for 2001–2020 period

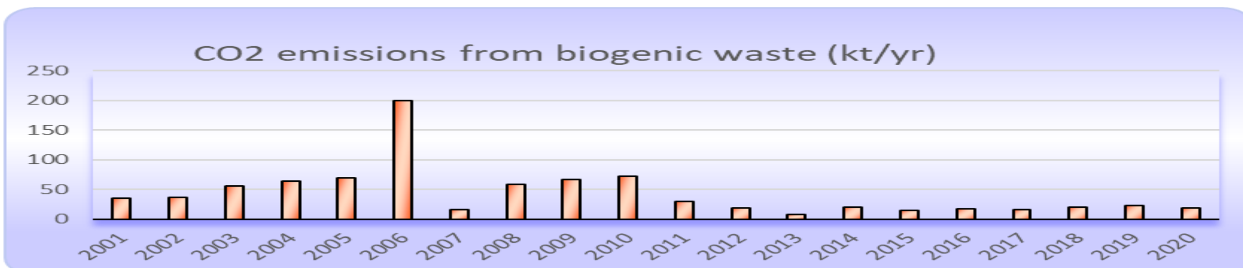


Figure 7.14 N_2O emissions trend from waste incineration, for 1992–2020 period

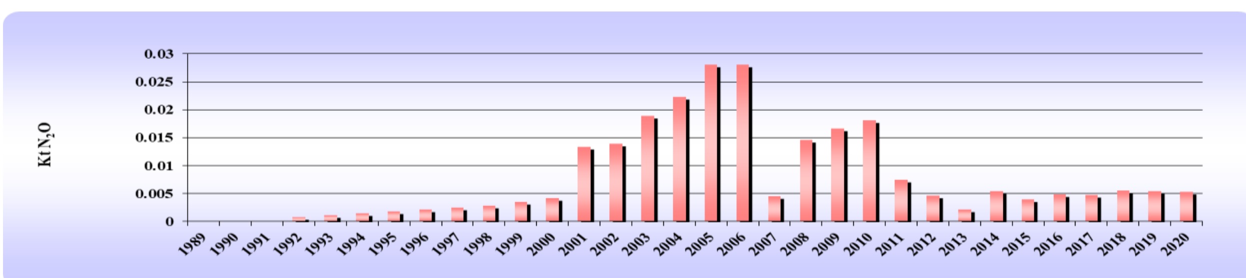
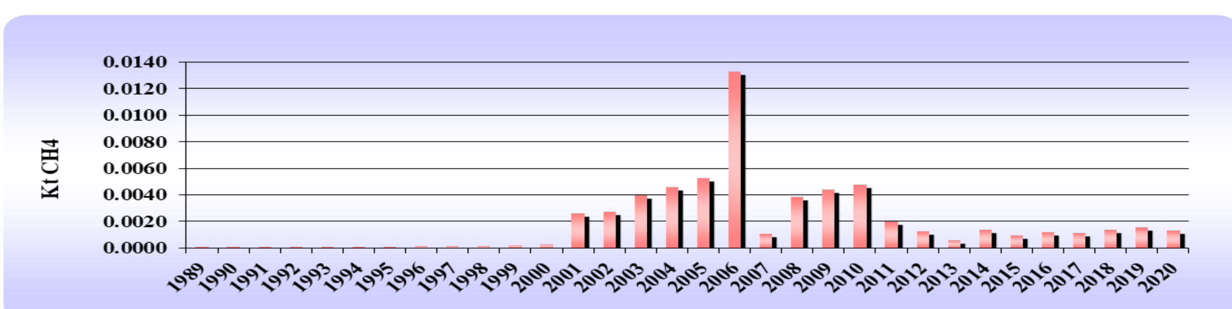


Figure 7.15 CH_4 emissions trend from waste incineration, for 1989–2020 period



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 1997-2019 the data were provided by the National Institute for Public Health. 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 2013-2019 period the amounts of incinerated hazardous waste without heat recovery were provided by Waste Directorate of NEPA. For 2020 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 7.16 N_2O emissions trend from clinical waste incineration, for 1989–2020 period

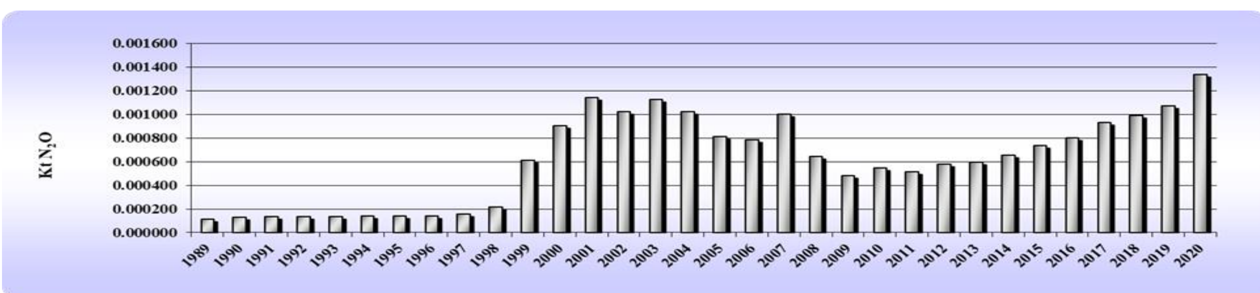


Figure 7.17 N_2O emissions trend from hazardous waste incineration, for 1992–2020 period

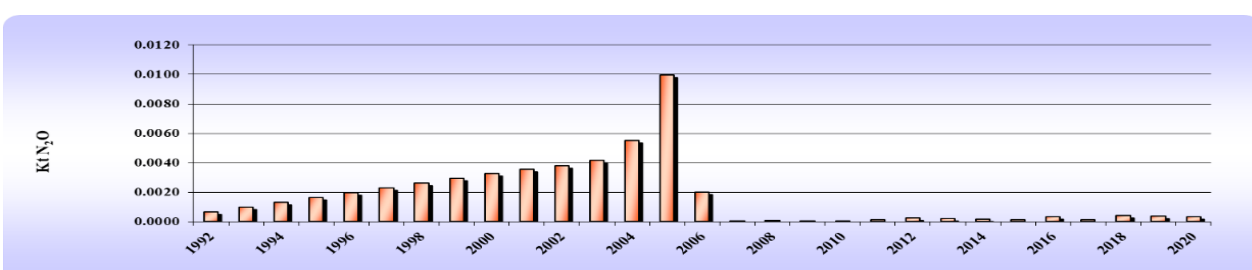


Figure 7.18 N_2O emissions trend from biogenic waste incineration, for 2001–2020 period

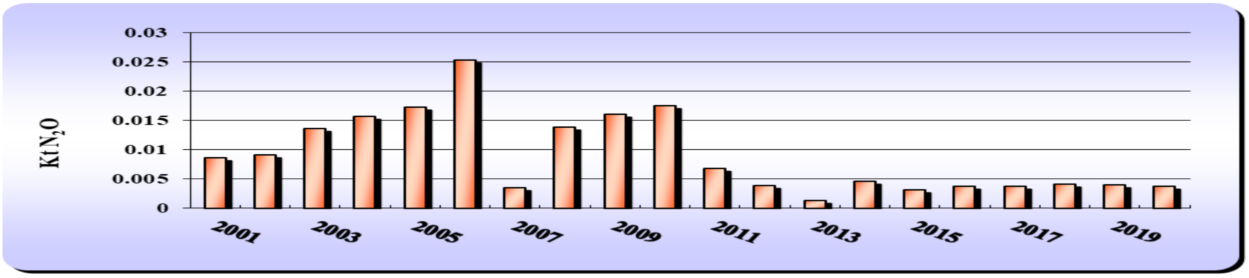


Figure 7.19 CH_4 emissions trend from clinical waste incineration, for 1989–2020 period

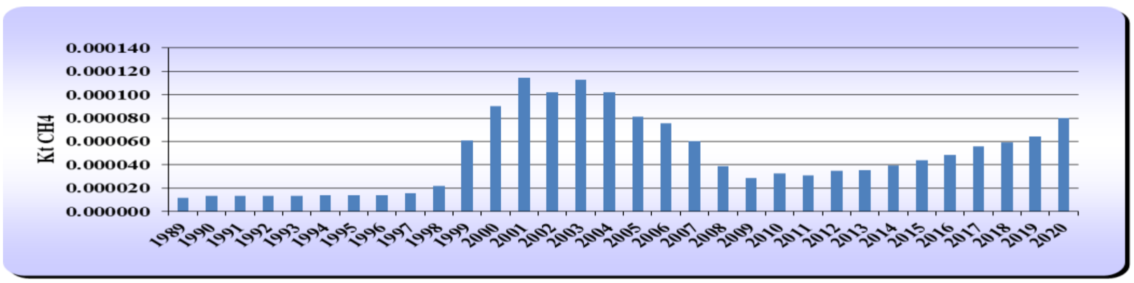


Figure 7.20 CH_4 emissions trend from hazardous waste incineration, for 1992–2020 period

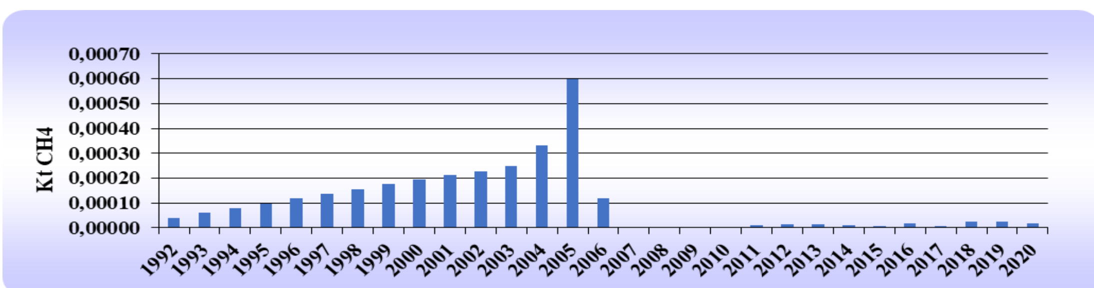
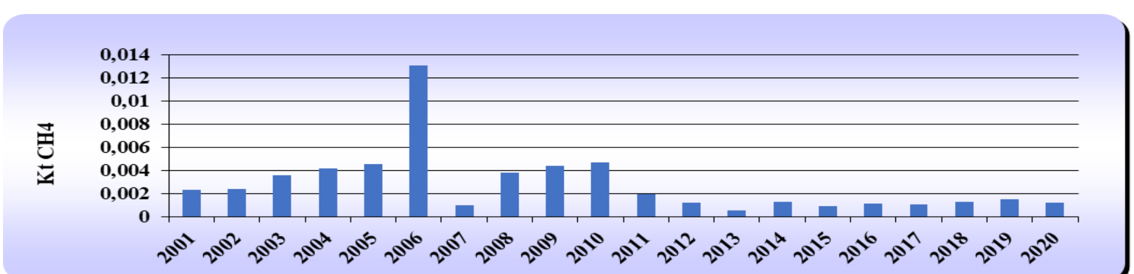


Figure 7.21 CH4 emissions trend from biogenic waste incineration, for 2001–2020 period



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

Type of incinerated waste	N_2O emission factors, in gN_2O/t_{waste}	Source
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 of clinical waste incinerated. 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	

Year	Clinical waste generated	Clinical waste incinerated	Source
	Unit [kt/yr]		
1995	3.97	2.32	
1996	4.05	2.35	Interpolation
1997	4.96	2.63	National Research and Development Institute for Environmental Protection
1998	6.47	3.63	ISPB
1999	10.15	10.15	
2000	15.03	15.03	
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	5.81	
2013	7.94	5.94	
2014	8.95	6.53	
2015	9.93	7.35	
2016	10.93	8.02	
2017	12.52	9.33	
2018	13.03	9.87	
2019	14.05	10.73	
2020	16.56	13.38	

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 - 2019 period the amounts of hazardous waste incinerated without heat recovery are provided by Waste Directorate of NEPA. For 2020 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		Clinical waste		Biogenic	
	Incinerated waste[kt/yr]	**Source**	**Incinerated waste[kt/yr]**	**Source**	**Incinerated waste[kt/yr]**	**Source**
1995	16.35	Study 2013	2.32	Study 2013	-	-
2000	32.53		15.03	ISPB	-	-
2005	99.54		13.55		76.33	Study 2013
2007	0.45		10.00		17.04	
2008	0.75		6.44		63.18	
2009	0.53		4.79		73.31	
2010	0.56		5.46		78.58	
2011	1.50		5.13		32.76	
2012	2.35	NEPA	5.81		20.09	
2013	2.34		5.94		8.76	
2014	1.63		6.53		21.75	
2015	1.19		7.35		15.38	Operators
2016	3.20		8.02		18.91	
2017	1.41		9.33		17.73	
2018	4.18		9.87		21.62	
2019	3.96		10.73		24.87	
2020 *	3.18		13.38		20.71	

* Preliminary data (final data for 2017 will be provided after statistical survey of the end of this year)

7.4.3 Uncertainties 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 6.3. 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	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CO_2 from waste incineration	CO_2	5.00	20.00	20.62
N_2O from waste incineration	N_2O	5.00	50.00	50.2
CH_4 from waste incineration	CH_4	5.00	100	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.

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

All activities regarding quality control (QC) as described in the QA/QC Programme have been undertaken. 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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Decision 166/2005/EC of the European Commission and in accordance with the Regulation 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.

7.4.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

The emissions associated to biogenic waste were recalculated for 2009-2019 period due to the amounts of sludge incinerated without energy recovery provided by the operators.

Table 7.23 Changes made at the activity data level related to biogenic waste incineration

Year	The changes in the activity data on Biogenic Waste Incineration		
	NGHGI 2021	NGHGI 2022	Difference [%]
	Amount of biogenic waste incinerated [Gg]		
2009	73.31	73.31	-0.00212
2010	78.58	78.58	-0.00290
2011	32.95	32.76	-0.57870
2012	20.11	20.09	-0.09481
2013	8.76	8.76	-0.00011
2014	21.75	21.75	-0.00009
2015	15.38	15.38	-0.00605
2016	18.89	18.91	0.09511
2017	17.30	17.73	2.47737
2018	21.36	21.62	1.25282
2019	24.85	24.87	0.09913

Table 7.24 The changes impact on emissions from biogenic waste incineration

Year	The changes impact on the CH_4 and N_2O emissions from Biogenic Waste Incineration					
	NGHGI 2021	NGHGI 2022	Difference	NGHGI 2020	NGHGI 2021	Difference
	CH_4 emissions [kt]			N_2O emissions [kt]		
2009	0.00440	0.00440	0.00000009	0.01608	0.01608	-0.0000014
2010	0.00471	0.00471	0.00000014	0.01750	0.01750	-0.0000021
2011	0.00198	0.00197	0.00001144	0.00695	0.00678	-0.0001716
2012	0.00121	0.00121	0.00000114	0.00387	0.00386	-0.0000172

Year	The changes impact on the CH_4 and N_2O emissions from Biogenic Waste Incineration					
	NGHGI 2021	NGHGI 2022	Difference	NGHGI 2020	NGHGI 2021	Difference
	CH_4 emissions [kt]			N_2O emissions [kt]		
2013	0.00053	0.00053	0.00000000	0.00130	0.00130	0.0000000
2014	0.00130	0.00130	0.00000000	0.00463	0.00463	0.0000000
2015	0.00092	0.00092	0.00000006	0.00312	0.00312	0.0000025
2016	0.00113	0.00113	-0.00000108	0.00378	0.00380	0.0000193
2017	0.00104	0.00106	-0.00002571	0.00344	0.00373	0.0002845
2018	0.00128	0.00130	-0.00001605	0.00391	0.00416	0.0002469
2019	0.00149	0.00149	-0.00000148	0.00395	0.00398	0.0000262

Starting this year CO_2 emissions from Incineration of other organic waste were estimated.

7.4.6 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 (CRF 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 2020 year, greenhouse gas emissions from 5.D Wastewater Treatment and Discharge contributed 33.08% to greenhouse gas emissions from the Waste sector. From 1989 to 2020, greenhouse gas emissions from this category decreased by 49.52%. 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 2020 was 4, 207.51 million m3 of which 2,484.19 million m3 (59.04%) represents cooling water, water classified in the category of wastewater which does not require treatment. The situation regarding the volumes of wastewater discharged in 2020 is presented in the table (Table 7.25).

Table 7.25 Wastewater evacuated into Romania, in 2020 (Source: National Administration "Romanian Waters")

Wastewater category	Volume (mil. mc)	Percentage (%)
Total wastewater evacuated	1,723.32	-
Total domestic wastewater evacuated	1,117.06	64.82
Total industrial wastewater evacuated	603.01	34.99
Domestic wastewater treated	841.50	48.83
Industrial wastewater treated	705.35	40.93
Total wastewater requiring treatment	1,723.32	100
Sufficient(appropriate) treated wastewater	1,378.92	80.02
Insufficient treated wastewater	174.84	10.15
Untreated wastewater	169.56	9.84

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 2020 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.

The coverage of population with sewerage services is between 1% and 100%, depending on location. For 2020 year, the number of municipal and industrial wastewater treatment plants, classified by appropriate treatment stage are as follows:

- primary stage: 38 treatment plants;
- secondary stage: 948 treatment plants;
- tertiary stage: 202 treatment plants.

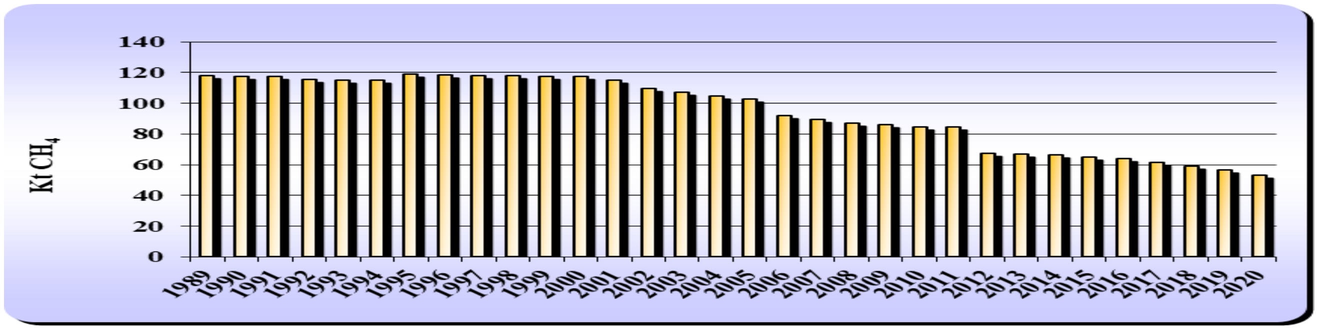
This situation is changing every year because the sewage system extends under projects financed by government programs, enhancing the connection to the sewerage and wastewater treatment.

CH_4 emissions from wastewater

CH_4 emissions from domestic and commercial wastewater and sludge (CRF 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 (Figure 7.22). The methane emissions level of 2020 compared to base year (1989) is in decreasing with 54.79%.

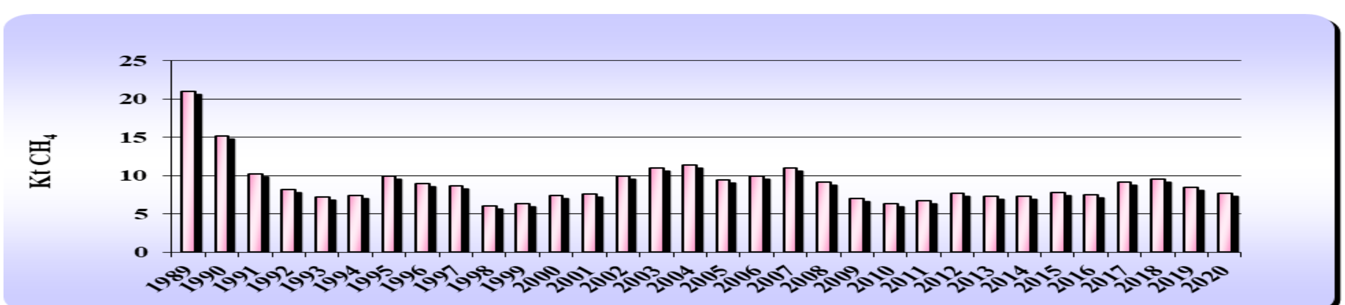
Figure 7.22 CH_4 emissions trend from domestic/commercial wastewater and sludge treatment for 1989–2020 period



CH_4 emissions from industrial wastewater (CRF 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. These fluctuations are due to the increasing or decreasing of industrial production, reflecting in the emissions trend fluctuation (see Figure 7.23). Since 2007, CH_4 emissions from industrial wastewater treatment have begun to fall due to the drastic decline of pulp production, industrial branch which produces wastewater with the highest organic load.

Figure 7.23 CH_4 emissions trend from industrial wastewater handling for 1989–2020 period



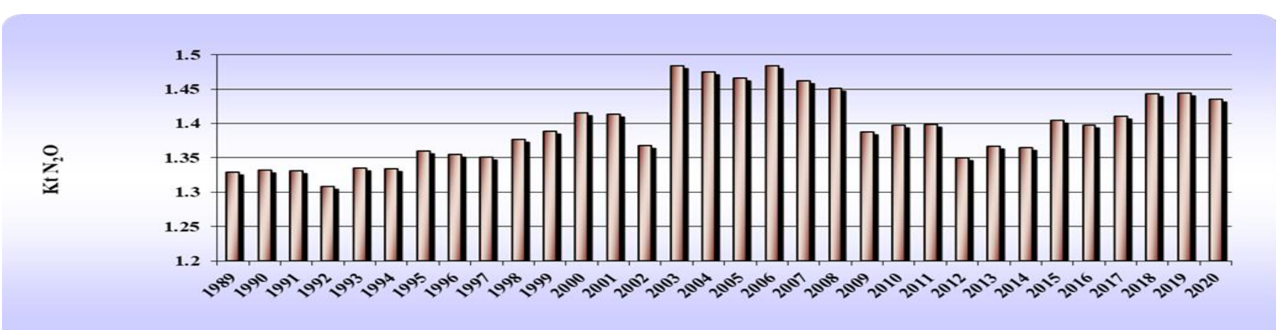
Compared with the base year (1989), CH_4 emissions from industrial wastewater treatment decreased with 63.36%.

Table 7.26 Explanations on methane emissions estimates

Period	Methane emissions from industrial wastewater treatment -Explanations
1989-1996	Values between 21.01–8.96 kt; These values are decreasing following decreasing industrial production.
1997-2004	Values between 8.65–11.34 kt; These values are relatively higher than previous period due to: • progress in Romanian economy, increase of the production; • increasing of fraction of wastewater treated anaerobically.
2005-2019	Values between 9.44 – 7.70; Relatively lower values compared with 1997-2004 period, but since 2009 following a sharp decline due to economic crisis, then sligthly increase 2010-2020.

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. The sharp decrease of N_2O emissions recorded in 2002, compared with 2001 year, is due to the severe loss of population number. 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 2015-2020 period the emissions increased due to the increasing values of protein consumption (Figure 7.24).

Figure 7.24 N_2O emissions trend from domestic wastewater for 1989–2020 period



7.5.2 Methodological issues

CH_4 emissions from domestic and commercial wastewater (CRF 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-privindcolectarea-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 2020, the values of the collection levels and treatment of biodegradable organic loading were 66.2% for wastewater collection, respectively 63.6% for wastewater treatment. According to the report made by the National Administration "Romanian Waters", in human agglomerations larger than 2000 l.e., the degree of connection to the collection system of wastewater recorded an increase of approx. 18% at the end of 2020 compared to 2007. Regarding the degree of connection to the urban treatment plants, it increased by approx. 25% in the period 2007-2020.

There is an increase in collection and treatment at the national level compared to 2019 which has the main causes: changing the number and size of agglomerations, following the development of feasibility studies for European funding for the period 2014-2020.

The number of wastewater treatment plants for each category in 2020 year:

- municipal treatment plants: 1188;
- industrial treatment plants: 753;
- individual treatment plants: 774.

Methodology

To estimate CH4 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 2018-2020 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 7.27 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	
	Urban	Rural	Urban	Urban	Rural	Urban
1989	45%	10%	55%	45%	10%	55%
1990	45%	10%	55%	45%	10%	55%
1993	45%	10%	55%	45%	10%	55%
1994	45%	10%	55%	45%	10%	55%
1995	40%	8%	60%	40%	8%	60%
2000	60%	8%	40%	60%	8%	40%
2005	39%	8%	61%	39%	8%	61%
2007	33%	8%	67%	33%	8%	67%

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	
	Urban	Rural	Urban	Urban	Rural	Urban
2008	33%	8%	67%	33%	8%	67%
2009	33%	8%	67%	33%	8%	67%
2010	30%	8%	70%	30%	8%	70%
2011	8%	8%	92%	8%	8%	92%
2012	8%	8%	92%	8%	8%	92%
2013	5%	8%	95%	5%	8%	95%
2014	4%	8%	96%	4%	8%	96%
2015	4%	8%	96%	4%	8%	96%
2016	3%	8%	97%	3%	8%	97%
2017	3%	8%	97%	3%	8%	97%
2018	3%	8%	97%	3%	8%	97%
2019	2%	8%	98%	2%	8%	98%
2020	2%	8%	98%	2%	8%	98%

Table 7.28 Calculation of Emission Factors domestic/commercial wastewater, for 1989-2020 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
	2018-2020	0.6	0.0065	0.0039
Source:		**IPCC 2006**	**Expert opinion/http://uwwtd.oieau.fr/**	**-**

Activity data

To estimates 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 7.29). The data regarding population unconnected to sewerage were obtained making the difference between total population and population connected to sewerage.

Table 7.29 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:* $\boldsymbol{P_{tot\ tr} = P_{urb\ tr} + P_{rur\ tr}}$ *;* *2006 – 2019: 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 7.30).

Table 7.30 Parameters used to estimate Total organic domestic/commercial wastewater (Source: Study finished in 2011)

Parameters	**Years**				
	1989-1999	**2000-2005**	**2006**	**2007**	**2008-2020**
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

Parameters		Years				
		1989-1999	2000-2005	2006	2007	2008-2020
Co-discharge of industrial WWH	Unconnected to sewerage	1				
	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 2008-2020 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. As the proportion of advanced treatment plants is small, 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 7.31 Values of Protein Consumption for Romania in period 1989-2020

Year	Protein consumption [kg protein/person/yr]	Source
1989	33.22	Statistical Yearbook 2004-2006
1990	33.22	FAO - Romania Country Profile
1993	33.95	Interpolation between 1992 and 1994 by expert judgement
1994	33.95	Statistical Yearbook 2009
1995	34.68	FAO - Romania Country Profile
2000	36.5	FAO - Romania Country Profile
2005	39.79	Statistical Yearbook 2010
2007	40.52	FAO - Romania Country Profile
2008	40.88	National Institute for Statistics
2009	39.42	
2010	39.93	
2011	40.15	
2012	38.95	
2013	39.57	
2014	39.64	
2015	40.99	
2016	41.03	
2017	41.65	
2018	42.85	
2019	42.96	
2020*	42.85	*Preliminary data*

CH_4 emissions from industrial wastewater and sludge (CRF 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 with minor methane emissions. 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 fraction of wastewater treated anaerobically (WS anaerobic) was calculated based on the wastewater generated in beer industry with anaerobic treatment and the total wastewater generated in the beer industry.

Table 7.32 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; treated aerobically	0.05	0.25	0.01
1998 - 2019; anaerobic treatment	0.70	0.25	0.18
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; treated aerobically	0.05	0.25	0.01
1998 - 2019; anaerobic treatment	0.20	0.25	0.01
	Expert judgement based on data provided by economic operators	**IPCC 2006, page 6.21**	

For Maximum methane producing capacity (Boi) were not found national values, in this case has been used the default value of 0.25 kg CH_4/kg COD (Chemical Oxygen Demand) from IPCC 2006.

Activity data

Activity data associated to industrial production are provided by the National Institute of Statistics (table 7.33).

Table 7.33 Industrial production of the industrial sectors with the greatest potential for methane emissions (source: NIS - Statistical Yearbook 2020)

Year	**Production (t/year)**			
	Beer	**Paper**	**Pulp**	**Petroleum Refining**
1989	1151300	552000	574000	30615000
1990	1052700	427000	380000	23664000
1991	980300	307000	235000	15191000
1992	1001400	262000	171000	13299000

Year	Production (t/year)			
	Beer	Paper	Pulp	Petroleum Refining
1993	992900	248000	132000	13191000
1994	904600	262000	128000	14744000
1995	876800	332000	194000	15259000
1996	811800	299000	177000	13426000
1997	765100	306000	154000	12429000
1998	998900	281000	129000	12520000
1999	1113300	276000	144000	9894000
2000	1266400	328000	187000	10532000
2001	1266300	388000	172000	10948000
2002	1162700	421000	199000	11906000
2003	1329200	457000	212000	10736000
2004	1440600	492000	187000	12371000
2005	1529500	385000	103000	13890000
2006	1748400	401000	80000	13237000
2007	1921300	461000	86000	13006000
2008	2024000	369000	22000	13095000
2009	1809000	310000	*	11340000
2010	1665600	325000	*	9931000
2011	1723900	335000	*	9516000
2012	1832500	343000	*	9142000
2013	1751900	372000	*	9366000
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	93	10,343,391

* Confidential data

For Degradable Organic Component and Wastewater generated, were used the default values from IPCC 2006 (Table 7. 34).

Table 7.34 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	9.0	1.0
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 4 operators of breweries (Table 7.38) For the 2020 year, according to the questionnaire completed by the operators, data on CH_4 recovered are both measured, 1.59 kt, and estimated, 0.31.

Table 7.35 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	

Year	Amount of Methane flared Gg/year	Amount of Methane for energy recovery Gg/year
2005	0.84	
2006	1.02	
2007	1.14	
2008	1.62	
2009	2.17	
2010	2.54	
2011	2.51	
2012	1.95	
2013	0.94	1.51
2014	1.03	1.33
2015	1.99	1.03
2016	0.78	3.09
2017	0.74	1.38
2018	0.51	1.31
2019	0.56	1.34
2020	0.50	1.40

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 Uncertainties 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 6.3. The uncertainties associated with CH_4 emissions from industrial wastewater are presented in the next table:

Table 7.36 Uncertainties for estimation of CH_4 emissions from industrial wastewater

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CH_4 from industrial wastewater	CH_4	30.00	42.40	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 6.3. In the table below are presented the uncertainties associated CH_4 emissions from domestic/ commercial wastewater treatment.

Table 7.37 Uncertainties for estimation of CH_4 emissions from domestic/commercial Wastewater

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CH_4 from domestic and commercial wastewater	CH_4	30.00	42.40	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 6.3. In the table below are presented the uncertainties associated to N_2O emissions from human sewage.

Table 7.38 Uncertainties for estimation of N_2O emissions from domestic wastewaster

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
N_2O from wastewater handling	N_2O	30.00	50.00	58.03

The percentages are associated with the overall uncertainty, as resulted after the aggregation of AD and

EF related uncertainties, according to to Chapter 3, Volume 1 of the IPCC 2006.

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

All activities regarding quality control (QC) as described in the QA/QC Programme have been undertaken. 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.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Decision 166/2005/EC of the European Commission and in accordance with the Regulation 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.

The number of population was provided by National Institute for Statistics the same parameter being reported to EUROSTAT. The differences between the two data sources come from different reference data (see Table 7.39).

The data reported to EUROSTAT were estimated for 1 January of each year considered while the data taking into account in NGHGI 2020 were estimated for 1 July of each year. Both data are corrected and are provided by NIS.

Table 7.39 Comparison between data provided by EUROSTAT and data provided by NIS

Year	**Total number of population (1000 persons)**		**Difference**
	NGHGI 2019 (*Source NIS*) *1 July*	**EUROSTAT *1 January***	
1989	23,151,564	-	-
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	21,319,673	21,382,354	62,681
2007	20,882,980	21,130,503	247,523
2008	20,537,848	20,635,460	97,612

Year	Total number of population (1000 persons)		Difference
	NGHGI 2019 (*Source NIS*) *1 July*	EUROSTAT *1 January*	
2009	20,367,437	20,440,290	72,853
2010	20,246,798	20,294,683	47,885
2011	20,147,657	20,199,059	51,402
2012	20,060,182	20,095,996	35,814
2013	19,988,694	20,020,074	31,380
2014	19,916,451	19,947,311	30,860
2015	19,822,250	19,870,647	48,397
2016	19,706,424	19,760,585	-54,161
2017	19,592,933	19,644,350	-52,682
2018	19,483,840	19,530,631	-53,918
2019	19,375,835	19,414,458	62,255
2020	19,261,714	19,328,838	62,255

7.5.5 Category-specific recalculation, including changes made in response to the review process and impact on emission trend

Recalculations have been performed for CH_4 emissions from domestic and commercial wastewater, for the 2018-2019 years, at the level of MCF-centralised WWTP. The values have been changed from 0.0152 for centralised aerobic treatment to updated values derived from the UWWTD website for 2018 -2019 years. For 2017-2019 period data regarding total population are updated by NIS.

Table 7.40 The effects of recalculations on CH_4 emissions from domestic and commercial wastewater

Year	CH_4 emissions [Kt]		Difference
	NGHGI 2021	NGHGI 2022	[%]
1989	117.78	117.78	0.00
1990	117.56	117.56	0.00
1991	117.53	117.53	0.00
1992	115.47	115.47	0.00
1993	115.19	115.19	0.00

Year	CH_4 emissions [Kt]		Difference
	NGHGI 2021	NGHGI 2022	[%]
1994	115.00	115.00	0.00
1995	118.77	118.77	0.00
1996	118.40	118.40	0.00
1997	118.03	118.03	0.00
1998	117.86	117.86	0.00
1999	117.66	117.66	0.00
2000	117.32	117.32	0.00
2001	114.85	114.85	0.00
2002	109.70	109.70	0.00
2003	106.98	106.98	0.00
2004	104.87	104.87	0.00
2005	102.56	102.56	0.00
2006	92.18	92.18	0.00
2007	89.54	89.54	0.00
2008	87.08	87.08	0.00
2009	85.91	85.91	0.00
2010	84.72	84.72	0.00
2011	84.71	84.71	0.00
2012	67.61	67.61	0.00
2013	67.10	67.10	0.00
2014	66.22	66.22	0.00
2015	65.07	65.07	0.00
2016	64.08	64.08	0.00
2017	61.55	61.56	0.01
2018	58.77	57.93	-1.42
2019	56.97	55.80	-2.05

For the calculation of indirect N_2O emissions from 5D1 the final data associated to protein consumption were updated by NIS for 2019 year (the value was exchanged from 43.11 kg protein/person/yr to 42.96 kg protein/person/yr). For 2017-2019 period data regarding total population are updated by NIS.

Table 7.41 The effects of recalculations on indirect N_2O emissions

Year	N_2O emissions [Kt]		Difference [%]
	NGHGI 2021	NGHGI 2021	
1989	1.33	1.33	0.00
1990	1.33	1.33	0.00
1991	1.33	1.33	0.00
1992	1.31	1.31	0.00
1993	1.34	1.34	0.00
1994	1.33	1.33	0.00
1995	1.36	1.36	0.00
1996	1.36	1.36	0.00
1997	1.35	1.35	0.00
1998	1.38	1.38	0.00
1999	1.39	1.39	0.00
2000	1.42	1.42	0.00
2001	1.41	1.41	0.00
2002	1.37	1.37	0.00
2003	1.48	1.48	0.00
2004	1.48	1.48	0.00
2005	1.47	1.47	0.00
2006	1.48	1.48	0.00
2007	1.46	1.46	0.00
2008	1.45	1.45	0.00
2009	1.39	1.39	0.00
2010	1.40	1.40	0.00
2011	1.40	1.40	0.00
2012	1.35	1.35	0.00
2013	1.37	1.37	0.00
2014	1.36	1.36	0.00
2015	1.40	1.40	0.00
2016	1.40	1.40	0.00

Year	N_2O emissions [Kt]		Difference [%]
	NGHGI 2021	NGHGI 2021	
2017	1.41	1.41	0.01
2018	1.44	1.44	0.06
2019	1.45	1.44	-0.20

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

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. A further step on improving the estimates is to continue to collect detailed data and information from the relevant economic operators during 2022.

7.6 Other (CRF 5.E)

This category is not occurring in Romania.

7.7 Memo items (CRF 5.F)

This category is not occurring in Romania.

8 OTHER (CRF Sector 6)

There are no additional GHG emissions, removals or activities characterized.

9 Indirect CO_2 and nitrous oxide emissions

9.1 Sources of indirect emissions in GHG inventory

9.1.1 ENERGY SECTOR (CRF 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 2005–2020 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 2005–2020 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 Uncertainties 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, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Solid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Gaseous fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Peat, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 7%.
- ❖ Biomass, CRF 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, CRF categories 1A1, 1A2: 40%;
  - Solid fuels, CRF categories 1A1, 1A2: 40%;
  - Gaseous fuels, CRF categories 1A1, 1A2: 40%;
  - Peat, CRF categories 1A1, 1A2: 40%;

- Other fuels, CRF categories 1A1, 1A2: 41%.
- Biomass, CRF categories 1A1, 1A2: 40%;
- Liquid fuels, CRF categories 1A4 and 1A5a: 125%;
- Solid fuels, CRF categories 1A4 and 1A5a: 125%;
- Gaseous fuels, CRF categories 1A4 and 1A5a: 125%;
- Peat, CRF categories 1A4 and 1A5a: 125%;
- Other fuels, CRF categories 1A4 and 1A5a: 125%.
- Biomass, CRF categories 1A4 and 1A5a: 125%;

- ***NMVOC gas:***
  - Liquid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 125%;
  - Solid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 125%;
  - Gaseous fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 125%;
  - Peat, CRF categories 1A1, 1A2, 1A4 and 1A5a: 125%;
  - Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 125%.
  - Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 125%;
- ***SO_2 gas:***
  - Liquid fuels, CRF categories 1A1: 6%;
  - Solid fuels, CRF categories 1A1: 6%;
  - Gaseous fuels, CRF categories 1A1: 6%;
  - Peat, CRF categories 1A1: 6%;
  - Other fuels, CRF categories 1A1: 9%.
  - Biomass, CRF categories 1A1: 6%;
  - Liquid fuels, CRF categories 1A2,: 20%;
  - Solid fuels, CRF categories 1A2: 20%;
  - Gaseous fuels, CRF categories 1A2: 20%;
  - Peat, CRF categories 1A2: 20%;
  - Other fuels, CRF categories 1A2: 21%.
  - Biomass, CRF categories 1A2: 20%;
  - Liquid fuels, CRF categories 1A4 and 1A5a: 40%;
  - Solid fuels, CRF categories 1A4 and 1A5a: 40%;
  - Gaseous fuels, CRF categories 1A4 and 1A5a: 40%;

- Peat, CRF categories 1A4 and 1A5a: 40%;
- Other fuels, CRF categories 1A4 and 1A5a: 41%.
- Biomass, CRF 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.
Recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission. *See the chapter 3.2.4.4* - Category-specific QA/QC and verification, if applicable *for the considerations related to the Activity data checks, Calculations checks, Transparency, Accuracy, Completeness, Consistency.*

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 3.2.4.5.

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 CRF 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 Uncertainties 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

In order to improve the emissions estimates quality some important recalculations were made at:

- ***emissions***: recalculations of the NO_x emissions, CO emissions, NMVOC emissions and SO_2 emissions for the 2007 – 2008 period and year 2015, in case of NO_x, NMVOC and SO_2, and also for the 1989 – 2019 period in case of CO have been made due to an error in calculation formula.

The implications of all changes made on emission estimates are described in the Tables below:

Table 9.6 Change made at emissions and their effects on NO_x, CO emissions estimates at Domestic aviation category (CRF 1.A.3.a)

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	362.88	362.88	0.00	0.09	0.09	0.00	0.04	0.04	0.00
1990	347.81	347.81	0.00	0.09	0.09	0.00	0.00	0.03	99,900.00
1995	441.81	441.81	0.00	0.11	0.11	0.00	0.00	0.04	99,900.00
2000	375.76	375.76	0.00	0.09	0.09	0.00	0.00	0.04	99,900.00
2005	2,640.35	2,640.35	0.00	0.66	0.66	0.00	0.00	0.26	99,900.00
2007	3,366.26	3,366.26	0.00	1.06	0.84	-20.72	0.00	0.34	79,184.49
2008	3,352.05	3,352.05	0.00	1.34	0.84	-37.63	0.00	0.34	62,271.82
2009	3,536.06	3,536.06	0.00	0.88	0.88	0.00	0.00	0.35	99,900.00
2010	4,660.49	4,660.49	0.00	1.17	1.17	0.00	0.00	0.47	99,900.00
2015	1,369.90	1,369.90	0.00	0.44	0.34	-22.29	0.00	0.14	77,612.87
2016	1,172.18	1,172.18	0.00	0.29	0.29	0.00	0.00	0.12	99,900.00
2017	2,064.17	2,064.17	0.00	0.52	0.52	0.00	0.00	0.21	99,900.00
2018	2,325.10	2,325.10	0.00	0.58	0.58	0.00	0.00	0.23	99,900.00

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2019	2,707.85	2,707.85	0.00	0.68	0.68	0.00	0.00	0.27	99,900.00
2020		1,618.32			0.40			0.16	

Table 9.7 Change made at emissions and their effects on NMVOC and SO_2 emissions estimates at Domestic aviation category (CRF 1.A.3.a)

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	362.88	362.88	0.00	0.02	0.02	0.00	0.01	0.01	0.00
1990	347.81	347.81	0.00	0.02	0.02	0.00	0.01	0.01	0.00
1995	441.81	441.81	0.00	0.04	0.04	0.00	0.01	0.01	0.00
2000	375.76	375.76	0.00	0.09	0.09	0.00	0.01	0.01	0.00
2005	2,640.35	2,640.35	0.00	0.24	0.24	0.00	0.06	0.06	0.00
2007	3,366.26	3,366.26	0.00	0.45	0.19	-58.10	0.09	0.07	-22.47
2008	3,352.05	3,352.05	0.00	0.82	0.21	-74.14	0.12	0.07	-39.32
2009	3,536.06	3,536.06	0.00	0.22	0.22	0.00	0.07	0.07	0.00
2010	4,660.49	4,660.49	0.00	0.29	0.29	0.00	0.10	0.10	0.00
2015	3,406.08	3,406.08	0.00	0.10	0.08	-19.82	0.00	0.03	2,574.60
2016	1,692.08	1,692.08	0.00	0.07	0.07	0.00	0.00	0.02	2,182.70
2017	1,910.22	1,910.22	0.00	0.11	0.11	0.00	0.00	0.04	4,640.35
2018	1,016.34	1,016.34	0.00	0.13	0.13	0.00	0.00	0.05	4,246.10
2019	1,369.90	1,369.90	0.00	0.15	0.15	0.00	0.00	0.06	3,113.25

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2020		1,618.32			0.09			0.03	

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 9.8 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

$$EF_{SO2}\ [kg/TJ] = 2 \times (s/100) \times 1/Q \times 10^6 \times (100 - r/100) \times (1\,0\,0 - n/100)$$

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 9.9 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 2005-2020***

Model Copert 4, Tier 3 was used for the period 2005-2020, detailed statistics necessary to use higher level methods have allowed. For period 2005-2020 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 Uncertainties and time-series consistency

Table 9.10 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
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 CRF 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 Uncertainties 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

In order to improve the emissions estimates quality some important recalculations were made at:

- ***activity data***: recalculations of the activity data values for 1989 – 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;
- ***emissions***: recalculations of the NO_x emissions, CO emissions and NMVOC emissions for the 1989 - 2019 period have been made due to updates of the Activity Data and Net Calorific Values.

The implications of all changes made on emission estimates are described in the Tables below:

Table 9.11 Change made at emissions and their effects on NO_x, CO emissions estimates at Railways category (CRF 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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	5,290.37	5,575.06	5.38	6.54	6.88	5.19	1.33	1.40	5.19
1990	6,032.78	6,324.98	4.84	7.76	8.13	4.70	1.59	1.66	4.70
1995	12,137.68	12,134.26	-0.03	14.95	14.95	0.00	3.09	3.09	0.00
2000	12,264.65	12,477.73	1.74	15.15	15.42	1.73	3.10	3.15	1.73
2005	3,122.74	3,334.93	6.79	3.84	4.10	6.83	0.79	0.84	6.77
2007	7,686.18	7,831.78	1.89	9.48	9.48	0.00	1.95	1.95	0.00
2008	7,188.80	7,153.43	-0.49	8.88	8.88	0.00	1.81	1.81	0.00
2009	5,309.92	5,362.27	0.99	6.62	6.62	0.00	1.35	1.35	0.00
2010	6,059.00	6,033.77	-0.42	7.52	7.53	0.05	1.54	1.54	0.05
2015	4,788.80	4,584.03	-4.28	5.88	5.87	-0.16	1.20	1.20	-0.16
2016	4,441.58	4,453.82	0.28	5.72	5.73	0.26	1.17	1.17	0.26
2017	4,626.85	4,676.85	1.08	5.97	6.03	1.01	1.22	1.23	1.01
2018	4,027.59	4,003.85	-0.59	4.88	4.85	-0.59	1.00	0.99	-0.59
2019	5,435.70	5,439.26	0.07	6.70	6.71	0.06	1.37	1.37	0.06
2020		4,498.93			6.71			1.37	

Table 9.12 Change made at emissions and their effects on NMVOC emissions estimates at Railways category (CRF 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 SO2 [Gg]		Diff [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2022	NGHGI 2022	
1989	5,290.37	5,575.06	5.38	0.58	0.61	5.19	1.24	1.31	5.21
1990	6,032.78	6,324.98	4.84	0.69	0.72	4.70	1.72	1.79	4.04
1995	12,137.68	12,134.26	-0.03	1.32	1.32	0.00	2.88	2.88	0.00
2000	12,264.65	12,477.73	1.74	1.34	1.37	1.73	2.88	2.93	1.74
2005	3,122.74	3,334.93	6.79	0.34	0.36	6.83	0.70	0.75	7.14
2007	7,686.18	7,831.78	1.89	0.84	0.84	0.00	0.72	0.72	0.00
2008	7,188.80	7,153.43	-0.49	0.79	0.79	0.00	0.36	0.36	0.00
2009	5,309.92	5,362.27	0.99	0.59	0.59	0.00	0.25	0.25	0.00
2010	6,059.00	6,033.77	-0.42	0.67	0.67	0.00	0.29	0.29	0.05
2015	4,788.80	4,584.03	-4.28	0.52	0.52	-0.16	0.22	0.22	-0.16
2016	4,441.58	4,453.82	0.28	0.51	0.51	0.26	0.22	0.22	0.26
2017	4,626.85	4,676.85	1.08	0.53	0.53	1.01	0.23	0.23	1.01
2018	4,027.59	4,003.85	-0.59	0.43	0.43	-0.59	0.19	0.19	-0.59
2019	5,435.70	5,439.26	0.07	0.59	0.60	0.06	0.26	0.26	0.06
2020		4,498.93			0.60			0.22	

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 CRF Reporter GHG inventory [1. Energy][1.AA Fuel Combustion - Sectoral approach] [1.A.3 Transport] [1.A.3.d Domestic Navigation]. The emission factors are default and provided in the *Revised 1996 IPCC Guidelines* and EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.

9.1.1.5.2 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.

9.1.1.5.3 Uncertainties 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%.
- 1.5008% residual fuel and diesel oil,1.5003% 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 2016.

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 emissions estimates quality some important recalculations were made at:

- ***activity data***: recalculations of the activity data values for 1989 – 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;
- ***emissions***: recalculations of the NO_x emissions, CO emissions, NMVOC emissions and SO_2 emissions for the 1989 - 2019 period have been made due to updates of the Activity Data and Net Calorific Values.

The implications of all changes made on emission estimates are described in the Tables below:

Table 9.13 ***Change made at emissions and their effects on NO_x, CO emissions estimates at Domestic navigation category (CRF 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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	20,435.55	20,269.21	-0.81	39.74	39.43	-0.79	3.90	3.87	-0.76
1990	14,850.70	14,688.75	-1.09	28.81	28.48	-1.17	2.90	2.87	-1.09
1995	4,291.56	4,294.54	0.07	8.16	8.16	0.00	0.79	0.79	0.00
2000	4,715.60	4,803.16	1.86	8.80	8.95	1.78	1.08	1.09	1.37
2005	1,738.87	1,738.70	-0.01	3.22	3.22	0.00	0.34	0.34	0.00
2007	3,585.35	3,537.21	-1.34	6.44	6.44	0.00	0.75	0.75	0.00
2008	3,263.50	2,974.64	-8.85	5.50	5.50	0.00	0.80	0.80	0.00
2009	2,306.08	2,306.17	0.00	4.24	4.24	0.00	0.61	0.61	0.19
2010	2,493.39	2,499.92	0.26	4.57	4.57	0.03	1.19	1.27	7.25

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2015	1,763.71	1,764.20	0.03	3.38	3.38	0.00	0.40	0.41	1.63
2016	1,641.49	1,643.03	0.09	3.14	3.14	0.01	0.50	0.52	4.07
2017	1,641.43	1,644.09	0.16	3.13	3.13	0.02	0.61	0.65	5.70
2018	1,757.21	1,761.25	0.23	3.13	3.13	0.03	0.77	0.83	6.88
2019	1,863.84	1,868.51	0.25	3.38	3.38	0.03	0.83	0.89	7.41
2020		1,714.93			3.25			0.83	

Table 9.14 Change made at emissions and their effects on NMVOC and SO_2 emissions estimates at Domestic navigation category (CRF 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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	20,435.55	20,269.21	-0.81	1.46	1.45	-0.76	14.44	14.40	-0.28
1990	14,850.70	14,688.75	-1.09	1.09	1.07	-1.10	10.21	10.17	-0.42
1995	4,291.56	4,294.54	0.07	0.30	0.30	0.00	2.12	2.12	0.00
2000	4,715.60	4,803.16	1.86	0.39	0.40	1.43	2.34	2.36	0.85
2005	1,738.87	1,738.70	-0.01	0.12	0.12	0.00	0.43	0.43	0.00
2007	3,585.35	3,537.21	-1.34	0.28	0.28	0.00	0.33	0.33	0.00
2008	3,263.50	2,974.64	-8.85	0.28	0.28	0.00	0.14	0.14	0.00
2009	2,306.08	2,306.17	0.00	0.22	0.22	0.17	0.11	0.11	0.00
2010	2,493.39	2,499.92	0.26	0.40	0.43	6.77	0.12	0.12	0.25
2015	1,763.71	1,764.20	0.03	0.15	0.15	1.41	0.09	0.09	0.03
2016	1,641.49	1,643.03	0.09	0.18	0.18	3.65	0.08	0.08	0.09
2017	1,641.43	1,644.09	0.16	0.21	0.22	5.21	0.08	0.08	0.15

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2018	1,757.21	1,761.25	0.23	0.26	0.28	6.40	0.08	0.08	0.23
2019	1,863.84	1,868.51	0.25	0.28	0.30	6.89	0.09	0.09	2.00
2020		1,714.93			0.28			0.08	

9.1.1.5.6 Category-specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

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 CRF 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 Uncertainties 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

In order to improve the emissions estimates quality some important recalculations were made at:

- ***activity data***: recalculations of the activity data values for 1989 – 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;
- ***emissions***: recalculations of the NO_x emissions, CO emissions, NMVOC emissions and SO_2 emissions for the 1989 - 2019 period have been made due to updates of the Activity Data and Net Calorific Values.

The implications of all changes made on emission estimates are described in the Tables below:

Table 9.15 Change made at emissions and their effects on NO_x, CO emissions estimates at Other transportation category (CRF 1.A.3.e)

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	710.37	710.38	0.00	0.15	0.15	0.00	1.79	1.79	0.00
1990	700.39	700.39	0.00	0.15	0.15	0.00	2.16	2.16	0.00
1995	195.13	195.13	0.00	0.10	0.10	0.00	0.09	0.09	0.00
2000	1,167.09	1,167.09	0.00	0.11	0.11	0.00	0.66	0.66	0.00
2004	1,704.36	1,704.29	0.00	0.36	1.07	194.60	2.26	2.33	2.95
2007	2,746.99	2,747.80	0.03	0.46	0.46	0.00	14.57	14.57	0.00
2008	4,353.77	4,353.54	-0.01	0.74	0.74	0.00	29.10	29.10	0.00
2009	2,470.93	2,471.91	0.04	0.32	0.32	0.07	2.43	2.44	0.53
2010	626.44	648.20	3.47	0.08	0.08	5.87	2.55	2.83	11.28
2015	94.16	97.67	3.73	0.01	0.01	5.40	0.59	0.64	7.84
2016	89.37	94.42	5.64	0.01	0.02	7.57	0.67	0.74	9.93
2017	46.87	51.05	8.91	0.01	0.01	10.06	0.50	0.55	11.09
2018	56.64	61.95	9.37	0.01	0.01	10.31	0.63	0.70	11.12
2019	75.21	83.85	11.49	0.02	0.02	11.78	0.95	1.06	12.01
2020		64.10			0.01			0.69	

Table 9.16 Change made at emissions and their effects on NMVOC and SO_2 emissions estimates at Other transportation category (CRF 1.A.3.e)

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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	710.37	710.38	0.00	0.52	0.52	0.00	0.08	0.08	0.00
1990	700.39	700.39	0.00	0.64	0.64	0.00	0.08	0.08	0.00
1995	195.13	195.13	0.00	0.03	0.03	0.00	0.01	0.01	0.00
2000	1,167.09	1,167.09	0.00	0.20	0.20	0.00	0.00	0.00	0.00
2004	1,704.36	1,704.29	0.00	0.71	0.73	3.57	0.04	0.13	238.99
2007	2,746.99	2,747.80	0.03	4.59	4.59	0.00	0.05	0.05	-0.14
2008	4,353.77	4,353.54	-0.01	9.18	9.18	0.00	0.10	0.10	0.01
2009	2,470.93	2,471.91	0.04	0.74	0.75	0.55	0.01	0.01	0.25
2010	626.44	648.20	3.47	0.80	0.89	11.34	0.01	0.01	11.35
2015	94.16	97.67	3.73	0.19	0.20	7.86	0.00	0.00	7.86
2016	89.37	94.42	5.64	0.21	0.23	9.95	0.00	0.00	9.95
2017	46.87	51.05	8.91	0.16	0.17	11.09	0.00	0.00	11.10
2018	56.64	61.95	9.37	0.20	0.22	11.12	0.00	0.00	11.12
2019	75.21	83.85	11.49	0.30	0.34	12.01	0.07	0.00	-94.67
2020		64.10			0.22			0.00	

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" of the Domestic RO Energy Balance 2020.

Emission Factors

The default emission factors from Revised 1996 IPCC Guidelines and from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 have been used.

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***
0.24	0.09	0.20	0.62

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 Uncertainties 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 2016.

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 (CRF 1.B.2.a):

❖ ***emissions***: recalculations of the NO_x emissions, CO emissions, NMVOC emissions and SO_2 emissions for the year 1989 and the 2000 – 2001 period in case of CO and NMVOC, and also for the 1989 – 2019 period in case of No_x and SO_2 have been made due to an error of transcription from the spreadsheet into the CRF tables.

The implications of all changes made on emission estimates are described in the Tables below:

Table 9.17 Change made at emissions and their effects on NO_x and CO emissions estimates at Fugitive emissions – Oil and natural gas – Oil (CRF 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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	1,84	7,33	298,90	2,76	2,75	-0,27

Year	Effects of changes on emission estimates for NO_x [Gg]		Diff [%]	Effects of changes on emission estimates for CO [Gg]		Diff [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1990	1,42	5,68	300,00	2,13	2,13	0,00
1995	0,92	3,66	300,00	1,37	1,37	0,00
2000	0,63	2,54	302,54	0,95	0,95	0,64
2005	0,83	3,33	300,00	1,25	1,25	0,00
2007	0,78	3,12	300,00	1,17	1,17	0,00
2008	0,79	3,14	300,00	1,18	1,18	0,00
2009	0,68	2,72	300,00	1,02	1,02	0,00
2010	0,60	2,38	300,00	0,89	0,89	0,00
2015	0,63	2,51	300,00	0,94	0,94	0,00
2016	0,69	2,75	300,00	1,03	1,03	0,00
2017	0,67	2,66	300,00	1,00	1,00	0,00
2018	0,69	2,78	300,00	1,04	1,04	0,00
2019	0,73	2,92	300,00	1,09	1,09	0,00
2020		2,54			0,95	

Table 9.18 Change made at emissions and their effects on NMVOC and SO_2 emissions estimates at Fugitive emissions – Oil and natural gas – Oil (CRF 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 [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
1989	6,12	6,11	-0,27	28,47	18,93	-33,52
1990	4,73	4,73	0,00	22,01	14,67	-33,33
1995	3,05	3,05	0,00	14,19	9,46	-33,33
2000	2,11	2,12	0,64	9,79	6,57	-32,91
2005	2,78	2,78	0,00	12,92	8,61	-33,33

Year	Effects of changes on emission estimates for NMVOC [Gg]		Diff [%]	Effects of changes on emission estimates for SO_2 [Gg]		Diff [%]
	NGHGI 2021	NGHGI 2022		NGHGI 2021	NGHGI 2022	
2007	2,60	2,60	0,00	12,10	8,06	-33,33
2008	2,62	2,62	0,00	12,18	8,12	-33,33
2009	2,27	2,27	0,00	10,55	7,03	-33,33
2010	1,99	1,99	0,00	9,24	6,16	-33,33
2015	2,10	2,10	0,00	9,74	6,50	-33,33
2016	2,29	2,29	0,00	10,64	7,09	-33,33
2017	2,22	2,22	0,00	10,31	6,87	-33,33
2018	2,32	2,32	0,00	10,77	7,18	-33,33
2019	2,43	2,43	0,00	11,30	7,54	-33,33
2020		2,12			6,57	

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 (CRF Sector 2)

9.1.2.1 MINERAL INDUSTRY (CRF 2.A)

9.1.2.1.1 Description of sources of indirect emissions in GHG inventory

GHG emissions reported include estimates for the Cement Production (CRF 2.A.1) category.

9.1.2.1.2 Methodological issues

9.1.2.1.2.1 Cement Production (CRF 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 9.19 Cement Production data and SO_2 emissions from Cement Production in the period 1989–2020

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

9.1.2.1.3 Uncertainties 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 2019.

9.1.2.1.4 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 Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were unconformities recorded.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the

European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

9.1.2.1.5 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.

9.1.2.1.6 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 (CRF 2.B)

9.1.2.2.1 Description of sources of indirect emissions in GHG inventory

The Chemical Industry subsector (CRF 2.B) includes the following categories: Ammonia Production (CRF 2.B.1), Nitric Acid Production (CRF 2.B.2), Adipic Acid Production (CRF 2.B.3) and Petrochemical and carbon black production (CRF 2.B.8).

9.1.2.2.2 Methodological issues

9.1.2.2.2.1 Ammonia Production (CRF 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.

Emission factors

CO emissions from ammonia production are estimated using the below equation.

Equation 9.3 CO emissions from ammonia production

$$CO\ [Gg] = Quantity\ of\ Ammonia\ Produced\ (t) \times Emission\ Factor \times 10^{-6}$$

SO_2 emissions from ammonia production are estimated using the below equation.

Equation 9.4 SO_2 emissions from ammonia production

$$SO_2\ [Gg] = Quantity\ of\ Ammonia\ Produced\ (t) \times Emission\ Factor \times 10^{-6}$$

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 9.20 Ammonia Production data and CO and SO_2 emissions from Ammonia Production in the period 1989–2020

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

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
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

9.1.2.2.2.2 Nitric Acid Production (CRF 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 2016-2019 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 2020 year there are currently two chemical plants, where four HNO_3 production facilities are in operation. 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;
- Starting with 2015, NOx emissions started to decrease due to the decrease of 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 9.21 Nitric Acid Production related to the NO_x emissions in the period 1989–2020

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
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

9.1.2.2.2.3 Adipic Acid Production (CRF 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 9.22 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 9.23 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 (CRF 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 9.24 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

Year	NOx emissions kt	CO emissions kt	NMVOC emissions kt	SO_2 emissions kt
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

9.1.2.2.3 Uncertainties and time-series consistency

9.1.2.2.3.1 Ammonia Production (CRF 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 2019.

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 2019.

9.1.2.2.3.2 Nitric Acid Production (CRF 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 2019.

9.1.2.2.3.3 Adipic Acid Production (CRF 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 2019.

9.1.2.2.3.4 Petrochemical and carbon black Production (CRF 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 2019.

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 2019.

9.1.2.2.4 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 Road transportation subsector, the results of these being mentioned on the Checklists level. Following these activities there were no unconformities recorded.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

9.1.2.2.5 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.

9.1.2.2.6 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 (CRF 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 (CRF 2.C.1), Aluminium Production (CRF 2.C.3) and Magnesium Production (CRF 2.C.4).

9.1.2.3.2 Methodological issues

9.1.2.3.2.1 Iron and Steel Production (CRF 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 9.25 NMVOC, NO_x, CO and SO_2 emissions for category CRF 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

9.1.2.3.2.2 Aluminium Production (CRF 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.

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 9.26 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 9.27 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

Year	SO_2 emissions kt	CO emissions kt
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
2020	0.173	76.980

9.1.2.3.2.3 Magnesium Production (CRF 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 (http://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/2-industrial-processes/2-c-metal-production/2-c-7-c-other/view).

Table 9.28 The SO_2 emissions from Magnesium Production

Year	SO_2 emissions, kt
2015	0.164

Year	SO_2 emissions, kt
2016	0.234
2017	0.208
2018	0.214
2019	0.311
2020	0.203

9.1.2.3.3 Uncertainties and time-series consistency

9.1.2.3.3.1 Iron and Steel Production (CRF 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 2019.

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 2019.

9.1.2.3.3.2 Aluminium Production (CRF 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 2019.

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 2019.

9.1.2.3.3.3 Magnesium Production (CRF 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 2019.

9.1.2.3.4 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 Road transportation subsector, the results of these being mentioned on the Checklists level. Following these activities there were no unconformities recorded.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

9.1.2.3.5 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.

9.1.2.3.6 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 (CRF 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 (CRF 2.D.3.b) and Asphalt roofing (CRF 2.D.3.c).

9.1.2.4.2 Methodological issues

9.1.2.4.2.1 Road Paving with Asphalt (CRF 2.D.3.b)

Methodology

The default CORINAIR emission inventory guidebook 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 CORINAIR emission inventory guidebook EF was used in order to estimate NMVOC emissions: 0.016 kg NMVOC/ tone material used.

Table 9.29 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	0.031

9.1.2.4.2.2 Asphalt Roofing Production (CRF 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 1996 and 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. These data are available starting with 2005 year. 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, asphalt board. 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 9.30 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 9.31 The CO and NMVOC emissions from Asphalt Roofing Production Sector

Year	Activity data kt	CO emissions kt	NMVOC emissions kt
1989	NE	NE	NE
1990	NE	NE	NE
1995	NE	NE	NE
2000	NE	NE	NE
2005	12.144	0.0001	0.03
2007	C	0.0000	0.01
2008	C	0.0000	0.01
2009	C	0.0000	0.01
2010	C	0.0000	0.01
2011	C	0.0009	0.24
2012	C	0.0003	0.09
2013	C	0.0000	0.00
2014	C	0.0001	0.033

Year	Activity data kt	CO emissions kt	NMVOC emissions kt
2015	C	0.0004	0.095
2016	C	0.0002	0.042
2017	C	0.0001	0.019
2018	C	0.0002	0.054
2019	C	0.0002	0.056
2020	C	0.0003	0.067

9.1.2.4.3 Uncertainties and time-series consistency

9.1.2.4.3.1 Road Paving with Asphalt (CRF 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 2019.

9.1.2.4.3.2 Asphalt Roofing Production (CRF 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 2019.

9.1.2.4.4 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 Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

9.1.2.4.5 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.

9.1.2.4.6 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 (CRF 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 (CRF 2.H.1), Food and beverages Industry (CRF 2.H.2). The activity data necessary to estimate these emissions are provided in the Statistical Yearbook.

9.1.2.5.2 Methodological issues

Methodology

According with 2006 IPCC Guidelines and 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 (CRF 2.H.1) Sub-sector the Pulp Production was broken down by kraft and acid sulphite processes. In the Food and Beverages Industry (CRF 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 (CRF 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 production of dried pulp took place. In the Food and Beverages Industry (CRF 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 Uncertainties 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 1989–2020.

9.1.2.5.4 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 Road transportation subsector, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

No recalculations were needed following the QA activities developed under the procedures for the compilation of the European Community GHG Inventory, described in the Regulation 525/2013 of the European Parliament and of the Council and Decision 166/2005/EC of the European Commission.

9.1.2.5.5 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.

9.1.2.5.6 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 (CRF 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 9.32 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 Uncertainties 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

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, including changes made in response to the review process and impact on emission trend

Were made recalculations due to of the update of the production and area for barley and of the change the areas burned due to of the update the amount of biomass burned. The changes impact are presented in the table below:

Table 9.33 The changes impacts on estimating emissions from Field Burning of Agricultural Residues

Year	The changes impacts on estimating NO_X and CO emissions from Field Burning of Agricultural Residues					
	NO_X and CO emissions from Field Burning of Agricultural Residues					
	NO_X			CO		
	NGHGI 2021	NGHGI 2022	Difference	NGHGI 2021	NGHGI 2022	Difference
1989	51.81865978	51.846605581	0.027945801	1354.194309	1354.924625	0.73
1990	49.36860888	49.397589568	0.028980688	1290.166312	1290.923674	0.76
1995	60.7043935	60.73389566	0.02950216	1586.408150	1587.179140	0.77
2000	98.19575882	93.36608231	-4.82967651	2566.182497	2439.966951	-126.22
2005	48.15299429	48.17988583	0.02689154	1258.398251	1259.101016	0.70
2007	90.73217279	90.79240494	0.06023215	2371.134116	2372.708182	1.57
2008	45.60972886	45.63769864	0.02796978	1191.934247	1192.665191	0.73
2009	49.82330040	49.85460885	0.03130845	1302.048917	1302.867111	0.82
2010	38.39557555	38.42162992	0.02605437	1003.404374	1004.085262	0.68
2011	38.85552094	38.87869085	0.02316991	1015.424281	1016.029788	0.61
2012	69.1184108	69.1578592	0.0394484	1806.294469	1807.325387	1.03
2013	40.93538759	39.05017245	-1.88521514	1069.778129	1020.511173	-49.27

Year	The changes impacts on estimating NO_X and CO emissions from Field Burning of Agricultural Residues					
	NO_X and CO emissions from Field Burning of Agricultural Residues					
	NO_X			CO		
	NGHGI 2021	NGHGI 2022	Difference	NGHGI 2021	NGHGI 2022	Difference
2014	38.79390152	36.93726758	-1.85663394	1013.813960	965.2939261	-48.52
2015	45.16554638	44.17189376	-0.99365262	1180.326279	1154.358824	-25.97
2016	38.96149559	38.98434323	0.02284764	1018.193751	1018.790836	0.60
2017	27.61584452	27.61216845	-0.00367607	721.6940702	721.5980023	-0.10
2018	24.12906371	24.61842061	0.4893569	630.5728649	643.3613919	12.79
2019	26.92616034	29.62553452	2.69937418	703.6703236	774.2139688	70.54

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 (CRF 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 9.34 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		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	102.6	50	1.44	0.7
2007	111.38	50	1.56	0.7
2008	114.53	50	1.6	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	154.88	50	2.17	0.7

9.1.4.1.2 Uncertainties 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, 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 2021 Greenhouse Gas Inventory submission and 2022 Greenhouse Gas Inventory submission. Since the 2021 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. The major changes in methodological descriptions in the present NIR, comparing to the NIR part of the 2021 NGHGI, are presented in Table 10.1.

Table 10.1 Major changes in methodological descriptions in the present NIR, comparing to the NIR part of the 2021 NGHGI

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**DESCRIPTION OF METHODS**	**RECALCULATIONS**	**REFERENCE**
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	**Please tick where this is also reflected in recalculations compared to the previous year CRF**	**If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc**
Total (Net Emissions)			
1. Energy			
A. Fuel Combustion (sectoral approach)			
1. Energy industries	√	√	Recalculations have been made for the 2007-2019 period due to taking into consideration in activity data provided from economic operators under EU-ETS for 1A1a, 1A1b and 1A1c categories. CO_2 - Subsections

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
			3.2.5.1 – 3.2.5.3 1.A.1.a, 1.A.1.b and 1.A.1.c categories.
2. Manufacturing industries and construction	√	√	Recalculations have been made for the 2007-2019 period due to taking into consideration in activity data provided from economic operators under EU-ETS for 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. CO_2 - Subsections 3.2.6.1 – 3.2.6.7 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.
3. Transport			
4. Other sector			
5. Other			
B. Fugitive emissions from fuels			
1. Solid fuels			
2. Oil and natural gas and other emissions from energy production	√	√	1.B.2.a.1, 1.B.2.a.6 subcategories – Subsection 3.3.3.2.1, 1.B.2.b.6 subcategory - Subsection 3.3.3.2.2
C. CO_2 transport and storage			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
2. Industrial processes and product use	√	√	
A. Mineral industry			
B. Chemical industry	√	√	2.B.8.a Methanol Production category, NIR Section 4.3.2.9
C. Metal industry			
D. Non-energy products from fuels and solvent use	√	√	2.D.3.a Solvent use, NIR Section 4.5.2.3
E. Electronic industry			
F. Product uses as substitutes for ODS	√	√	2.F.1.e Mobile Air-Conditioning category, NIR Section 4.7.2.1.5 2F.1.f Stationary air-conditioning category, NIR Section 4.7.2.1.6 2.F.3 Fire Protection category, NIR Section 4.7.2.3
G. Other product manufacture and use			
H. Other			
3. Agriculture			
A. Enteric fermentation			
B. Manure management			
C. Rice cultivation			
D. Agricultural soils			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	**Please tick where this is also reflected in recalculations compared to the previous year CRF**	**If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc**
E. Prescribed burning of savannahs			
F. Field burning of agricultural residues			
G. Liming			
H. Urea application			
I. Other carbon containing fertilisers			
J. Other			
4. Land use, land-use change and forestry			
A. Forest land	√	√	4.A.1 Forestland remaining Forestland, CO_2 emissions/removals, NIR Section 6.2.5 4.B.2 Land converted to Forestland, CO_2 emissions/removals, NIR Section 6.2.5. 4. (V) Biomass burning CO_2, CH_4, N_2O emissions/removals, NIR Section 6.10.5
B. Cropland	√	√	NIR 2022, march submission, section 6.1.7. Chapter 6.3.5

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	**Please tick where this is also reflected in recalculations compared to the previous year CRF**	**If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc**
C. Grassland	√	√	NIR 2022, march submission, section 6.1.7. Chapter 6.4.5
D. Wetlands	√	√	NIR 2022, march submission, section 6.1.7. Chapter 6.5.5
E. Settlements	√	√	NIR 2022, march submission, section 6.1.7. Chapter 6.6.5
F. Other land	√	√	NIR 2022, march submission, section 6.1.7. Chapter 6.7.5
G. Harvested wood products	√	√	4.G Harvest wood products, CO_2 emissions/removals, NIR Section 6.8
H. Other			
5. Waste			
A. Solid waste disposal			
B. Biological treatment of solid waste			
C. Incineration and open burning of waste			
D. Wastewater treatment and discharge			
E. Other			
6. Other (as specified in Summary 1.A)			
KP LULUCF			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	**Please tick where this is also reflected in recalculations compared to the previous year CRF**	**If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc**
Article 3.3 activities	√	√	Article 3.3 CO_2 emissions/removals, NIR Section 11.4.
Afforestation/reforestation	√	√	Article 3.3 CO_2 emissions/removals, NIR Section 11.4.
Deforestation	√	√	Article 3.3 CO_2 emissions/removals, NIR Section 11.4.
Article 3.4 activities	√	√	Article 3.3 CO_2 emissions/removals, NIR Section 11.5.
Forest management	√	√	Article 3.3 CO_2 emissions/removals, NIR Section 11.5.
Cropland management (if elected)			
Grazing land management (if elected)			
Revegetation (if elected)	√	√	Article 3.3 CO_2 emissions/removals, NIR Section 11.5.
Wetland drainage and rewetting (if elected)			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
NIR Chapter	DESCRIPTION		REFERENCE
	Please tick where the latest NIR includes major changes in descriptions compared to the previous year NIR		If ticked please provide some more detailed information for example reference to pages in the NIR
Chapter 1.2 Institutional arrangements			
Chapter 1.6 QA/QC plan			

10.1 Explanations and justifications for recalculations, including in response to the review process and for KP-LULUCF activities

10.1.1 GHG Inventory

Recalculations by categories

The inventory contains improvements in the following sectors:

<u>Energy</u>

- **Energy sector – Stationary Combustion**
- **Fuel combustion (1.A.)**

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

1. Activity data

Solid fuels

1.A.1.a Public Electricity and Heat Production category

- ✓ The recalculations for the *Other bituminous coal and Sub-bituminous coal* are due to, the use of activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Lignite* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the years 2007, 2008,. 2011, 2012, 2014, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2009, 2010, 2013 and the period 2015-2020; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.b Petroleum Refining category

- ✓ The recalculations for the *Lignite* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.e Food Processing, Beverages and Tobacco category

- ✓ The recalculations for the *Other bituminous coal* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the 2012-2017 period; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Coke oven coke* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, ETS consumptions, for the periods 2008-2011, 2013-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2007, 2012; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.f Non-Metallic Minerals category

- ✓ The recalculations for the *Other bituminous coal* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Lignite* are due to, the use of sum between the non-ETS and ETS consumptions for the period 2013-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Coke oven coke* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 2011-2014, 2017-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

Liquid fuels

1.A.1.a Public Electricity and Heat Production category

- ✓ The recalculations for the *Refinery gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 2007-2010, 2014-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the 2011-2013 period; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual fuel oil* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2011, 2012 and period 2014-2017, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2010 and years 2013, 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Petroleum coke* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2019 and period 2011-2016; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Heating and other gasoil* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme (the ETS consumptions) for the year 2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2018; in this case the CO_2, CH_4 and N_2O emissions are updated;

1.A.1.b Petroleum Refining category

- ✓ The recalculations for the *Refinery gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2007 and period 2009-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2008; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of sum between the non-ETS and ETS consumptions for the years 2014, 2015; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual fuel oil* are are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 207-2009, 2014-2018, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2010-2013 and year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Petroleum coke* are are due t, the use of sum between the non-ETS and ETS

consumptions for the year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.c Manufacture of Solid Fuels and Other Energy Industres category

- ✓ The recalculations for the *Transport diesel* are due to, the use of sum between the non-ETS and ETS consumptions for the periods 2007-2008, 2011-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;

1.A.2.a Iron and Steel category

- ✓ The recalculations for the *LPG* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions. for the year 2011 and period 2013-2017, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of sum between the non-ETS and ETS consumptions for the periods 2011-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.b Non Ferrous Metals category

- ✓ The recalculations for the *Residual fuel oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2007; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.c Chemicals category

- ✓ The recalculations for the *Refinery gas* are due to, the use of sum between the non-ETS and ETS consumptions for the period 2012-2014; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2015-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.d Pulp, Paper and Print category

- ✓ The recalculations for the *Residual fuel oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2008; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.e Food Processing, Beverages and Tobacco category

- ✓ The recalculations for the *LPG* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2013; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2017 and year 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual Fuel Oil* are due to, the use the activity data from monitoring

reports provided by the economic operators under the EU-ETS trading scheme. the ETS consumptions, for the years 2007, 2015, as well as, the use of the sum between the non-ETS and ETS consumptions for the periods 2008-2014, 2016-2017; in this case the CO_2, CH_4 and N_2O emissions are updated;

- ✓ The recalculations for the *Heating and Other Gasoil* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.f Non-Metallic Minerals category

- ✓ The recalculations for the *LPG* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2011 and period 2013-2016, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2017-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual Fuel Oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 2011-2015, 2017-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2008, 2016; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Petroleum Coke* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the periods 2008-2010, 2017-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2011-2016; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Heating and Other Gasoil* are due to because use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2011, 2012, 2015, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2016; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.g Other category

- ✓ The recalculations for the *Transport diesel* are due to, the use of the sum between the non-ETS and ETS consumptions for the years 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated;
- ✓ The recalculations for the *Residual Fuel Oil* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS

consumptions, for the years 2009, 2010, 2013, 2017, 2018, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2012, 2015; in this case the CO_2, CH_4 and N_2O emissions are updated;

- ✓ The recalculations for the *Heating and Other Gasoil* are due to, the use of the sum between the non-ETS and ETS consumptions for the periods 2011-2012, 2017-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

Gaseous fuels

1.A.1.a Public Electricity and Heat Production category

- ✓ The recalculations for the *Natural gas* are due to because use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the period 2013-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2012; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.b Petroleum Refining category

- ✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.1.c Manufacture of Solid Fuels and Other Energy Industres category

- ✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.a Iron and Steel category

- ✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.b Non Ferrous Metals category

- ✓ The recalculations for the *Natural gas* are due to, the use of the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the period 2007-2017, as well as, the use of the sum between the non-ETS and ETS consumptions for the years 2018, 2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.c Chemicals category

- ✓ The recalculations for the *Natural gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2012, 2014, 2018, 2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2011 and years 2013, 2015, 2016, 2017; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.d Pulp, Paper and Print category

- ✓ The recalculations for the *Natural gas* are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the years 2011, 2012, 2018, as well as, the use of the sum between the non-ETS and ETS consumptions for the periods 2007-2010, 2013-2017, 2019-2020; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.e Food Processing, Beverages and Tobacco category

- ✓ The recalculations for the *Natural gas* are due to, the use of the sum between the non-ETS and ETS consumptions for the period 2007-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.f Non-Metallic Minerals category

- ✓ The recalculations for the Natural gas are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2008, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2007 and period 2009-2019; in this case the CO_2, CH_4 and N_2O emissions are updated.

1.A.2.g Other category

- ✓ The recalculations for the Natural gas are due to, the use the activity data from monitoring reports provided by the economic operators under the EU-ETS trading scheme, the ETS consumptions, for the year 2007 and period 2009-2019, as well as, the use of the sum between the non-ETS and ETS consumptions for the year 2008; in this case the CO_2, CH_4 and N_2O emissions are updated.

Other fossil fuels

- The recalculations for the CRF 1.A.2.f category – other fossil fuels - Industrial waste are due to, the use only the ETS consumptions for the period 2007-2017, as well as, the use the non-ETS and ETS consumptions for the period 2018-2020; in this case the CO_2, CH_4 and N_2O emissions are updated.

2. Net Calorific Value

- For *1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction, 1.A.4 Other Sectors* and *1.A.5 Other (Not specified elsewhere) categories* for the 1990-2019 period, 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 *1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction*, *1.A.4 Other Sectors* and *1.A.5 Other (Not specified elsewhere) categories* for the 1990-2019 period, have been updated the CO_2 emission factors; this has been resulted in the update of CO_2, CH_4 and N_2O emissions.

4. CO_2 emissions

- ✓ In *1.A.2.a Iron and Steel category* for year 2019 was identified a transcription error in the CRF Reporter of the CO_2 emissions for the *other fossil fuels*.

✓ In *1.A.2.g Other category* for year 2019 was identified a transcription error in the CRF Reporter of the CO_2 emissions for the *other fossil fuels*.

➢ **<u>Transport (1.A.3)</u>**

➢ **Railways (1.A.3.c)**

Activity data:

- recalculations have been made for the 1989 – 2019 period, because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;

Emission factors:

- recalculations have been made for the 1989 – 2019 period, because the country specific emissions factors have been updated

***Emissions*:**

- recalculations of the CO_2, CH_4 and N_2O emissions for the 1989 - 2019 period have been made due to updates of the Activity Data, Net Calorific Values and National Emission Factors.

➢ **Domestic navigation (1.A.3.d)**

Activity data:

- recalculations have been made for the 1989 – 2019 period, because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;

Emission factors:

- recalculations have been made for the 1989 – 2019 period, because the country specific emissions factors have been updated;

***Emissions*:**

- recalculations of the CO_2, CH_4 and N_2O emissions for the 1989 - 2019 period have been made due to updates of the Activity Data, Net Calorific Values and National Emission Factors.

➢ **Other transportation (1.A.3.e)**

Activity data:

- recalculations have been made for the 1989 – 2019 period, because the activity data values from the IEA/Eurostat Questionnaire 2020 have been updated;

Emission factors:

- recalculations have been made for the 1989 – 2019 period, because the country specific emissions factors have been updated;

***Emissions*:**

- recalculations of the CO_2, CH_4 and N_2O emissions for the 1989 - 2019 period have been made due to updates of the Activity Data, Net Calorific Values and National Emission Factors.

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

Liquid Fuels

- ***Activity data***
  - Recalculations were made for the following fuels:
    - Gas/Diesel Oil (for 1999, 2001 and 2006 years), Residual Fuel Oil (for 1993, 1994, 1995, 1998, 1999, 2001 and 2006 years) and Refinery Gas (for 1992, 1993, 1994, 1999, 2004, 2005 and 2006 years) due to updating the activity data (the Net Calorific Values); this resulted in the updating of emissions for the 1992–2006 period.
    - Petroleum Coke (for the period 2007–2019) are due to including the activity data from monitoring reports provided by the economic operators under EU-ETS trading scheme, this resulted in the updating of emissions for the 2007–2019 period.

➢ **<u>Fugitive emissions from fuels (1.B)</u>**

➢ **Solid fuels (1.B.1) – Coal mining and handling - *Abandoned underground mines* (1.B.1.a.1.iii):**

Emissions:

- recalculations have been made for the 2015 - 2016 period, and for the year 2019 for CH_4, due to an error of transcription from the spreadsheet in the CRF tables, in subcategory 1.B.1.a.1.iii – Abandoned underground mines.

➢ **Oil and natural gas and other emissions from energy production (1.B.2):**

1) Oil (1.B.2.a)

❖ ***Oil - Exploration (1.B.2.a.1) subcategory:***

Activity data:

- recalculations of activity data values for 1992 – 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;

Emissions factors:

- the Default Emission Factor values for CO_2 and CH_4, for 1989-1999 period have been modified, according to the 2006 IPCC GL for "Flaring and Venting", volume 2, chapter 4.2.2.3, page 4.55, Table 4.2.5; also, for 2000 – 2020 period, the Default Emission Factor values for CO_2 and CH_4 have been modified according to the 2006 IPCC GL for "Flaring and Venting", volume 2, chapter 4.2.2.3, page 4.48, Table 4.2.4;

Emissions:

- recalculations of the CO_2 emissions and CH_4 emissions for the 1989 - 2019 period have been made due to improvements of the Activity Data and Default Emission Factors.

❖ ***Oil - Production (1.B.2.a.2) subcategory:***

Emissions:

- recalculations of the CO_2 emissions for the 1992 - 2019 period have been made due to update of the Activity Data.

❖ ***Oil - Transport (1.B.2.a.3) subcategory:***

Activity data:

- recalculations of activity data values for 1989, 1995 – 2008 period and 2015 – 2018 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;

Emissions:

- recalculations of the CO_2 emissions and CH_4 emissions for the year 1989 have been made due to update of the Activity Data.

❖ ***Oil - Other (1.B.2.a.6) subcategory:***

Activity data:

- recalculations of activity data values for 2007 - 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been improved and combined with data from the refineries operators, and higher tier were used;

Emissions:

- recalculations of the CO_2 emissions for the 2007 - 2019 period have been made due to update of the Activity Data.

2) Natural Gas (1.B.2.b):

❖ ***Natural gas – Transmission and storage (1.B.2.b.4) subcategory:***

Activity data:

- recalculations of activity data values for 2016 and 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;

Emissions:

- recalculations of the CH_4 emissions for the 2001 - 2019 period have been made due to updates of the Activity Data.

❖ ***Natural gas - Other (1.B.2.b.6) subcategory:***

Activity data:

- recalculations of activity data values for 2007 - 2019 period have been made because the activity data values from the IEA/Eurostat Questionnaire 2020 have been revised;

Emissions:

- recalculations of the CH_4 emissions for the 2007 - 2019 period have been made due to updates of the Activity Data.

Industrial Processes And Product Use

- **Ammonia production (2.B.1)**
  - Recalculations have been made for the 2019 year due to the recalculation of the values for NCV and EFox for natural gas (errors were identified in the calculation formulas for NCV and EFox for this year).
- **Methanol Production (2.B.8.a)**
  - Recalculations of CO_2 emissions from methanol production for the 1989-2014 and 2018-2019 periods:
    - for the years 2013, 2014, 2018 and 2019, by choosing the tier 2 approach by using EU-ETS data on methanol production and CO_2 emissions (calculated on the basis of mass balance);
    - for the period 1989-2012, by using the IEF calculated for 2014 (emission / activity data) from EU-ETS data.
  - Recalculations of CH_4 emissions for 2014 and 2018 due to the improvement of activity data by taking into account EU-ETS data.
- **Other – Petroleum coke use (2.D.3.d)**
  - Recalculations have been made for the 2019 year due to the recalculation of the values for NCV and EFox for petroleum coke (errors were identified in the calculation formulas for NCV and EFox for this year).
- **Solvent use (2.D.3.a)**
  - Recalculations have been made for the 1990-2019 period. Recalculations were made as a result of due to an improvement in activity data for 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 under Directive 2001/81/EC and under the UNECE Convention on Long-range Transboundary Air Pollution.
- **Mobile Air-Conditioning (2.F.1.e)**
  - Recalculations of the HFC emissions have been made for the 1996-2019 period due to improvement in activity data for the rail transport (an operator transmitted data for these years).
- **Stationary air-conditioning (2.F.1.f)**
  - Recalculations have been made for the period 2015-2019 due to the change in the disposal loss factor used to estimate the actual emissions from disposal (the default recovery assumption of 85% was adopted).
- **Fire protection (2.F.3)**
  - Recalculations have been made for the 2009-2019 period due to improvement in activity data

regarding the quantity of banks in the fire protection equipments.

Agriculture

- **Rice cultivation (3C)**

Was made recalculations for 2019 for CH_4 emissions for following reason:

- due to of the transcription error of the area of the rice.

- **Direct N_2O emissions from Managed soils (3D.1)**

Was made recalculations for 2019 for N_2O emissions for following reason:

- due to transcription errors of the N bedding which is the 0 value use in the calculation amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes for pigs fattening;
- due to of the update of the production and area for barley.

Was made recalculations for the 1989-2019 period for N_2O emissions for following reason:

- due to of the change the areas burned due to of the update the amount of biomass burned.

- **Indirect N_2O emissions from Managed soils (3D.2)**

Was made recalculations for the 2019 period for indirect N_2O emissions for following reason:

- due to transcription errors of the N bedding which is the 0 value use in the calculation amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes for pigs fattening;
- due to of the update of the production and area for barley.

Was made recalculations for the 1989-2019 period for indirect N_2O emissions for following reason:

- due to of the change the areas burned due to of the update the amount of biomass burned.

- **CH_4 and N_2O emissions from Field burning of agricultural residues (3F)**

Was made recalculations for the 1989-2019 period for N_2O emissions for following reason:

- due to of the change the areas burned due to of the update the amount of biomass burned.

Land use, land-use change and forestry

- **Forestland (4.A)**

CO_2, N_2O, CH_4

New L-FL and FL-L conversions areas have been estimated for the all-time series. Much smaller sizes reported for both L-FL and FL-L categories for 2022 submission have driven a decrease in CO2 stock in the FLFL.

- **Cropland (4.B)**

CO_2, N_2O

The changes in absolute values of the GHG emission/removal levels, are due to a basket of variables/

drivers, respectively: (i) explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies; (ii) estimation of EF, soil carbon pool; (iii) re-estimation of the parameters specific to carbon pools, LB and DOM; (iv) re-estimation of direct N_2O emissions from the mineralization of organic carbon in the soil, Land converted to cropland.

- **Grassland (4.C)**

CO_2, N_2O

The changes in absolute values of the GHG emission/removal levels, are due to a basket of variables/drivers, respectively: (i) explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies; (ii) for soil carbon pool, estimation of EF as country specific parameters; (iii) re-estimation of the parameters specific to carbon pools, LB and DOM. The impact of the above changes on the time trend has generated negative emissions, removals. All these methodological changes have resulted in reduced emissions for the entire time period, 1989-2019, compared with the previous submission. The reasons and justifications for the category-specific recalculations are to mainly improve accuracy and consistency.

- **Wetlands (4.D)**

CO_2, N_2O

The changes in absolute values of the GHG emission/removal levels, are due to a basket of variables/drivers, respectively: (i) explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2007-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies; (ii) re-estimation of the parameters specific to carbon pools, LB and DOM. The impact of the above changes on the time trend has generated negative emissions, removals. All these methodological changes have resulted in reduced emissions for the entire time period, 1989-2019, compared with the previous submission. The reasons and justifications for the category-specific recalculations are to mainly improve accuracy and consistency.

- **Settlements (4.E)**

CO_2, N_2O

The changes in absolute values of the GHG E(+)/R(-) levels, are due to a basket of variables/drivers, respectively: (i) explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies; (ii) re-estimation of the parameters specific to carbon pools, LB and DOM. The impact of the above changes on the time trend has resulted in a 45% lower emission level compared to the previous submission. The reasons and justifications for the category-specific recalculations are to mainly improve accuracy and consistency.

- **Other land (4.F)**

CO_2, N_2O

The changes in absolute values of the GHG emission/removal levels, are due to a basket of variables/ drivers, respectively: (i) explicit geospatial maps, approach 3, by updating AD(kha) surfaces using LPIS/IACS [2008-2019] and CLC [reference year 1990; 2006; 2012; 2018] technologies; (ii) re-estimation of the parameters specific to carbon pools, LB and DOM. The impact of the above changes on the time trend has significantly contributed to the major reduction in emission levels compared to the previous submission. The reasons and justifications for the category-specific recalculations are to improve accuracy.

- **Harvested wood products (4.G)**

CO_2

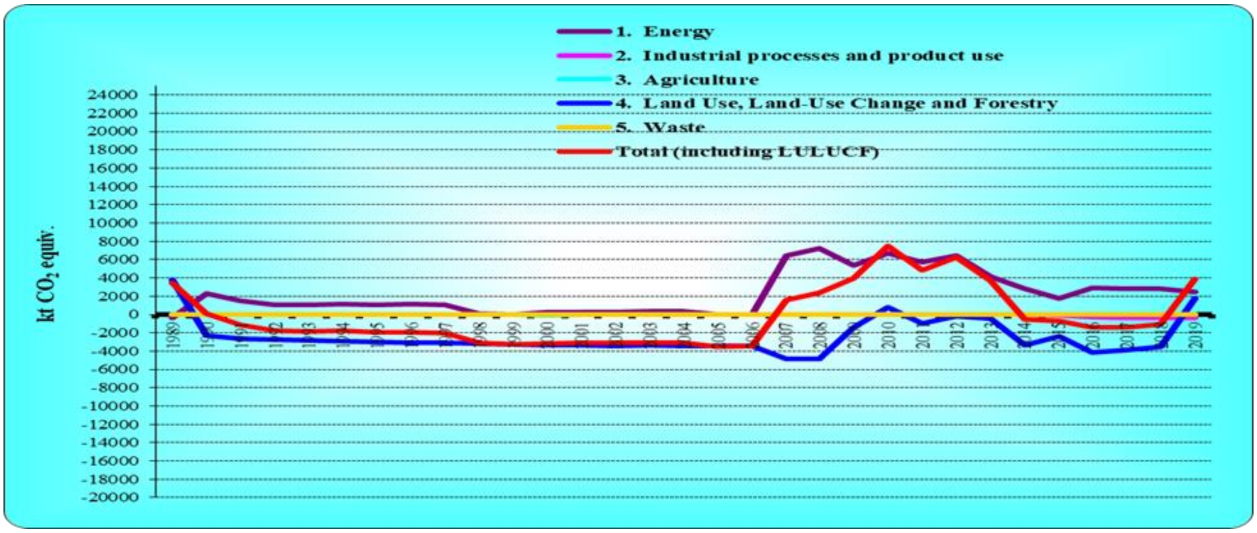
Updated to AD from FAOSTAT on all wood products categories. Updated the eq. of the annual fraction of feedstock (fDP) to eq.2.8.1 and 2.8.2 of the KP supplement applied to respective input data and a carbon conversion factor to table 2.8.1 of the Kp supplement.

carbon conversion factor to table 2.8.1 of the Kp supplement.

<u>Waste</u>

- **Anaerobic digestion at biogas facilities (5.B)**
  - CH_4 emissions from anaerobic digestion at biogas plants have been estimated for the first time.
- **Waste Incineration and Open Burning of Waste (5.C)**
  - The CH_4 and N_2O emissions associated to biogenic waste were recalculated for 2009-2019 period due to the amounts of sludge incinerated without energy recovery provided by the operators.
  - CO_2 emissions from Incineration of other organic waste were estimated for the first time.
- **Wastewater Treatment and Discharge (5.D)**
  - Recalculations have been performed for CH_4 emissions from domestic and commercial wastewater, for the 2018-2019 years, at the level of MCF-centralised WWTP. The values have been changed from 0.0152 for centralised aerobic treatment to updated values derived from the UWWTD website for 2018 -2019 years. For 2017-2019 period data regarding total population are updated by NIS.
  - For the calculation of indirect N_2O emissions from 5D1 the final data associated to protein consumption were updated by NIS for 2019 year (the value was exchanged from 43.11 kg protein/person/yr to 42.96 kg protein/person/yr). For 2017-2019 period data regarding total population are updated by NIS.

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 2021 submission



Recalculations by gases

<u>CO_2 recalculations</u> were carried out in the following sectors:

- Fuel combustion – Sectoral Approach (CRF 1.A);
- Energy Industry sub-sector (CRF 1.A.1);
- Public Electricity and Heat Production (CRF 1.A.1.a);
- Petroleum Refining (CRF 1.A.1.b);
- Manufacture of Solid Fuels and Other Energy Industries (CRF 1.A.1.c);
- Manufacturing Industries and Construction (CRF 1.A.2);
- Iron and Steel (CRF 1.A.2.a);
- Non Ferrous Metals (CRF 1.A.2.b);
- Chemicals (CRF 1.A.2.c);
- Pulp, Paper and Print (CRF 1.A.2.d);
- Food Processing, Beverages and Tobacco (CRF 1.A.2.e);
- Non-Metallic Minerals (CRF 1.A.2.f);
- Other (CRF 1.A.2.g);
- Transport – Railways (CRF 1.A.3.c);
- Transport – Domestic Navigation (CRF 1.A.3.d);
- Transport – Other transportation (CRF 1.A.3.e);
- Other sectors (commercial/institutional, residential, agriculture/ forestry/ fisheries) (CRF 1.A.4);

- Other (Not specified elsewhere) (CRF 1.A.5);
- Fugitive emissions - Oil and Natural Gas – Oil - Exploration (CRF 1.B.2.a.1);
- Fugitive emissions - Oil and Natural Gas – Oil - Production (CRF 1.B.2.a.2);
- Fugitive emissions - Oil and Natural Gas – Oil - Transport (CRF 1.B.2.a.3);
- Fugitive emissions - Oil and Natural Gas – Oil - Other (CRF 1.B.2.a.6);
- Feedstocks and non-energy use of fuels (CRF 1.AD);
- Ammonia production (CRF 2.B.1);
- Methanol production (CRF 2.B.8.a);
- Solvent Use (2.D.3.a);
- Other – Petroleum coke use (CRF 2.D.3.d);
- Forest Land (CRF 4.A);
- Cropland (CRF 4.B);
- Grassland (CRF 4.C);
- Wetlands (CRF 4.D);
- Settlements (CRF 4.E);
- Other land (CRF 4.F);
- Harvested Wood Products (HWP) (CRF 4.G);
- Waste Incineration and Open Burning of Waste (CRF 5.C);

CH_4/N_2O recalculations were carried out in the following sectors:

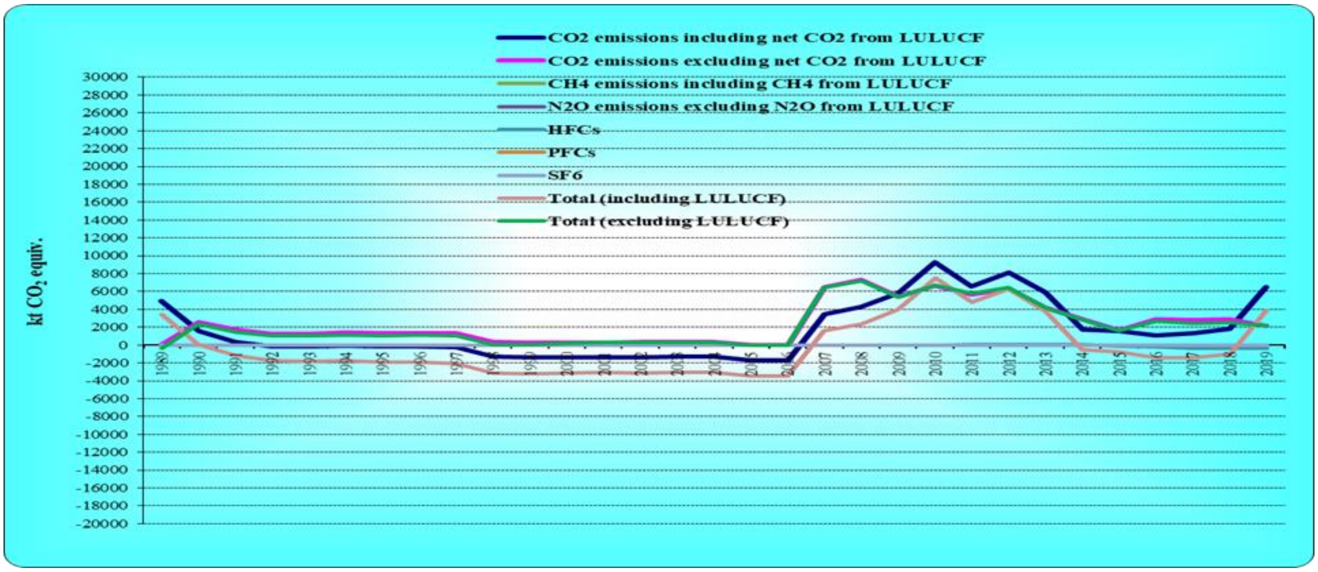
- Fuel combustion – Sectoral Approach (CRF 1.A);
- Energy Industry sub-sector (CRF 1.A.1);
- Public Electricity and Heat Production (CRF 1.A.1.a);
- Petroleum Refining (CRF 1.A.1.b);
- Manufacture of Solid Fuels and Other Energy Industries (CRF 1.A.1.c);
- Manufacturing Industries and Construction (CRF 1.A.2);
- Iron and Steel (CRF 1.A.2.a);
- Non Ferrous Metals (CRF 1.A.2.b);
- Chemicals (CRF 1.A.2.c);
- Pulp, Paper and Print (CRF 1.A.2.d);
- Food Processing, Beverages and Tobacco (CRF 1.A.2.e);
- Non-Metallic Minerals (CRF 1.A.2.f);
- Other (CRF 1.A.2.g);
- Transport – Railways (CRF 1.A.3.c);

- Transport – Domestic Navigation (CRF 1.A.3.d);
- Transport – Other transportation (CRF 1.A.3.e);
- Other sectors (commercial/institutional, residential, agriculture/ forestry/ fisheries) (CRF 1.A.4);
- Other (Not specified elsewhere) (CRF 1.A.5);
- Feedstocks and non-energy use of fuels (CRF 1.AD);
- Fugitive emissions - Solid fuels – Coal mining and handling – Underground mines (CRF 1.B.1.a.1.iii);
- Fugitive emissions - Oil and Natural Gas – Oil - Exploration (CRF 1.B.2.a.1);
- Fugitive emissions - Oil and Natural Gas – Oil - Transport (CRF 1.B.2.a.3);
- Fugitive emissions - Oil and Natural Gas – Natural Gas – Transmission and storage (CRF 1.B.2.b.4);
- Fugitive emissions - Oil and Natural Gas – Natural Gas - Other (CRF 1.B.2.b.6);
- Methanol production (CRF 2.B.8.a);
- Rice cultivation (3C);
- Direct N_2O emissions from Managed solis (CRF 3.D.1);
- Indirect N_2O emissions from Managed solis (CRF 3.D.2);
- CH_4 and N_2O emissions from Field burning of agricultural residues (3F);
- Forest Land (CRF 4.A);
- Cropland (CRF 4.B);
- Grassland (CRF 4.C);
- Wetlands (CRF 4.D);
- Settlements (CRF 4.E);
- Other land (CRF 4.F);
- Anaerobic digestion at biogas facilities (CRF 5.B);
- Waste Incineration and Open Burning of Waste (CRF 5.C);
- Wastewater Treatment and Discharge (CRF 5.D).

HFC/PFC/SF_6 recalculations were carried out in the following sectors:

- Mobile air-conditioning (CRF 2.F.1.e);
- Stationary air-conditioning (CRF 2.F.1.f);
- Fire protection (CRF 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 2021 submission



10.1.2 KP-LULUCF inventory

Recalculations by categories

- Changes applied to the reported areas under the UNFCC, this submission, implied update the activities areas under the article 3.3 and 3.4. The time series stating with 1989 was revised as well for activity area, but also implied recalculation on emission. Changes by category are discussed in section 11.3.1.4 of NIR.

Recalculations by gases

Not applicable.

10.2 Implications for emissions levels, including on KP-LULUCF emissions levels

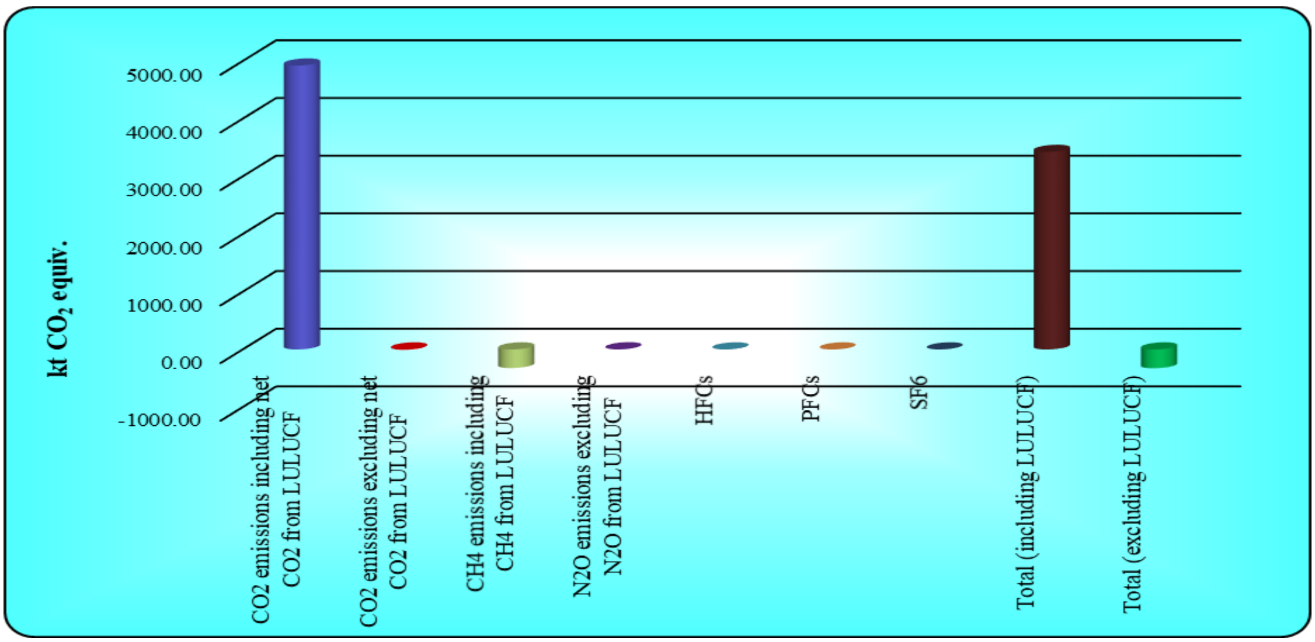
10.2.1 GHG inventory

Emissions changes due to recalculations, for 1989, are as follows:

- CO_2 including LULUCF (2.67%), CO_2 excluding LULUCF (-0.003%);
- CH_4 including and excluding LULUCF (-0.49%);
- N_2O including LULUCF (-4.29%), N_2O excluding LULUCF (0.01%);

- HFC (0.00%);
- PFC (0.00%);
- SF_6 (0.00%);
- Total GHG including LULUCF (1.21%);
- Total GHG excluding LULUCF (-0.11%).

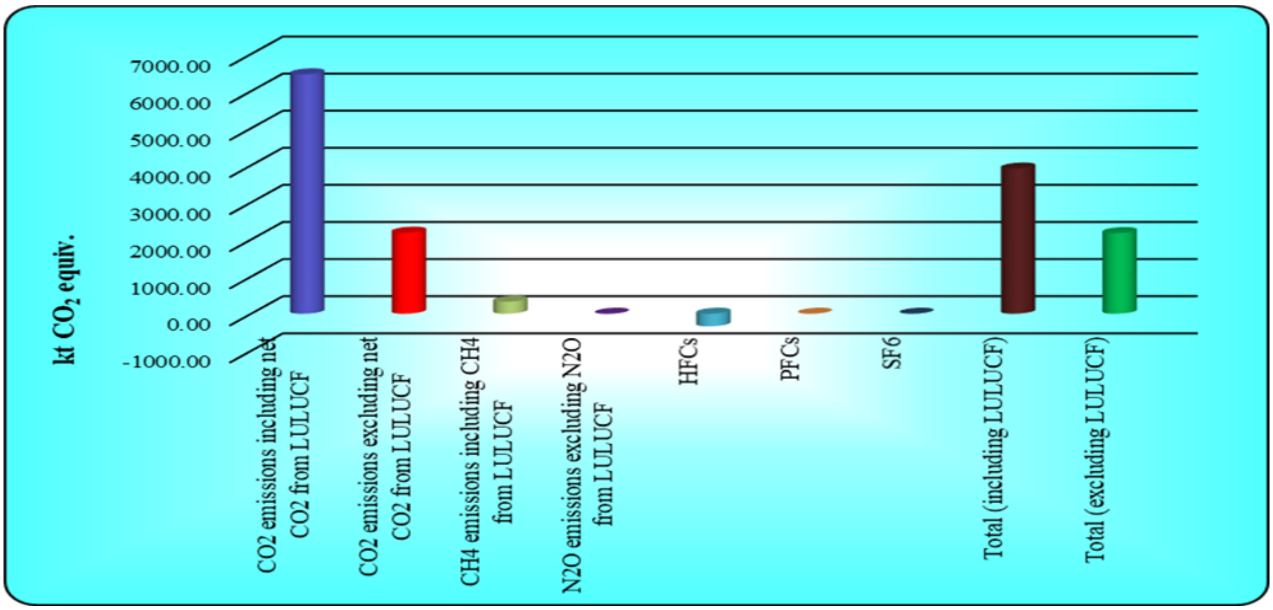
Figure 10.3 Effects of recalculations (presented in the 2022 submission) for 1989, by gas



Emissions changes due to recalculations, for 2019, are as follows:

- CO_2 including LULUCF (15.34%), CO_2 excluding LULUCF (2.92%);
- CH_4 including LULUCF (1.42%), CH_4 excluding LULUCF (1.44%);
- N_2O including LULUCF (-17.79%), N_2O excluding LULUCF (-0.03%);
- HFC (-15.02%);
- PFC (0.00%);
- SF_6 (0.00%);
- Total GHG including LULUCF (4.80%);
- Total GHG excluding LULUCF (1.94%).

Figure 10.4 Effects of recalculations (presented in the 2022 submission) for 2019, by gas



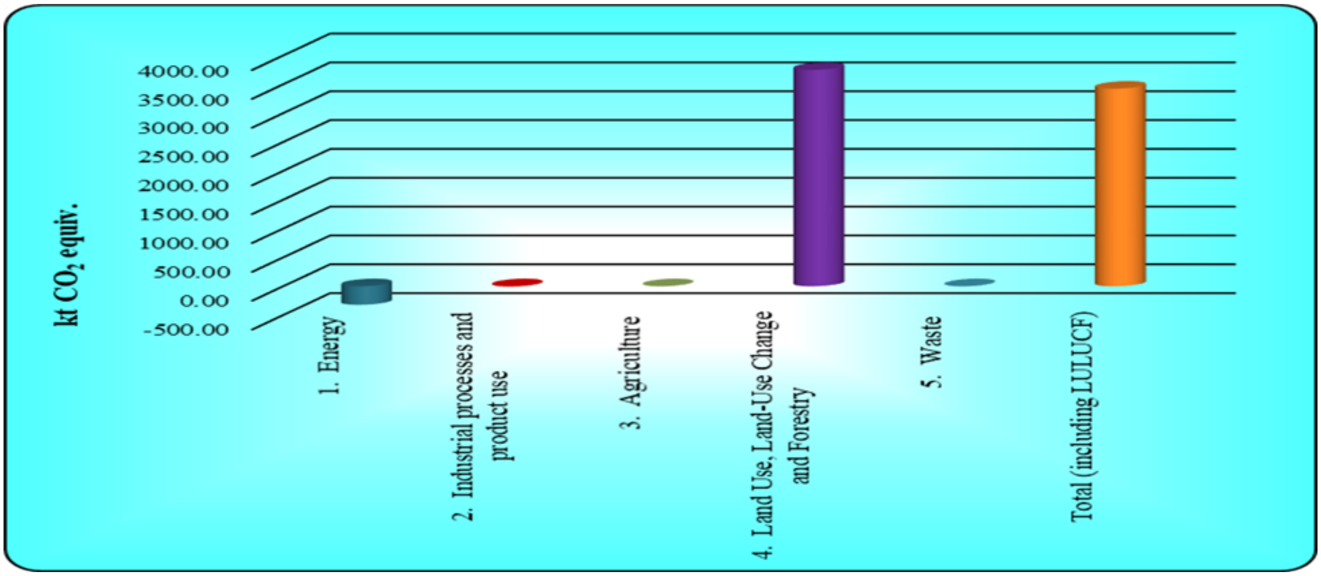
Impacts on 1989 emissions levels

Total emissions in 1989, including LULUCF have increased with 1.21% compared to the 2021 submission.

Table 10.2 Recalculation of total emissions/removals, by sector, for all gases, for 1989

Differences for 1989 estimates	Differences		2022	2021
	kt CO_2 eq.	%	kt CO_2 eq.	kt CO_2 eq.
1. Energy	-320.69	-0.15	217,441.87	217,762.56
2. Industrial Processes and Product Use	-5.26	-0.01	46,047.50	46,052.76
3. Agriculture	0.35	0.00	38,358.51	38,358.15
4. Land Use, Land-Use Change and Forestry	3,750.60	-14.88	-21,456.19	-25,206.79
5. Waste	0.00	0.00	5,197.85	5,197.85
Total (including LULUCF)	3,425.01	1.21	285,589.53	282,164.52

Figure 10.5 Changes of 1989 emissions/removals, in respect to the 2022 figures



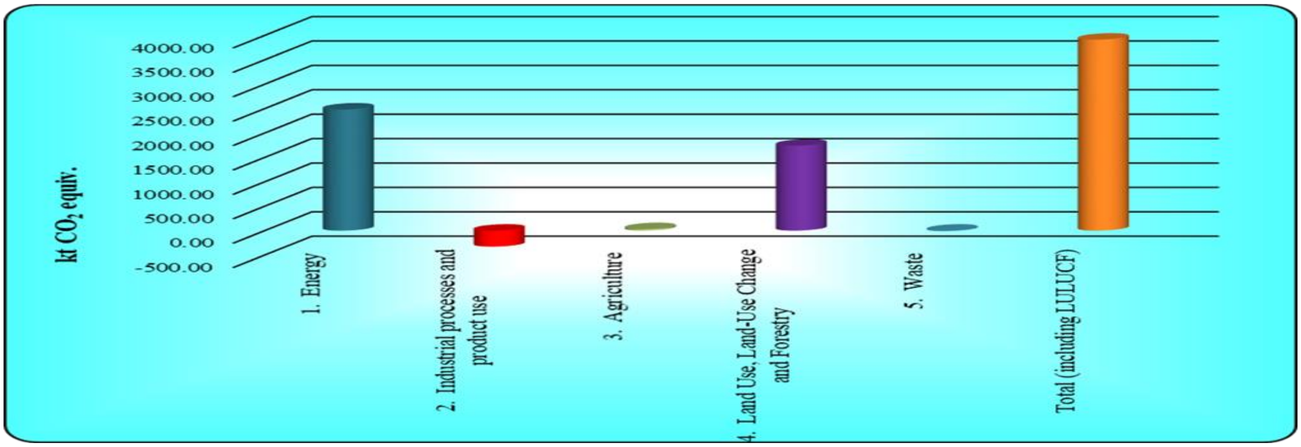
Impacts on 2019 emissions levels

Total emissions in 2019, including LULUCF have increased with 4.80% compared to the 2021 submission.

Table 10.3 Recalculation of total emissions/removals, by sector, for all gases, for 2019

Differences for 2019 estimates	Differences		2022	2021
	kt CO_2 eq.	%	kt CO_2 eq.	kt CO_2 eq.
1. Energy	2,481.12	3.36	76,350.44	73,869.32
2. Industrial Processes and Product Use	-327.72	-2.50	12,786.25	13,113.98
3. Agriculture	30.75	0.16	18,861.24	18,830.49
4.Land Use, Land-Use Change and Forestry	1,740.03	-5.76	-28,476.68	-30,216.71
5. Waste	-11.82	-0.20	5,941.45	5,953.27
Total (including LULUCF)	3,912.36	4.80	85,462.70	81,550.34

Figure 10.6 Changes of 2019 emissions/removals, in respect to the 2022 figures



10.2.2 KP-LULUCF inventory

Not applicable.

10.3 Implications for emissions trends, including time series consistency, and also for KP-LULUCF trends and time series consistency

10.3.1 GHG inventory

The time-series consistency has been improved as a result of recalculations.

10.3.2 KP-LULUCF inventory

Not applicable.

10.4 Planned improvements, including in response to the review process and for the KP-LULUCF activities

10.4.1 GHG inventory

The planned improvements for GHG Inventory activities are presented in table below:

Table 10.4 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 (CRF 1.A)	***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 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	Addressing	2027 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		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.		
2.	Road transportation (CRF 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	2024 inventory
3.	Road transportation (CRF 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	2024 inventory
Industrial processes and product use				
1.	Non-energy products from fuels and solvent use (CRF 2.D)	Improve the estimation of CO_2 emissions from the use of urea as a catalyst in SCR systems under 2.D.3 category.	Addressing	2024 inventory
Agriculture				
1.	Source category Enteric Fermentation (CRF 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 2023 inventory
2.	Source category Manure Management (CRF 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 (CRF 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 (CRF 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 (CRF	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 (CRF 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 (CRF 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 (CRF sector 5.D)	In order to improve the next submission, we will try to obtain more detailed data in respect to IPCC 2006.	Addressing	2023 inventory
LULUCF				
1.	Forest Land (CRF sector 4.A.)	Regarding the activity data: Improvement of the spatial and temporal scale resolution of geospatial products used to retrieve reported areas, such as: - continue the digitization of historical maps into area marginal to forest were conversion apparently (initial studies) occurred. - cross check areas classified under conversion from the remote sensing analysis data with local authorities. - improve the point sampling scheme for conversion areas (currently 100 x100 m). Regarding the emission factors:	Addressing	2023 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		- revise the EF for soil carbon on land under conversion to Forestland Overall improvements to the forestland category: - estimate E/R from DOM and SOC to whole time series;		
2.	Forest Land (CRF sector 4.A.)	Regarding the activity data: Improvement of the spatial and temporal scale resolution of geospatial products used to retrieve reported areas, such as: - continue the digitization of historical maps into area marginal to forest were conversion apparently (initial studies) occurred. - cross check areas classified under conversion from the remote sensing analysis data with local authorities. - improve the point sampling scheme for conversion areas (currently 100 x100 m). Regarding the emission factors: - revise the EF for soil carbon on land under conversion to Forestland Overall improvements to the forestland category: - estimate E/R from DOM and SOC to whole time series;	Addressing	2023 inventory
3.	Cropland (CRF sector 4.B.)	- interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period; - methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete; - eview of SOC parameters in CL; not all transitions are estimated and the values used for the land use Ata were not transparent; update and revise calculations in the SOC carbon pool, where necessary. To improve	Addressing	2023 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		the country specific estimates for emission factors, during the year of 2022 will be measure soil organic carbon in mineral soils in selected survey areas. This will allow to refine the CS parameters developed in 2020-2021; - estimation of the country specific emission factors for the soil carbon pool in organic soils, during the year of 2022 will be use measured data by estimating the response ratio of the measured SOC values in comparison with the reference SOC values. The soil organic carbon content in organic soils in selected survey areas will be measured; - additional QA/QC elements to prevent issues like inconsistency in the time serie that regard AD(kha), in compliance with 20 year transition period.		
4.	Grassland (CRF sector 4.C.)	- interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period; - methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete; - update and revise calculations in the SOC carbon pool, where necessary. To improve the country specific estimates for emission factors, during the year of 2022 will be measure soil organic carbon in mineral soils for Grassland category in selected survey areas. This will allow to refine the CS parameters developed in 2021. Also for estimation of the country specific emission factors (FInput), the methodology for evaluation at the Territorial Administrative Unit level of the production and processing potential in agriculture be used;	Addressing	2023 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		- estimation of the country specific emission factors for the soil carbon pool in organic soils, during the year of 2022 will be use measured data by estimating the response ratio of the measured SOC values in comparison with the reference SOC values. Will be measure the soil organic carbon content in organic soils in selected survey areas; - additional QA/QC elements to prevent issues like inconsistency in the time serie that regard AD(kha), in compliance with 20 year transition period.		
5.	Wetlands (CRF sector 4D)	- interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period; - methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete; - update and revise calculations in the SOC carbon pool, where necessary; - estimation of the country specific emission factors for the soil carbon pool in organic soils, during the year of 2022 will be use measured data by estimating the response ratio of the measured SOC values in comparison with the reference SOC values. Will be measure the soil organic carbon content in organic soils in selected survey areas; - additional QA/QC elements to prevent issues like inconsistency in the time serie that regard AD(kha), in compliance with 20 year transition period.	Addressing	2023 inventory
6.	Settlements (CRF sector 4E)	- interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period; - methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete;	Addressing	2023 inventory

No.	Category subject to improvement	Description of improvement	Status of implementation	Deadline for implementation
		- update and revise calculations in the SOC carbon pool, where necessary; - additional QA/QC elements to prevent issues like inconsistency in the time serie that regard AD(kha), in compliance with 20 year transition period.		
7.	Other land (CRF sector 4F)	- interrogation of explicit geospatial maps/data, using of CLC+, 1990-2006 time period; - methodology review of DOM. Calculating CSC to ensure that estimates are accurate and complete; - update and revise calculations in the SOC carbon pool, where necessary; - additional QA/QC elements to prevent issues like inconsistency in the time serie that regard AD(kha), in compliance with 20 year transition period.	Addressing	2023 inventory
8.	Harvested Wood Products (HWP) (CRF sector 4G)	- Update to the methodology described in the 2019 Refinement (currently implement the 2006 IPCC GL in combination with KP Supplement)	Addressing	2023 inventory

In the interest of improving LULUCF E(+)/R(-) estimates the used input parameters and applied methods are continuously re-evaluated. A number of potential future improvements have been identified, which will be considered for inclusion in future NGHGI submissions. These include:

- regarding the FL category, additional data checks and improvements of AD and EF are considered for the next NGHGI submissions;
- interrogation of explicit geospatial maps, datasets, respectively using of CLC+ as a source of maps;
- 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;
- Cropland improvements for mineral soils: to improve the CS estimates for EFs, during the year of 2022 will be measured soil organic carbon in mineral soils, in selected survey areas. This will allow

to refine the CS parameters developed in 2020-2021 years for CL;

- Grassland improvements for mineral soils: to improve the CS estimates for EFs, during the year 2022 will be measured soil organic carbon in mineral soils, in selected survey areas. This will allow to refine the country specific parameters developed in 2021 year for GL. Also, for estimation of the CS EFs (FInput), the methodology for evaluation at the Territorial Administrative Unit level of the production and processing potential in agriculture will be used;
- planned improvements for organic soils: for estimation of the CS EFs for the soil carbon pool in organic soils, during 2022 year measured data for estimating the response ratio of the measured SOC values in comparison with the reference SOC values, will be used. The soil organic carbon content in organic soils, in selected survey areas under CL, GL and WL categories will be measured;
- additional QA/QC elements to prevent issues like time series inconsistency that regard AD(kha), in compliance with 20 year transition period.

10.4.2 KP-LULUCF inventory

Not applicable.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 KP-LULUCF

11.1 General information

As part of the Kyoto Protocol (KP), Romania submits information on land-use, land-use change, and forestry (LULUCF) that is supplementary to what is contained in the report under the UNFCCC (i.e., section 6). Information regarding the forest and GHG estimation methods already described under the UNFCCC, which are also applied under the KP, will be referenced in section 6 of the NIR. Romania started to report initial information regarding KP-LULUCF activities in its initial KP Report of the Kyoto Protocol, available at:
https://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/application/pdf/romanias_initial_report_under_the_kyoto_protocol.pdf

11.1.1 Definition of the forest and any other criteria

Romania's forest definition to report the elected activities under the KP uses the same thresholds as in the Forestland category described in section 6 under the UNFCCC and the Initial Report. The forest definition has not changed between the first and second commitment periods under the KP. ***According to the above, forests*** include areas covered by woody vegetation larger than 0.25 hectares with a minimum tree height of 5 meters at maturity, a canopy cover of more than 10 percent and a minimum of 20 m. It also includes lands that are partially or entirely, but temporarily, without tree cover, areas under regeneration (e.g., clear-cut regions and areas affected by natural disturbances), see Table 11.1.

Table 11.1 Selected parameters defining forest in Romania under UNFCCC and KP

Parameter	Chosen value	Justification
Minimum land area	0.25 ha	The minimum parcel area included in the forest management plans; also includes minimum forest areas reported by NFI – regulated by national Law No. 46/2008

Parameter	Chosen value	Justification
Minimum with of forest area	20 m	It is defined in the NFI methodology.
Minimum tree crown cover value	10%	It is defined in the NFI methodology.
The minimum tree height value	5 m	It is defined in the NFI methodology.

The Forest land category contains areas covered by woody vegetation that temporarily do not meet the minimum above thresholds but are expected to reach them in the future. Other lands not covered by trees, yet under forest management, including forest roads, water bodies, and administrative areas, are not included in the Forest land category. The above-elected definitions match those applied in the forest inventory and forest management plans and are reported to FAO statistics.

11.1.2 Elected activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol

In addition to the mandatory categories under Article 3, paragraph 3 (i.e., **afforestation and reforestation, A/R, and deforestation, D)**, and under paragraph 4 (i.e., **forest management, FM)** Romania elected the activity **revegetation (Rv)** under Art.3, paragraph 4 in the first commitment period (CP). Forest management and Revegetation activities in the first commitment period under the KP continued to be accounted for during the second CP. The accounting will be done at the end of the second commitment period.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

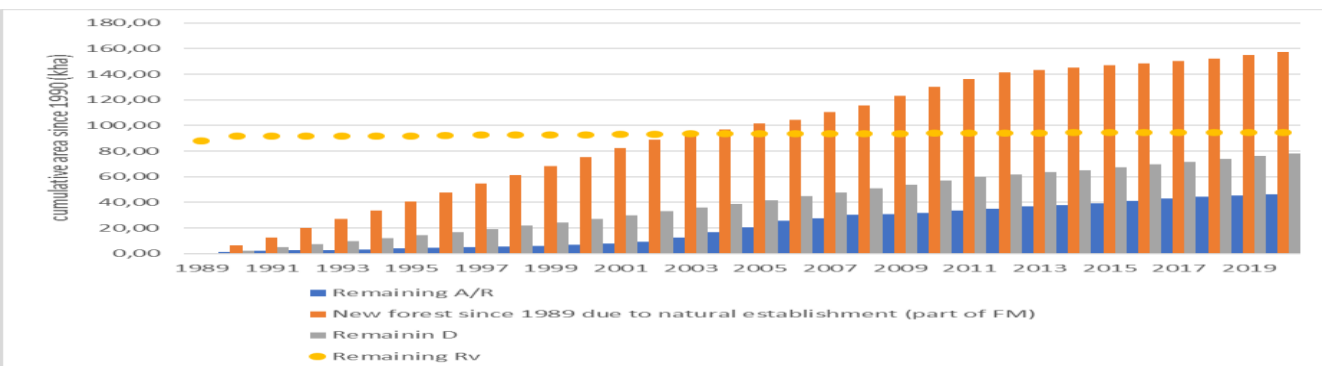
Romania implements a spatial point sampling method for forest land identification and tracking the activities over time series (see section 6.1.3). It applies approach 3, reporting method 1 for the FM and D activities, and approach 3, reporting method 2 for AR and Rv, which uses authority records reported annually by forest districts. The association between the land area categories under the UNFCCC and the activities reported under the KP are presented in Table 11.2.

Table 11.2 The association of the area activities under the KP with land-use and land-use change categories under the UNFCCC

Land-use and land-use change category under the UNFCCC	**Activity reported under the KP**
FL-FL	FM
L-FL due to the natural establishment of stands	FM
L-FL due to afforestation (by forest plantations, implying direct anthropogenic intervention)	AR
FL-L	D
CL-CL (Rv included under CL as forest belts not meeting the definition of forests, see above the threshold of forest definition)	Rv

The demonstration of the evolution of area activity reported under the KP and traced consistently over time is shown in Figure 11.1.

Figure 11.1 Evolution of the area for each activity under the KP.



Afforestation/ reforestation, are according to national legislation Law no. 46/2008, conversion of non-forest land by establishing forest plantations, implying direct anthropogenic intervention. These areas are reported annually in the statistical surveys (SILV 4). Specifically, the statistical reports are derived based on forest management planning documentation, which allows any parcel to be tracked back in time to the respective spatial unit in the field. This activity is reported under SILV-4's Chapter 1 "Regenerated areas on land categories," under the following sub-categories:

i. unproductive lands;

ii. degraded lands included (transferred) into the national forest fund;

iii. degraded and unproductive lands;

iv. amelioration perimeters and unproductive lands;

v. degraded lands from the forest fund.

Forestry legislation does not distinguish between afforestation (A) and reforestation activities (R) in the sense of Decision 16/CMP.1. They were treated similarly in the national GHG inventory and additional reporting, and they will be referred to below as A/R. The A/R activities have been funded totally or partially from public funds and are considered direct human-induced. These lands are included in CRF 4.A.2, land converted to forest lands. According to the Forest Code (Law no. 46/2008), the actual plantation has to be started two years after the afforestation activities. However, the natural expansion of forest vegetation on other lands is not considered direct human-induced action, which explains that the area reported as AR is less than 4.A.2 activity. According to the Forest Code (Law no. 46/2008). Areas of the natural expansion of forests become automatically subject to management planning. For this reason, these areas are included under the FM area and not under AR, which explains that areas are larger under FM than 4.A.1.

In Romania, the legislation defines ***deforestation*** (D) activity as *the definitive leave of Forest land from the national forest fund (NFF)*, which means permanent change of the land use from forest to another land category. These land-use changes are strictly regulated and occur in only particular cases and under the compensation rule, for which an area of five times more significant must be included in the NFF through afforestation. As Romania accounts for all forest areas, thus also forests outside the NFF, this above definition must be extended to include all areas under D activity. The land identification system based on the point sampling approach tracks any permanent change from one forest to another land use.

Forest management *(FM*) applies to all forest areas (except for AR), as all forests are considered managed. Most forest management is regulated by forest management plans consistent with the forest's environmental, economic and social objectives. Forests management is regulated by the forest code (Law no 46/2008) through forest norms implemented in forest management plans consistent with the forests' environmental, economic, and social objectives. Forest management activity is associated with the "Forest Land remaining Forest Land – 4.A.1" category in 1989, and they are the same value. Since the starting year, FM is increasing by the amount of a subcategory of areas reported under 4.A.2 Land converted to Forest land is counted as a natural expansion of forest vegetation, and it is decreased by the area of deforestation activity (which is the same as FL converted to other land-use categories under UNFCCC) (Figure 11.1).

Revegetation includes areas created by the planting activity, thus directly human-induced. These areas do not meet the forest definition parameters (at least one of them, usually the minimum area) but are still reported by forest districts (SILV 4) as:

i. plantations on excessively degraded lands outside of the forest fund;

ii. plantations on degraded lands not included in the national forest fund;

iii. tree plantations including tree lines (e.g., along roads), tree belts for field protection (implemented according to the Law 83/1993, Law 107/1999), green belts around urban and industrial platforms, anti-erosional plantations, and land amelioration perimeters (implemented according to the Law 18/1991, Law 107 / 1999).

This activity occurs on non-forest land categories, practically entirely associated with the subcategory "4.B.1 - Cropland remaining Cropland".

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how the land was classified

The ranking of priority is given in this order: Deforestation – Afforestation – Forest management - Revegetation. Revegetation activity is associated strictly with non-forest land categories and does not interfere with any other activity under the Kyoto Protocol under the strict implementation of the forest regime. Revegetation can be identified through indicators outlined in section 11.1.

11.1.5 Application of provision to exclude emissions from natural disturbance

Several disturbances are quantitatively relevant to Romania's forest land: windfalls, drought events, insect attacks, and wildfires. For this reason, Romania applied the provisions to exclude emissions from natural disturbances for AR under Article 3, paragraph 3, of the KP, and FM under Article 3, paragraph 4 of the KP, during the second commitment period (Table 11.3).

The assumption in the forest management reference level (FMRL) is that volume affected by disturbance was entirely subject to salvage logging, an approach consistent between the national GHG inventory under the UNFCCC and FM activity estimates under KP (i.e., all harvests are included in the annual wood harvest reports by the National Institute of Statistics, or NIS, and included in the gain-loss balance).

However, a survey among the professional foresters revealed that a probability reaching 10 % of the affected standing volume of large windfalls might not be harvested (e.g., left untouched in scattered forest small areas and because of inaccessibility). For Romania, based on historical data, a windfall is considered significant when the annual estimated total affected volume is above five million m3. The low level of damage may also support this situation on average during these disturbance events. According to forestry statistics, more than 90% of the affected area is graded as slightly damaged (e.g., low volume in large areas), making economically unattractive harvesting. Estimates are now established for the background level (see Table 11.3), although investigations on actual biomass left in forests continue.

Table 11.3 Background level values (Gg CO_2 yr^{-1}) for natural disturbances for FM and A/R activities

Parameter	FM value	AR value
Background level	66	0.2
Margin	61	0.22
Background level plus margin	188	0.64
Calibration period for windstorms	1986-2009	-
Calibration period for wildfires	1986-2009	1990-2009
Years excluded (outliers)	1997, 1998, 2002	1990, 1992, 2000, 2002

Information on how background level was estimated for Forest Management activity. . For wildfires, cumulative net emissions from these sources are negligible, representing less than 1 % (~10 Gg CO_2 eq year^{-1}, reported by national GHG inventory) of the annual net CO_2 removals. Estimates of GHG emissions were developed using Equation 2.27 and default factors (combustion factor, emission factors for CH_4, N_2O) from the 2006 IPCC 2006 GL. Activity data is the event's annual area (following the annual survey and report by the Forest Authority). The average of dead organic matter gives the combustible amount (DOM) estimates in Romania (NFI). The calibration period covers 1986 - 2010. Forest area changes of +5% from 1970 to 2009 were considered in the margin estimation. Background level and margin estimates include emissions of CO_2, CH_4, and N_2O.

For windfalls, annual estimates of standing volume affected are available for a historical period from 1986 to 2009. Estimation of CO_2 emission associated with background level assumed:

a) from affected area/standing volume, 90% are conifer species, and 10% are broadleaved;

b) 10% of the affected standing stock volume of large windfalls (a total of max 1.7 million m^3 at the country level) is not subject to harvest/salvage logging (which remains untouched in the forests) because of inaccessibility or lack of capacity/resources to collect entire wood;

c) the rest, i.e., 90% of the affected volume, is harvested. Traditionally, "salvage logging" and phytosanitary felling from disturbance events receive the highest harvesting priority, ensuring a relatively constant harvest across time.

d) entire affected volume not harvested is transferred to the DOM pool in the calendar year of the event;

e) the decay of such additional DOM input occurs following decomposition function with half-time of 5 years. Thus, CO2 emissions associated with disturbance events occurring over the next ten years, e.g., at the end of the 10th year, resulted in some 88 % (or 91% in the 12th year) of the original biomass carbon and assumed emitted to the atmosphere.

Information on how the background level was estimated for afforestation/reforestation (AR) activity. For AR activity, only the forest fires are only relevant. A background level was established assuming the same share of the burnt area as AR to FM total area (i.e., 4.2 % on average for 2013-2020). Because of the size of trees in young plantations, the entire living biomass is assumed ultimately be affected by fires, along with litter and deadwood pools (total of 12.4 t C ha^{-1} as estimated from an afforestation project monitored for emissions reduction purposes).

The expectation for net credits or debits. Salvage logging always follows any disturbance in Romania, although there is some doubt that the entire volume affected is collected, especially after windfalls. Exclusion from the accounting of disturbance-related emissions will be first supported by an in-depth analysis of the actual rate of salvage logging. Technical correction of the FMRL would ensure consistency between FMRL and FM estimates. Technical correction should consider actual changes in DOM and SOM caused by historical disturbances (for blown down volume) and forest area abandonment. In the FMRL, DOM and SOM changes were assumed as "no change" and assumed that the entire affected standing volume was subject to salvage logging (slightly revised now and further checks).

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3 and Article 3.4

Afforestation and Reforestation activity. The conversion of non-forest land by forest plantations, implying direct anthropogenic intervention on land, is regulated in Romania by the Forest Code (Law 46/2008), as stated before. The new forest due to AR activity is included in the NFF, which applies, unlike land under Rv, the minimum area threshold of the forest definition elected by Romania. Moreover, data used to report this activity is collected from the forestry districts each year which implies applying the forest norms regarding the minimum area. Romania implements an afforestation/ reforestation JI under the KP.

Forest management activity. Forest management applies to all forests in Romania, excluding AR. This includes forests under management plans and forests outside the NFF, which are under direct anthropogenic impact by wood harvesting (wood traceability regulation applies). Forest included in the NFF (approx. 6,500 kha – 93 % of total FL area), as indicated above (Table 11.1), includes information of forest stands as small as 0.25 ha and larger. Romania also applies a point sampling system (see section 6.1.3) to identify all forests in Romania, which also covers the NFF system.

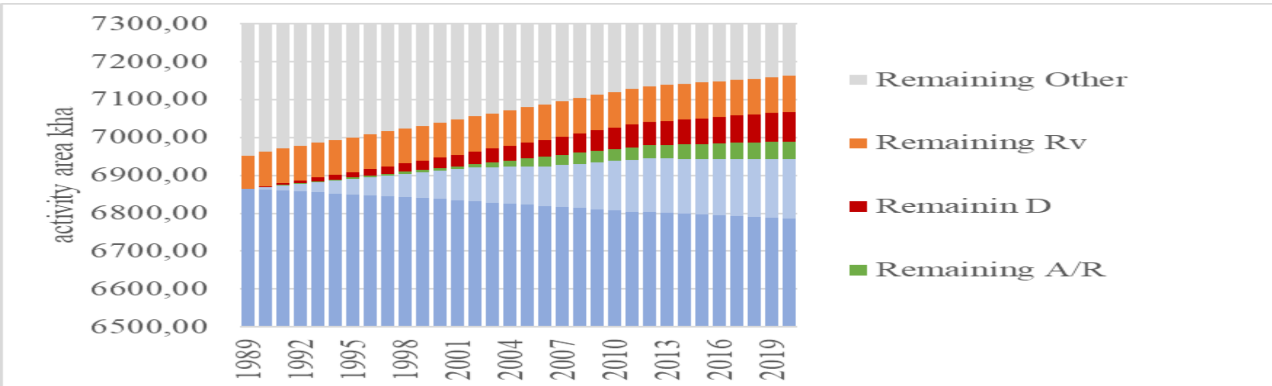
Deforestation activity. The deforestation area is derived from the point sampling land identification system described in the LULUCF sector in section 6.1.3.

Revegetation activity. The conversion activity, same as in AR, of non-forest land by plantation of forest belts not meeting the forest definition is also regulated by law and reported annually by the National Statistics.

11.2.2 The methodology used to develop the land transition matrix

The methodology for developing the land-use change matrix is described in the LULUCF sections 6.1.3, as a point sampling system based on several temporal, and geospatial datasets. Two matrices were developed: one starting in 1970 for inventory purposes under the UNFCCC and another one starting in 1989 for the Kyoto Protocol reporting and accounting purposes. The two matrices are entirely consistent. The one under the Convention implements a 20 years reporting period between land-use categories. Some lands are associated with KP activity under the KP matrix (i.e., lands under conversions to forestland resulting from natural forest expansion are reported under FM). Since Rv has to be accounted for on a net-net basis and 1989 is the base year for Romania, pre-1990 data was needed to provide a net GHG emission/removals estimate for the Revegetation activity in 1989, including the time series from 1970. The complete matrix used to estimate emission/removals on KP eligible lands is available in NIR-2. The cumulated activity areas reported in NIR 2 table are displayed in Figure 11.2.

Figure 11.2 Demonstration on changes in the area reported on different activities since 1990



For the practicality of the representation, the vertical scale is shown partially. The remaining other land category is completed to the total country area in each reporting year.

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The national boundary applies to all activities where relevant. Nevertheless, more explicit sub-national boundaries can also apply to all activities.

Afforestation and reforestation (AR). They identify land areas eligible as AR activities are based on forest management plans and their forest maps (with a resolution of 1/5000). According to the national forest code, the respective areas are included in the forest fund based on legal documents, which allow funding of afforestation-related work. These areas are included in the forest fund after the conversion. Thus, the precise location and plantation/stand description are available for each area. The land "entering into the forest fund" is registered in the management plan documentation and is reported at the end of each year in the statistical report (SILV 1), then after the initiation of plantation work in SILV 4. With the "entering into the forestry fund," the land area is measured and temporarily mapped. At the same time, it is fully included in the forest maps with the following management planning of the respective forest district.

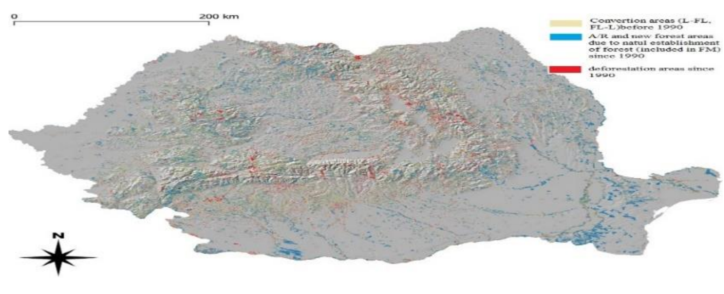
Further on, such land can be tracked in time through the numbering systems of the forest parcels (compartments), as long as the number (code) remains unchanged over the planning cycles. New areas in the forest fund are subject to the plantation and, if necessary, repeated gap-filling according to technical norms for afforestation. If the area is not covered by forest, it will be declared "non-productive land" and reported in statistics as part of "other lands from the forest fund."

Deforestation (D). The forest sampling method identifies areas included in the deforestation activity (see section 6 on land area identification) using maps described in section 6.1.3 and table 6.6.

Revegetation (Rv). Activity data on land areas eligible for the revegetation activities are provided by SILV 4, with the possibility to make a precise location of all areas reported under such activities that can be identified based on initial plantation establishment documentation. SILV 4 is filled in by the forest authority.

Forest management (FM). Forest areas are identified by the point sampling methods applied, which enclose forests included in the NFF (see figure 6.12, section 6.2.1) and define the limits for forests outside the NFF. A summary and description of the database used can be found in Table 6.6 in the 6.1.3 section.

Figure 11.3 Representation of the cumulative conversion area to and from forest, based on the spatial point sampling method



The representation summarises the total cumulative area on the whole time series described in section 6.1.3

11.3 Activity-specific information

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1 Description of the methodologies and the underlying assumptions used

The methodology used to report the GHG emissions according to each activity is the same as those used under the UNFCCC, more details can be found in section 6.2. A summary of methodologies and emission factors is presented in Table 11.4.

Table 11.4 Summary of methods and EF used to report GHG in each activity under the KP

Activity		CO_2		CH_4		N_2O	
		Tier	EF	Tier	EF	Tier	EF
Afforestation/ Reforestation							
KP A.1	AGB	T2	CS	-	-	-	-
	BGB	IE	NA	-	-	-	-
	Litter	T2	CS	-	-	-	-
	Deadwood	IE	NA	-	-	-	-
	Mineral soils	T2	CS	-	-	-	-
	Organic soils	NO	NA	-	-	-	-
Deforestation							
KP A.2	AGB	T2	CS	-	-	-	-
	BGB	IE	NA	-	-	-	-
	Litter	T2	CS	-	-	-	-
	Deadwood	IE	NA	-	-	-	-
	Mineral soils	T2	CS	-	-	-	-
	Organic soils	NO	NA	-	-	-	-
4 (KP-II)3	N_2O emissions from N mineralization/immobilization due to carbon loss	-	-	-	-	T1	D
Forest Management							
KP B.1	AGB	T2	CS				
	BGB	IE	NA				
	Litter	NR	NA				
	Deadwood	NR	NA				
	Mineral soils	NR	NA				
	Organic soils	T1	D				
4 (KP-II) 4	Biomass Burning	T1	D	T1	D	T1	D
4 (KP-II) C	Carbon stock changes in the harvested wood products (HWP) pool	T1	D	-	-	-	-

Afforestation/reforestation. . Net changes in C stocks in above-ground and below-ground biomass and for the litter and soil organic matter pools during each annual commitment period are estimated and reported for accounting purposes under Tier 2. DW is reported as IE (included elsewhere), as is estimated in the total DOM pool for the young plantations (less than 20 years old). Based on measurement in the JI project and reasoning based on ecosystem functioning, C stock could only increase in this pool. The estimation methodology and data used are described under section 4A2 - Land converted to Forest Land (artificial plantations). There are no afforestation areas that have been subject to harvest (mainly because of large planting schemes and slow-growing long cycles of planted species). The AR is a key category under KP.

Deforestation. Emissions are calculated using Tier 2 methods and input data described in section 6.2.2.1. All carbon pools are reported, and D is a key activity under KP. In the case of conversions from forest land, in D activity, it was considered that the emissions from biomass and dead organic matter (DW, LT) occur in the year of conversion. Therefore in D activity, all biomass loss is considered instant oxidation. The C stock change in biomass was estimated based on the average standing stock wood volume per hectare, estimated from the linear interpolation of volume stocks estimated at the 1984 NFF and 2012, 2018 NFI. The interpolation was calculated between the 240 m^3 ha^{-1} value from 1984 and 322 to 340 m^3 ha^{-1} between 2012 and 2018. Wood volume was multiplied by the weighted average of wood density (based on the percentage of species from total harvest in a year) to estimate biomass. The exact weighting procedure was applied to root-to-shoot and carbon fractions to estimate the total biomass and carbon loss. The average wood density, R, and CF used to estimate carbon loss are shown in Table 6.21 in section 6.2.2.1.

Emissions from DOM were also estimated from two different databases: i) lying deadwood C pool from NFI as a national average of 0.74 t C ha^{-1} and ii) national average litter pool C stock of 7.42 t C ha^{-1} from ICP Forest database (author Surdu A., 2006).

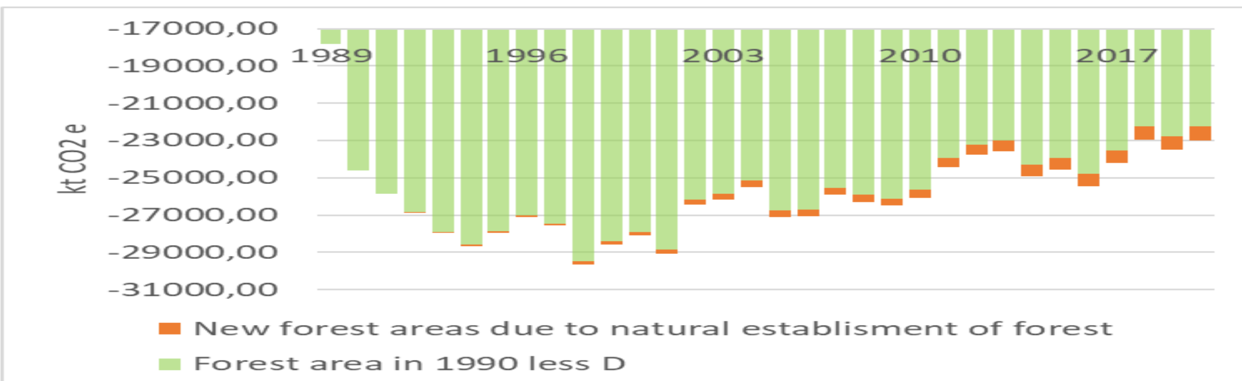
Deadwood density was considered 400kg/m^3 for all species and deadwood sizes. An average standing deadwood stock is also estimated from NFI. However, the standing deadwood is not included in this pool because it is assumed to be subject to immediate harvesting, and it is already included in the regular harvest statistics under intensive forest management in Romania.

A transition period of 20 years was considered for carbon stock change in mineral soil. Similar estimation method and EF as under the UNFCCC was used according to the land where the conversion from forest land occurred.

Forest management. FM carbon stock change methods are consistent with methods of forest area reported under 4.A.1 – Forest Land remaining Forest Land (see section 6.2). Supplementary to the 4.A.1

for the FM activity, the carbon stock change estimated for new forest areas due to the natural establishment of forest (i.e., natural expansion since 1990) is also included. The method for estimating carbon stock change of areas included in the FM due to the natural establishment of the forest stands is described under the 4.A.2 (where this change is first included in the L-FL category under the UNFCCC, later to be transferred to FL-FL) in section 6.2. Carbon pools reported are above-ground and below-ground biomass, where the below-ground carbon is considered as a percentage (20%) of the AGB, and therefore the IE notation key is used. The change in mineral soil, deadwood, and litter are not reported, for which the argumentation that they are not a source is described below.

Figure 11.4 Contribution to CO_2 emissions from biomass of areas included in FM under KP



The carbon stock in organic soil is reported using the same method as under 4.A.1 applying T1 and default EF. FM is a key category.

Revegetation. Net estimate for the base year 1989 considered all areas subject to revegetation established since 1970. Net estimate for the commitment period years considers all revegetated areas existing in the years of CP. This approach is consistent with the 2013 KP supplement (IPCC, 2013). Actual revegetation data is drawn from statistics back till the 1974 year, while for the 1970-1974 time period, data is linearly extrapolated. For GHG inventory purposes, this activity is entirely included in category 4B1 Cropland. This activity is subject to "net-net accounting" (i.e., the difference between the annual sinks in 1989 and 2013-2020 on land subject to revegetation each year). C stock changes are estimated precisely as in the case of 4A2 land converted to forestland (artificial plantations) under the assumption that plantations differ only by their legal status (land classification). Revegetation on revegetation areas is cut and rejuvenated (not replaced with other crops) in about 25 years. Thus, it is estimated that after the first cycle of 25 years, the biomass growth follows the same pattern as in the initial plantation, while all other pools are assumed as not to change any more 21 years after the conversion and later (following reasoning under Tier 1 of IPCC as supported by data shown under AR). DW change was always assumed as null. Revegetation is not a key activity under KP, but a Tier 2 estimate was achievable under the type of data available for the estimation.

11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Afforestation/Reforestation. No pool is excluded in the AR carbon stock change estimation. The DW pool in AR and Rv activities is reported IE because it was considered a small sink, if any, and is included in the litter estimation. Litter has become a measurable pool in AR lands in some four years since planting (sampled data is available from Romanian JI and national FORLUC project mentioned under AFOLU sector chapter). As the plantation further develops, this should lead to a continually increasing number of dead trees, expecting that inputs are larger than decomposition.

AD for biomass burning, which is relatively rare on AR land, is reported on total forest land; therefore, the emissions related to this activity are included in the FM estimation.

Deforestation. No pools are excluded. Nevertheless, usually, deforestation activity occurs in forest areas outside the NFF. These forests are not subject to the strict regulation of the forest code (Law no. 46/2009) and usually happen in small patches on private properties; therefore, the wood removals from these areas were considered instant oxidation in the year when the activity occurs.

Forest Management. Under FM, Romania is not reporting carbon stock change occurring in the litter, deadwood, and mineral soils pools. Justification of the Tier 1 approach under the UNFCCC is described in sections 6.2.2.1.2 and 6.2.2.1.3. Apart from these reasons also, qualitative and quantitative arguments are presented below.

Carbon stock in mineral soils. Assessments of several existing datasets focus on two approaches: the arguments are based on their source and methodological approach, independent of each other. These show that the mineral soil carbon pool most likely behaves like a small sink or instead as a neutral, in which case, the "not a source" applies (key category NR is reported in NIR-2 and NE in sectoral table 4.A.1 Cropland remaining Cropland).

i. *First approach. Simulation by CBM-CFS of C stocks in mineral soils with data from IFN 1984 and NFI 2010. The simulation outputs are validated with data from the soil database of the forest management plans (FMP) combined with the 2010 NFI soil data. The validation exercise, conducted by XXXX in year XXXX, involves the actual NFI data of C stocks in available pools (deadwood and organic matter in mineral soils).*

ii. *the Second approach consisted of the statistical analysis of forest soil records from the FMP database in a recent study ("The determination of emission/removals of forest land and the land conversion from forest pools following its obligations as a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and its obligations as a party to Kyoto Protocol (KP)," funded by the Ministry of Environment and Climate Change). It contains soil analysis of forest management plans from 1970 on. Datasets include hummus (%, relative humus content for 30 cm depth), among many other soil chemical parameters, and site and stand descriptors. The limitation could come from the particularity of sampling points that were randomly and non-repetitively located. In the Romanian forest management planning system, the country NFF was several times completely "screened" every ten years since 1960, so a time series is available. Nevertheless, soil analysis data was retrieved for some 20 forest districts randomly spread in the country (together representing 0.8% (i.e., 60000 ha) of total national forests) and representing the major forest types, geographical regions, and altitude gradient. Data were processed on strata entirely consistent in time: 3 main types of forests (broadleaved, resinous, and mixed forests), forest stand age (categories of 4 years till 140), and time since the first measurement (TSFM, 22 years over 1979-2011 with few gaps) and two soils horizons (A horizon of 0-20 and B of 20-30 cm depth).*

Simple linear regressions of humus content (%) vs. TSFM shows a minimal positive slope, which, although with some uncertainty, can be interpreted as this pool most likely behaving as a sink or source in time.

Multiple analyses of humus content (%) variance against all independent variables counted above also showed non-significant differences for humus content.

iii. *Recent peer-reviewed paper regarding soil carbon stock on forest soil, based on a modeling approach on soil data collected from NFI, shows a small increase in carbon stocks (Blujdea V. N. et al., 2021): "the only available C stock change estimates were simulated by Yasso07 [56], showing a country-wide average gain of 0.05 MgC h-1 yr-1 , with a variation from a gain of 0.14 MgC ha-1 yr-1 for hardwood forests to a loss of 0.01 MgC ha-1 yr-1 for softwood forests."*

These arguments demonstrate that the SOC pool is not a source.

Other qualitative information regarding the FM practices can support this assumption:

a) intensification of forest management and halving wood harvesting in post- than pre-1990 (as shown by National Statistics), which led to an increase of both the standing stock and likely of the lying deadwood under natural competition, reflected in recent estimates, which is the source of the increase of C stocks in the soil;

b) rather a low rate of temporary forest cover loss, which could lead to soil C loss, as the impact of forest *management, the annual clear cut area is reported by National Statistics as around 25 Kha/year, which is less than 1 % of the national forest fund area and also by independent studies when comparing 2010 to 1990 (e.g., Olofsson et al., 2011 in Environ. Res. Lett. 6 (2011) 044202, working with average standing stock, showed that only half of the annual harvest originates from a clear-cut type of harvest. Others occur from other less intensive forest operations (thinning, extensive regenerations cuts) that do not disturb the forest soil;*

c) negligible area of fire and non-fire disturbances over the 1990-2020 time period.

Carbon stock in deadwood and litter pools. No historical quantitative data regarding dead organic matter pools in Romanian forests are available, except time-point estimates from NFI. In order to derive the time series for the 1990-2014 time period, which was then later extended until 2020 by linear interpolation, C stock change from the deadwood pool is simulated with a model based on the forest inventory data. Pools were finally validated against sampled NFI data, and another judgment was made if changes in this pool were significant or negligible over CP. For such simulation, INCDS has retrieved the entire database of 1984 forest fund inventory (e.g., standing volume, annual growth, species composition, and age structure) at the most disaggregate level available (namely 400 forest districts covering the entire country), and ran CBM-CFS3 (Carbon Budget Model of the Canadian Forest Sector). New approaches are considered to estimate the C stock change in the DOM pool accurately. A similar approach is applied to the Litter pool; modeled data is validated against sampled data from 1st NFI. Different expert judgment was made if changes in this pool were significant or negligible over CP. The CBM outputs and additional ecological reasoning based on information from points (a) to (c) under mineral soils prove that DW and LT are not net sources of emissions under Forest management lands. CBM and Yasso07 runs were achieved and under ongoing improvements to support better the reporting (i.e., models parameterization of soil pools is complex under missing national data). Data reported by the NFI during the two cycles in Romania (2012 and 2017) indicate both an increasing growing stock of Romanian forests and an increase in dead biomass in the overall DW pool, Table 11.5.

Table 11.5 DW stock according to NFI two cycles (2008-2012 and 2013-2017)

NFI component	**Species**	**2012**	**2017**	**Difference**	**%**
		m^3 ha^{-1}	**m^3 ha^{-1}**	**m^3 ha^{-1}**	
Lying deadvood	Conifers	4.65	4.07	-0.59	**-6.72%**
	Broadleaves	5.25	5.17	-0.08	

NFI component	Species	2012	2017	Difference	%
		m^3 ha^{-1}	m^3 ha^{-1}	m^3 ha^{-1}	
	Total	**9.90**	**9.23**	**-0.67**	
Standing deadwood	Conifers	3.79	4.82	1.03	**38.06%**
	Broadleaves	3.97	5.89	1.92	
	Total	**7.76**	**10.71**	**2.95**	

The results imply that in the current forestry management conditions, also due to the actual age structure of forests, the deadwood and litter are not a source of emissions during the period covered by NFI measurements. Based on reasoning, we assume that an increase in the DW pool also implies an increase in organic matter in the litter pool and, therefore, this pool is not a source of emissions either.

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Available activity data and methodologies did not make it possible to separate indirect and natural GHG emissions from the present estimation of anthropogenic GHG emissions for the relevant activities.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

Recalculation was made for all categories under the KP (Table 11.6). All changes have been applied for the same reason as under the UNFCCC, and the description is presented in section 6.2.5. The significant changes are triggered by the inclusion of new datasets in the temporal coverage of the point sampling land identification method, which determined a correction on conversion categories in the whole time series.

Table 11.6 The difference between this submission and the previous submission on each activity under KP

Activity	Year of submission	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
AR	**NIR 2021**	**Area (kha)**	23	24	26	27	28	29	29	30	31	31	32	32
	NIR 2022		30	31	32	34	35	37	38	39	41	43	44	45
	Difference %		**31%**	**27%**	**24%**	**25%**	**25%**	**27%**	**29%**	**31%**	**35%**	**38%**	**40%**	**40%**
	NIR 2021	**Emissions CO_2 e**	-444	-465	-480	-488	-484	-501	-502	-496	-494	-486	-485	-481
	NIR 2022		-456	-527	-548	-560	-606	-646	-676	-701	-725	-753	-781	-796
	Difference %		**3%**	**13%**	**14%**	**15%**	**25%**	**29%**	**35%**	**41%**	**47%**	**55%**	**61%**	**66%**
D	**NIR 2021**	**Area (kha)**	263	277	292	307	321	328	335	343	350	357	364	371
	NIR 2022		51	54	57	60	62	63	65	67	70	72	74	76
	Difference %		**81%**	**81%**	**81%**	**80%**	**81%**	**81%**	**81%**	**80%**	**80%**	**80%**	**80%**	**79%**
	NIR 2021	**Emissions CO_2 e**	7229	7352	7355	7349	4623	4558	4512	4483	4434	4385	4326	4271
	NIR 2022		1325	1358	1371	1383	991	985	984	1120	1121	1164	1163	1162
	Difference %		**82%**	**82%**	**81%**	**81%**	**79%**	**78%**	**78%**	**75%**	**75%**	**73%**	**73%**	**73%**
FM	**NIR 2021**	**Area (kha)**	6930	6931	6933	6934	6943	6944	6944	6944	6945	6945	6946	6946
	NIR 2022		6929	6933	6938	6941	6944	6944	6944	6944	6943	6943	6943	6943
	Difference %		**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
	NIR 2021	**Emissions CO_2 e**	-36528	-36932	-37774	-36261	-35071	-35584	-36535	-35766	-36633	-34946	-32363	-32610
	NIR 2022		-27765	-27659	-28431	-26934	-27926	-28454	-29390	-29005	-29959	-28342	-26142	-26697
	Difference %		**24%**	**25%**	**25%**	**26%**	**20%**	**20%**	**20%**	**19%**	**18%**	**19%**	**19%**	**18%**
Rv	**NIR 2021**	**Area (kha)**	101	101	102	102	102	102	102	102	102	102	102	102
	NIR 2022		94	94	94	94	94	94	94	94	94	94	94	94

Activity	Year of submission	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	Difference %		**7%**	**7%**	**8%**	**8%**	**8%**	**8%**	**8%**	**8%**	**8%**	**8%**	**8%**	**8%**
	NIR 2021	**Emissions**	-1241	-1208	-1194	-1198	-1199	-1195	-1198	-1219	-1249	-1270	-1281	-1279
	NIR 2022	**CO_2 e**	-726	-651	-611	-609	-611	-613	-613	-613	-608	-606	-606	-604
	Difference %		**42%**	**46%**	**49%**	**49%**	**49%**	**49%**	**49%**	**50%**	**51%**	**52%**	**53%**	**53%**
HWP	**NIR 2021**	**Emissions**	-2473	-2469	-3638	-3805	-5475	-6002	-5649	-5561	-5615	-5342	-4038	-3854
	NIR 2022	**CO_2 e**	-1495	-1218	-2383	-2594	-4349	-4912	-4509	-4513	-4553	-4212	-3229	-3268
	Difference %		**40%**	**51%**	**34%**	**32%**	**21%**	**18%**	**20%**	**19%**	**19%**	**21%**	**20%**	**15%**

11.3.1.5 Uncertainty estimates

The methodology of the uncertainty estimates is covered in section 6.2.3 and follows Tier 1 method (2006 IPCC GL). Table 11.7 presents a summary of the results.

Table 11.7 Uncertainties under the KP for each activity.

Activity under FM	Carbon pool	AD	EF	Combined uncertainty	Source of AD and EF estimates
		%			
Afforestation/ Reforestation	LB	1.00	10.00	10.05	NIS/ JI Project
	DOM	1.00	10.00	10.05	NIS/ JI Project
	SOC	1.00	10.00	10.05	NIS/ JI Project
Reforestation	Same as AR				
Deforestation	LB	10.00	28.64	30.33	Expert judgement/ NFI/ IPCC 2006

Activity under FM	Carbon pool	AD	EF	Combined uncertainty	Source of AD and EF estimates
		%			
	DOM	10.00	20.45	22.76	Expert judgement/ ICP/ IPCC 2006
	SOC	10.00	10.00	14.14	Expert judgement/ ICP/ IPCC 2006
Forest Management	LB	1.03	30.72	30.74	Expert judgement/ ICP/ IPCC 2006

11.3.1.6 Information on other methodological issues

Similar methodological approaches were implemented under the Convention and KP reporting. Estimating GHG emissions from sources is consistent with data, and methods used in the convention estimation are described under section 6.2 of the NIR. For developing all the Kyoto-related estimates, the best available data was used.

11.3.1.7 The year of the onset of activity, if after 2008

Data on the year of the onset of activity is reflected in the time series used to derive the activity data. Under the current method, which determines the land-use change periodically, interpolation is used between successive moments in time. In the case of AR and Rv the onset, as reported above, is the year before planting itself starts, but site preparation is quickly followed by planting.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2020 and are direct human-induced

Afforested areas are reported by the national statistics (SILV 4) when the planting work starts, which may be later than the year when land entered into the forest fund, so the actual year of planting activity is reported (actually with soil preparation). In any case, reporting of all AR indicators is annual, ensuring the capture of any activity initiation. Afforestation could only occur on non-forest land, which is observed by the approval of documentation for funding. Otherwise, it is “regeneration after wood harvesting” under the national forestry regime (included in forest management). Under Revegetation, tree plantations are identified precisely under the same manner as AR but reported under different headings of statistical report SILV 4 due to its different definition as reported above. According to the current sampling-based land assessment system, D was forested on 1 January 1990 and is no longer forest at the end of 2020.

The area is generated by interpolation between several different temporal datasets for the D activity. The activity areas can be identified each year based on this approach (as shown in Figure 11.3).

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of the forest is distinguished from deforestation

The forest disturbance alone cannot trigger land conversions from forestland, i.e., the land is subject to regeneration (if needed) and further forest management. Thus the distinction between harvested and disturbance affected areas, on the one hand, and deforestation, on the other, is made as follows: for the former, there is a legal obligation for the forest owner/administrator to maintain the land use under the forests land category and forestry regime (including tree harvest based on the permit), to apply the forest management plans specifications and regenerate it within a given timeframe (maximum two years after the end of the final cutting); for the latter, following legal procedure with the issuance of the approval, a new land use category is assigned to that land, and the forestry regime is no longer applicable.

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

A fundamental requirement of the forest regime in Romania is that an area must be regenerated after forest cover loss in a maximum of 2 years, without reference to a minimum area. In practice, such lands can be regenerated either by plantations (usually followed by state forests), assisted natural regeneration (in private forests), or their combination. Its implementation is supervised by the public authority responsible for forestry. These areas cannot be confounded with deforested areas as they are subject to continuous planning and management (i.e., planting/ gap filling, maintenance).

11.4.4 Information related to the natural disturbances provision under article 3.3

According to the relevant provision, Romania intended to exclude emissions from natural disturbances for both AR and FM activities during the second commitment period (see section 11.1.5) in case significant disturbance events happen. However, since no such big events happened and since no appropriate data were available for the second commitment period 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 in the 4 (KP A1).

11.4.5 Information On Harvested Wood Products Under Article 3.3

The carbon stock change in HWP was not estimated for activities under article 3.3 as the statistics do not report AD data separately. Also, in AR activity, the wood is not yet extracted for commercial use, and any wood loss that occurs is assumed to be subject to instant oxidation. In the case of D activity, as mentioned before, it occurs on land outside the NFF (outside the management plans). The wood removal occurring in these areas is also subject to instant oxidation.

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Revegetation activity occurs on non-forest lands. They result from tree planting (also publicly funded at their establishment since 1970). Confirmation that the FM activity is human-induced and occurred since 1990 can be demonstrated because all associated lands were reported as part of the national economic system by continuous planning and implementation of the management measures or subject to forest regime (see also the next section).

11.5.2 Information relating to Forest Management

Forest management activity refers to the forest for which a management plan has been set up (some 93% of forests), while the rest are subject to wood harvesting permission. The first category is managed according to management plans. They are continuously surveyed for disturbances; forest operations and harvesting are subject to 10 years of cycle planning; forest regeneration is closely and intensively assisted and supervised. Such lands are mapped, landmarked, and annually updated in statistics. The forestry regime relies primarily on the forest law (no. 46/2008), then on subsequent legislation and professional and technical norms to ensure sustainable forest management on a national scale.

11.5.2.1 Conversion of natural forest to planted forest

Romania does not apply the Carbon Equivalent Forest Conversion (CEFC) provision and does not replace any converted natural forests with plantations. According to the forestry norms and Law no. 46/2008 in Romania, converting natural forests (all managed) to plantation forests can not occur.

11.5.2.2 Information relating to Forest Management Reference Level (FMRL)

Romania is one of the European Union (EU) Member states for which the Joint Research Centre (JRC) of the European Commission developed projections to derive the FRML. The projections were made in collaboration with two EU modeling groups using G4M (Global Forestry Model) from JRC and the European Forest Information Scenario Model from the European Forest Institute (EFISCEN). The net annual removals from HWP were estimated using the C-HWP model.

Romania's original FMRL submission is available at https://unfccc.int/files/meetings /ad_hoc_working_groups /kp/application/pdf/awgkp_romania_2011.pdf, and the review report of the original FRML is available at https://unfccc.int/ sites/default/ files/resource/ docs/2011/tar/rou01.pdf set the final values after the recalculation of the historical forest management data for the time period 2000–2008, which in turn was based on the improvement of the GHG inventory.

Romania elected forest management for the first commitment period of the Kyoto Protocol and has continued to report on FM for the second CP. For the construction of the reference level, Romania used the following information:

- **The area** under FM was estimated for the 2000–2008 time period using the area reported under the Convention for FL-FL. The NGHG 2011 submission was used for the area estimation used to construct the FRML.
- Forest Inventory 1985 (NFFI) and other forest statistics (available from NIS) provided the estimated **age-class distribution** for the modeling by the EFISCEN.

- Romania provided in its submission the historical **harvesting rates** reported under the Convention for the time period 2000–2008 (from FAO) and the projected harvesting rate used by the G4M and EFISCEN models for the years 2000, 2005, 2010, 2015, and 2020.
- The **HWP estimate** was based on the approach proposed in document FCCC/ KP/ AWG/ 2010/ 18/ Add.1, with annual production data, the application of the first-order decay function using equation 12.1 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and default half-lives of two years for paper, 25 years for wood panels and 35 years for sawn wood, as well as instantaneous oxidation assumed for wood in solid waste disposal sites. Historical data dating back to 1964 and an extrapolation of these data from 1900 using the average from 1964 to 1968 were considered. The estimate for HWP was **–349 kt CO_2 e**. applying the first-order decay function.
- It was assumed that **wood resulting from disturbance** is entirely subject to salvage logging.
- The construction of the FMRL considered all the pools and gasses in the GHG inventory; however, estimates for dead organic matter, litter, and soil organic carbon applied a Tier 1 approach of net-zero emissions.

Under a 'business as usual scenario, Romania anticipated a slight decrease in CO2 removals from forest management for 2013–2020. The FRML is inscribed in the appendix to the annex to Decision 2/SMP.7, amounted to:

- -15,444.00 kt CO_2 eq. (assuming instantaneous oxidation of HWP)
- -15,793.00 kt CO_2 eq. (applying first-order decay function for HWP)

In the initial technical assessment of the FRML submission, the ERT made several recommendations including the below items:

- "The uncertainty regarding the future harvesting rate due to potential infrastructure developments and the possibility of more favorable prices for wood in the future …. could increase the harvesting rate which …. might lead to less reliable estimates of the FMRL";
- "areas of forest land remaining forest land used as a proxy for historical forest management …. the modeled projections have not been rerun based on the new GHG inventory data … The ERT recommends technical corrections when updated modeled results based on the new GHG inventory become available.";
- "The ERT notes that technical corrections to the FMRL may be necessary after the agreement is reached on the treatment of HWP in the construction of the reference level or if higher-tier approaches are used, to estimate dead organic matter, soil organic matter, and other GHG sources."

Romania considered all recommendations and implemented some of them during the revision of the

FRML, whereas recommendations concerning the Technical Correction is implemented this year, as reported below.

11.5.2.3 Technical Corrections of the FMRL

According to requirements in Decision 2/CM.7, para 14 and 15, to ensure methodological consistency between the FMRL and reporting for Forest Management during CP2, Romania calculated a technical correction (TC). In this submission, Romania calculates TC in GHG Inventory for the first time. The TC was triggered by methodological inconsistencies between the FMRL and the revision of GHG estimates reported for the managed forest.

To calculate the FRML corrections, Romania implemented the following methodological elements:

- Romania used the same historic period, 2000-2008, to source information.
- As in the initial FRML submission, no additional policies to GHG emissions from the FM activity were considered.
- The GHG emissions from the FM activity were recalculated and submitted for all years succeeding the 2011 submission (based on which the FRML was estimated) using an age class structure based on the linear interpolation of the NFFI 1985, NFI 2012, and NFI 2018, that is thus similar to the age class structure used by the models (G4M, EFISCEN).
- The same pools and gasses were used to report E/R from the FM activity as in the initial FMRL.
- The same approach was used for emissions from salvage logging, i.e., it is included in the annual harvest in the initial FRML and used in the carbon stock change in the current FM estimates.

During the revision of the estimation methodology of the FM emissions, the following methodological elements were identified as possible inconsistencies compared to methods used to develop the FRML that led to a TC:

- Change of area under FM.
- Change of the historical emissions of FM activity from GHG inventory.
- Change of estimated emissions due to revision of data and methodology used to report on the HWP pool.

A step-by-step method for developing the recalculated FRML, i.e., FRMLcorr is presented below and in Table 11.8.

i. The first part of the table (L1 – L12) presents the initial models used to develop the FRML. The difference between the average of the two models (i.e., G4M and EFISCEN) and the estimates of the

GHG emissions for the 2000-2008 period was initially addressed by using an offset of the same value at the time of the FRML. Since the historical FM net emissions from biomass for the 2000-2008 time period and also emissions from wildfires were recalculated (L16 and L18), the offset values (L7-L9) also had to be recalculated in 2020 as shown in the Table 11.8 (L17-L18).

ii. There is a difference between the area assumed in the models that were used to develop the FMRL and the reported area this year for the 2000-2008 time period and also for the years of the second CP. For the models, historical data was taken from remote sensing (Gallaun, H., G. Zanchi, G. J. Nabuurs, G. Hengeveld, M. Schardt and P. J. Verkerk 2010, "EU-wide maps of growing stock and above-ground biomass in forests based on remote sensing and field measurements." Forest Ecology and Management 260(3): 252-261) for G4M and from the UNFCCC reporting for EFISCEN (NIR 2011 submission). However, data used by EFISCENas reported by the NIS was aggregated from all forest stands in the country. This area refers only to forests included in the National Forest Fund, which does not include all the forests in Romania according to the threshold of the definition elected (see section 6.8). Starting with the 2015 GHG submission, Romania reports an area method based on a spatial sampling grid, updated in the 2022 submission, and the area estimate in this submission (L13) is thus different from the average by the models (Table 11.8 L3). Using a ratio of this new area estimate and the one assumed in the model (L14) allows the recalculation of the new corrected model estimate of the emissions from biomass (Table 11.8 - L15), based on which a new offset estimate has been applied L19 of the same table.

iii. The above changes made it necessary to derive a corrected calibrated average of models (Table 11.8 – L20).

iv. The carbon stock change methodology of the HWP pool was also updated to meet the requirements of the 2013 KP Supplement, which generated an inconsistency with the FRML initial estimates. The average E/R estimates from HWP for the CP2 demonstrate a significant deviation from the initial HWP offset (Table 11.8 - L21).

v. The above calculations resulted in a corrected FRML (Table 11.8, L22), i.e., FRMLcorr=-21,995 ktCO_2e.

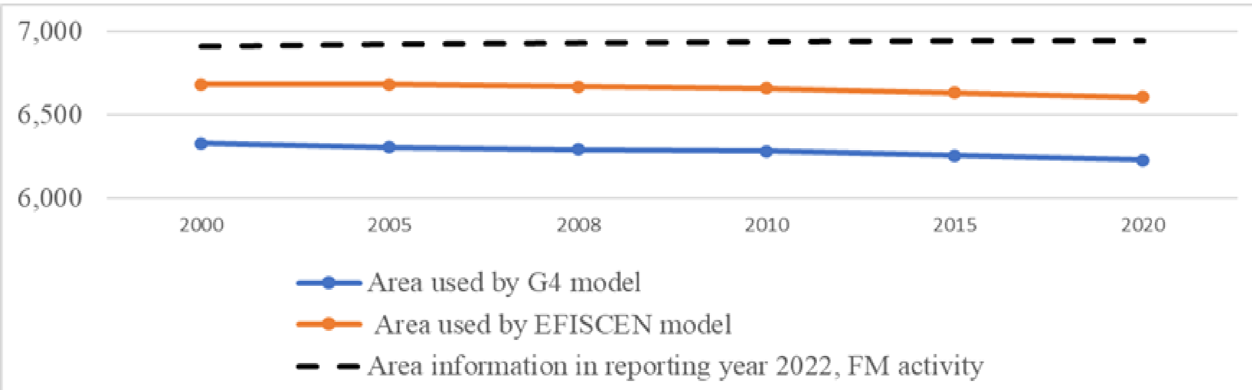
vi. Finally, the value of the TC is calculated (Table 11.8, L23) and amounts to -6,202 ktCO_2e.

The corrected values is due to:

- HWP new estimates information reported to NIR 2022, amount for -3,693 kt CO_2
- the combined new area estimates and GHG emissions amount reported in NIR 2022 for -2,508 kt CO_2

Differences between the initial area used for the FRML development and the information about the FM activity area reported in NIR 2022 are shown in Figure 11.5.

Figure 11.5 Activity area used for the initial FRML (by model) and the FRMLcorr (dashed line in black)



A comparison of emissions from FM in NIR 2011 and NIR 2022 is reported in Figure 11.6 and 11.7.

Figure 11.6 Historical and projected emissions from FM and HWP according to NIR 2011 and NIR 2022. The left scale displays the CO_2 emissions in FM activity, and the scale on the right the CO_2 emissions from the HWP pool.

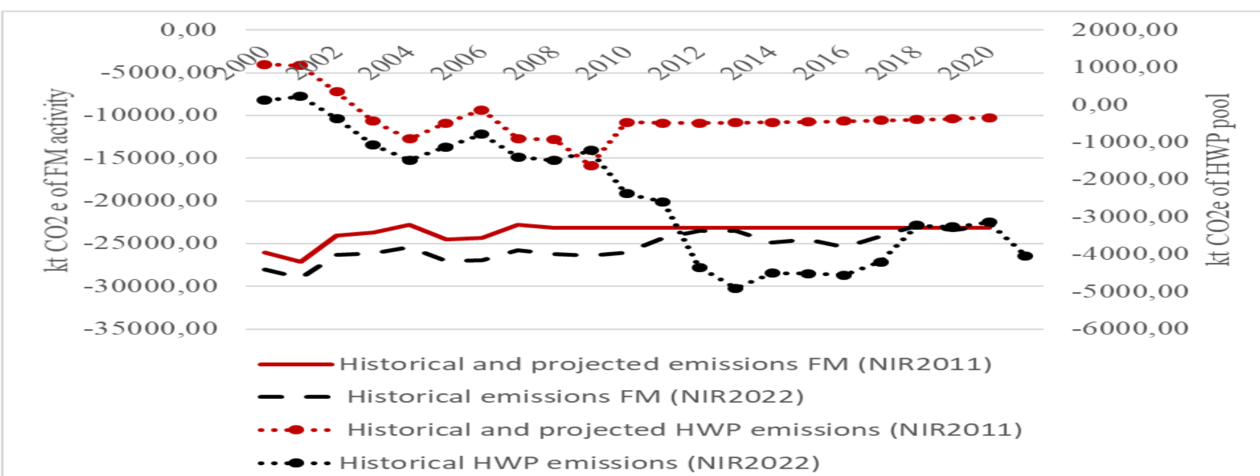


Figure 11.7 Summary of differences between the data used for the initial FRML and the FRMLcorr

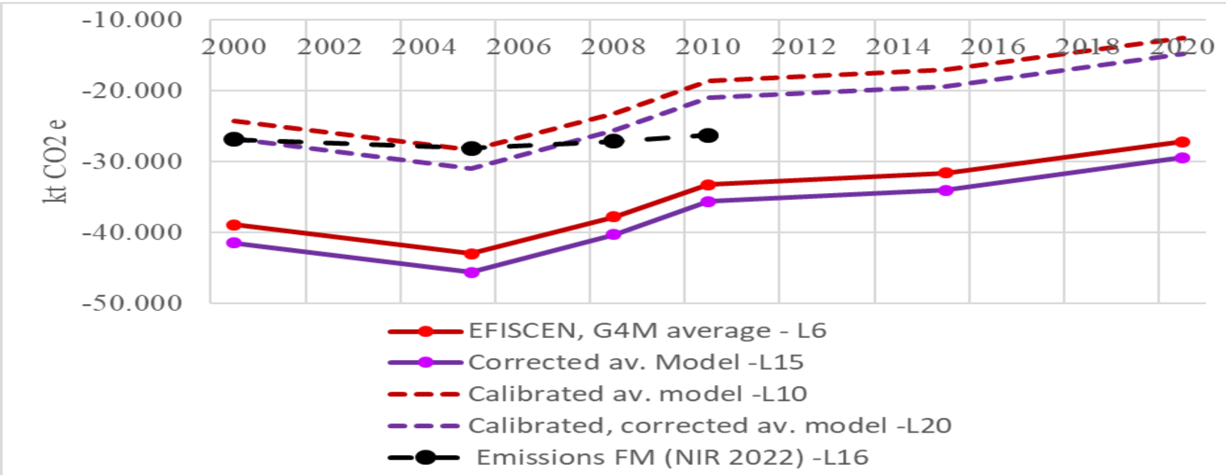


Table 11.8 Elements for the calculation of the Technical Corrections and the technically corrected FMRL

No.	FRML estimation steps	FRML components			Unit	av. 2000-2008	2000	2005	2008	2010	2015	2020	av. 2013-2020
L1	FRML adopted in the Decision 2/CMP.7	Areas applicable for FM activity used by the models as in Table 4 of https://unfccc.int/files/meetings /ad_hoc_working_groups /kp/application/pdf/awgkp_romania_2011.pdf	G4M		kha	6,311	6,332	6,308	6,294	6,284	6,256	6,230	6,257
L2			EFISCEN			6,680	6,685	6,685	6,670	6,660	6,633	6,608	6,634
L3			Area, average of models: = [(L1+L2)/2]			**6,496**	**6,509**	**6,497**	**6,482**	**6,472**	**6,445**	**6,419**	**6,445**
L4		Step 1: models' results (only biomass) as in https://unfccc.int/sites/default/files/resource/docs/2011/tar/rou01.pdf	G4M		kt CO_2	-34,795	-38,367	-34,425	NA	-27,344	-21,293	-17,692	-20,396
L5			EFISCEN			-42,965	-47,513	-41,092	NA	-39,090	-41,851	-36,656	-39,696
L6			Biomass emissions average of models:			**-38,880**	**-42,940**	**-37,758**	**NA**	**-33,217**	**-31,572**	**-27,174**	**-30,046**
L7		Step 2: expost processing	Offset	above and below-ground biomass		14,560	NA	NA	NA	NA	NA	NA	NA
L8				GHG emissions from forest fires		43	NA	NA	NA	NA	NA	NA	NA
L9				total offset		14,603	NA	NA	NA	NA	NA	NA	NA
L10			Calibrated average of models			-24,278	-28,338	-23,156	NA	-18,615	-16,969	-12,572	**-15,444**

No.	FRML estimation steps	FRML components			Unit	av. 2000-2008	2000	2005	2008	2010	2015	2020	av. 2013-2020
L11		Step 3: adding HWP using a first-order decay function	Offset due to first-order decay function from HWP			NA	NA	NA	NA	NA	NA	NA	-349
L12			**FMRL adopted in 2011, including HWP decay function**			NA	NA	NA	NA	NA	NA	NA	**-15,793**
L13	FRML technical correction	Areas applicable for FM activity in the reporting year 2022	Area information in the reporting year 2022, FM activity		kha	6,922	6,913	6,924	6,929	6,938	6,944	6,943	6,943
L14			Area ratio 2022 / 2011 = (L13 / L3)			1.07	1.06	1.07	1.07	1.07	1.08	1.08	1.08
L15		Step 1: correction for area	Corrected model average = [model average 2011 (L6) * area ratio (L14)]		kt CO_2	-41,432	-45,606	-40,242	NA	-35,607	-34,018	-29,394	-32,598
L16		Step 2: revision of ex-post processing	Emissions from biomass from FM activity un the reporting year 2022			-26,822	-28,086	-27,085	-26,277	-26,053	-24,525	-22,987	-23,996
L17			Offset	Above and below-ground biomass: = (L16-L15)		14,610	NA	NA	NA	NA	NA	NA	NA
L18				GHG information from forest fires (av.		35	NA	NA	NA	NA	NA	NA	NA

No.	FRML estimation steps	FRML components			Unit	av. 2000-2008	2000	2005	2008	2010	2015	2020	av. 2013-2020
				2000-2008) in the reporting year 2022									
L19				total offset: = (L17+L18)		14,645	NA	NA	NA	NA	NA	NA	NA
L20			Corrected calibrated average of models = [(Corrected model average (L15) + Corrected total offset (L19)]			-26,787	-30,961	-25,598	NA	-20,962	-19,373	-14,749	**-17,953**
L21		Step 3: revision of the HWP	Information on emissions from HWP using a first-order decay function (NIR 2022)			NA	NA	NA	NA	-2,383	-4,513	-3,143	**-4,042**
L22			**FM RL including HWP decay functions**			**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**-21,995**
L23		**Eq. 2.7.1 Kp Supplement**	**Technical_Correction = FMRLcorr – FMRL (L21 - L12)**										**-6,202**

11.5.2.4 Information related to the natural disturbances provision under Article 3.4

According to the relevant provision, Romania elected the provision to exclude emissions from natural disturbances for both AR and FM activities during the second commitment period (see section 11.1.5) in case significant disturbance events happen. However, since no such big events happened and since no appropriate data were available for the second commitment period 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 in the 4 (KP B1).

11.5.2.5 Information on Harvested Wood Products under Article 3.4

The C stock change in the HWP pool under the KP **uses the same methodological approach as HWP reported under the UNFCCC; see section 6.8 for the methodological description**.
The CO_2 emissions in HWP are estimated based on the domestic consumption of wood products and the application of the first-order decay function using the 2006 IPCC GL and default half lifetime values from the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol. The AD is obtained from the FAOSTAT database for production, imports, and exports and modeled back to 1900. Instant oxidation is assumed for wood in solid waste disposal sites. The carbon stock change values of the HWP pool for the FM activity are identical to those estimated for the FL-FL land category by implying that the harvest in D activity is deducted from the total harvest.

11.5.3 Information Relating to Cropland Management, Grazing Land Management and Revegetation, Wetland Drainage and Rewetting if elected, for the base year

Information relating to Revegetation.

This activity has no direct equivalent in the Romanian forestry or land management system but corresponds with trees plantation on non-forest lands, mainly in forest belts. Its election for KP compliance was related to plans to develop a national forest belt system, initially thought flexible concerning forest definition thresholds, the legal classification of the land, ownership, management obligations, and administration patterns. Activity data is available either as the number of planted trees or km of tree lines or ha (depending on the indicator in the statistical report SILV 4). Though information on these areas is available in statistical reports (SILV 4), their management is in the competence of the landowners of the agricultural land or companies that own/administrate infrastructure (e.g., railways, roads). Thus, there is no guarantee that the area initially planted is maintained. However, the acknowledged practice is that trees are always replanted (so this is the scenario we assume in GHG estimations).

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

Using Approach 1 of the IPCC 2006 GL (Level Assessment, including LULUCF) showed that all activities under article 3.3 (Afforestation/ Reforestation and Deforestation) as well as under Article 3.4 (Forest Management and Revegetation) are key categories.

11.7 Information relating to Article 6

Romania is implementing an AR activity project as a Joint Implementation project within the framework of the flexible mechanism under Article 3.3 of the Kyoto Protocol. The project lasted from 2002 to 2017. The emission reduction transaction is subject to a commercial contract between RNP Romsilva (Romania) and Carbon Prototype Fund (managed by the World Bank). Calculation of the emissions reduction is based on the partner's agreed monitoring plan, while emission reduction/removals amount is subject to independent verification. The first verification was performed in 2007 and the second in 2014 (overlapping on pre-CP1 and CP1 (under JI Track II scheme). Following internationally agreed procedures, CO_2 removals from the JI project activities will be further allocated to third parties (project partners). Project methodology provides net removals and associated non-CO_2 emissions pre-2008, 2008-2012, and 2014-2017. Meanwhile, activity data is reported according to the annual afforestation area in the project. The amount of tradable emission reduction associated with the project is determined for three consecutive stages:

- An independent verification report is already available for the pre-commitment period (until the end of 2007). The net removals reported for the period 1 January 2002 to 31 December 2007 are 10767 MgCO2 eq on a total area of 6,033 kha on which plantations started in 2002 and are under various stages of development. The estimated uncertainty of the net removals estimate was ±14%.
- net removals for the 1st CP of the KP (2008-2013) coinciding with the second project verification period is also available, as follows:

- The claimed verified amount for the second verification was 229641 tCO_2 with an uncertainty of ±8.5%. The most considerable contribution is given by removals of living biomass, DOM, and SOM pools of 24,0361 $MgCO_2$;

The JI project's non-CO_2 emissions are nevertheless non-explicitly reported as they are already included by the national statistics under forest fire or fuel consumption emissions.

12 INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1 Background information

The standard electronic format (SEF) for providing information on ERUs, CERs, tCERs, lCERs, AAUs and RMUs for the year 2021 for the Romanian registry is submitted together with this report (Annex 6.2.1). The data in the Romanian registry reflect the transactions to and from the Community registry and to and from ITL. Summary of information reported in the SEF tables for the Community Registry. The SEF reporting software has been used for submission the standard electronic format tables for the Romanian registry. The tables include information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Romanian registry at 31.12.2021 as well as information on transfers of the units in 2021 to and from other Parties of the Kyoto Protocol (Table 12.1). Neither AAUs, nor RMUs have been issued in the Romanian Registry in 2021.

Table 12.1 Information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Romanian registry at 31.12.2021

Annual Submission Item	Reporting
15/CMP.1 annex I.E paragraph 11: Standard Electronic Format (SEF)	**12.2**. The Standard Electronic Format report for 2021 has been submitted to the UNFCCC Secretariat electronically and the contents of the report can also be found in Annex 6.2.1 of this document.
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	**12.3.** No discrepant transaction occurred in 2021
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2021
15/CMP.1 annex I.E paragraph 15: List of non-replacement	No non-replacement occurred in 2021
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2021
15/CMP.1 annex I.E paragraph 17: Actions and changes to address discrepancies	No actions were taken or changes made to address discrepancies for the period under review

Annual Submission Item	Reporting
15/CMP.1 annex I.E Publicly accessible information	**12.4.** The information based on the requirements in the annex to decision 13/CMP is publicly available on the Romanian registry http://rnges.anpm.ro/content.aspx?id=100
15/CMP.1 annex I.E paragraph 18: CPR Calculation	**12.5.** Relevant data/information are presented below, under Section 12.5.

12.2 Summary of information reported in the SEF tables

The relevant information is present under Section 12.1.

12.3 Discrepancies and notifications

The relevant information is present under Section 12.1.

12.4 Publicly accessible information

The relevant information is present under Section 12.1.

12.5 Calculation of the commitment period reserve (CPR)

The Kyoto Protocol, under Article 4, provides the option for Parties to fulfil their commitments under Article 3 jointly. For the second commitment period, upon adoption of the Doha amendment to the Kyoto Protocol, the European Union, its Member States and Iceland stated that the European Union and its 28 Member States again intend to fulfil their reduction targets under the second commitment period jointly (declaration made in footnotes 4, 6 and 8 to Annex B of the Doha Amendment). The European Union ratification decision (Council Decision (EU) 2015/1339 of 13 July 2015) sets out the terms of the joint fulfilment between the Union and its Member States and Iceland. The emission level for Romania cover the emissions from sectors and gases listed in Annex A to the Kyoto Protocol not covered by Directive 2009/29/EC of the European Parliament and of the Council amending Directive 2003/87/EC.[5] This

[5]Directive 2009/29/EC of the European Parliament and of the Council amending Directive 2003/87/EC covers emissions of greenhouse gases listed in Annex A to the Kyoto Protocol that are covered by the EU Emissions Trading System (EU ETS).

includes all emissions from sources and removals by sinks covered by Article 3(3) and (4) of the Protocol as well as all emissions of nitrogen trifluoride (NF_3) under the Kyoto Protocol. In Annex I to this decision, point 3 (Respective emission levels allocated to the members to the agreement) it is specified that:

a) The assigned amounts of the members shall be equal to their respective emission levels;
b) The emission level of Romania (before application of Article 3(7bis)) in terms of tonnes of carbon dioxide equivalent for the second commitment period of the Kyoto Protocol are 656,059,490.

In Annex I to this decision, point 2 (Joint fulfilment of the commitments under Article 3 of the Kyoto Protocol for the second commitment period of the Kyoto Protocol) is it clarified that: if land use, land-use change and forestry (LULUCF) constituted a net source of greenhouse gas emissions in 1990 for any Member State or Iceland, the relevant member shall, pursuant to Article 3(7bis) of the Kyoto Protocol, include in its emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in the base year or period from land use, land-use change and forestry for the purpose of calculating the joint assigned amount of the members determined in accordance with Article 3 (7bis), (8) and (8bis) of the Kyoto Protocol. This is not the case for Romania. More information on this is provided below under the chapter on the calculation of the assigned amount.

Pursuant to Annex I to Decision 3/CMP.11, section I, B para 2 those Parties that have reached an agreement in accordance with Article 4 to fulfil their commitments under Article 3 jointly shall use the respective emission level allocated to each of the Parties in that agreement instead of the percentage inscribed for it in the third column of Annex B. This emission level (the assigned amount) is for Romania 656,059,490 tonnes of carbon dioxide equivalent. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8. For the purposes of the joint fulfilment, the commitment period reserve applies to the EU, its Member States and Iceland individually.

The calculations of the commitment period reserve for Romania are follows:

Method 1: 90 % of assigned amount results in:

0.90 * 656,059,490 = 590,453,541 tonnes of carbon dioxide equivalent

Method 2: 100% of most recently reviewed inventory, taken the 2022 submission as the most recently reviewed inventory, multiplied by 8 results in:

109,934,328 * 8 = 879,474,621 tonnes of carbon dioxide equivalent.

The commitment period reserve consequently amount to 590,453,541 tonnes of carbon dioxide equivalent.

12.6 KP-LULUCF accounting

Romania selects accounting of activities under Article 3.3 and 3.4 (forest management and revegetation) of the Kyoto Protocol, for the entire commitment period and intends to report at the end of the commitment period.

13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

Description of the National System

The elements on the Romanian NS, according to paragraphs 30 and 31 of Decision 15/CMP. 1, are described within Chapter 1.

Changes in the National System

Changes in the National System performed before the submission of the 2021 NGHGI are presented in Annex 6.8.

Changes implemented after submitting the 2021 NGHGI

No changes occurred after submitting the 2021 NGHGI.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Romania have therefore occurred in 2021.

Table 14.1 Changes to the national registry

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	There was a change in the cooperation arrangement during the reported period as the United Kingdom of Great Britain and Northern Ireland no longer operate their registry in a consolidated manner within the Consolidated System of EU registries, CS EUR.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There has been 6 new EUCR releases (versions 12.4, 13.0.2, 13.2.1, 13.3.3 , 13.5.1 and 13.5.2) after version 11.5 (the production version at the time of the last Chapter 14 submission). No changes were applied to the database, whose model is provided in Annex A. No change was required to the application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The changes that have been introduced with versions 12.4, 13.0.2, 13.2.1, 13.3.3, 13.5.1 and 13.5.2 compared with version 11.5 of the national registry are presented in Annex B. It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and are carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security were introduced.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change to the registry internet address during the reported period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	No change during the reported period.

15 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

No changes occurred compared to the previous inventory submission.

According to the Article 3.14 of the Kyoto Protocol, Annex I countries will take mitigation measures in such a way as to minimize adverse social, environmental and economic impacts on developing countries. As Romania pointed out in the previous National Communications on Climate Change following the Article 12 of the UNFCCC and also to the European Commission and the European Environmental Agency, following the Regulation 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 the Commission Implementing Regulation (EU) no. 749/2014, the levels of GHG emissions during 1989-2012 were far below the reduction commitment taken within the Kyoto Protocol. This reduction of emissions was mainly the consequence of the decline of the economic activities, the upgrading of technologies and energy efficiency projects promoted as a result of the implementing the European Union acquis communitaire. The GHG emissions reduction achieved have allowed our country to participate from the early stage at the implementation of the AIJ and JI mechanism in order to upgrade and refurbish the old technologies and improve energy efficiency. An important role in the reduction of GHG emissions was played by the participation since 2007 at the application of the Emission Trading Scheme. Therefore we can appreciate that the national climate change policy developed so far to reduce GHG emissions has had no impact abroad and especially on developing countries. Nevertheless Romania is of the opinion that the technical and financing assistance towards the developing countries is very important for the development of international policy on climate change, and is willing to join the European Union initiative to provide a “fast start financing” for the developing countries. Under the fast start financing Romania decided to focus its contribution for the benefit of developing countries associated to the Copenhagen Accord, countries which have committed to take GHG emissions reducing measures and have developed economic strategic partnership relations with our country. The Republic of Moldova has associated itself to the Copenhagen Accords and has committed to reduce the GHG emissions until 2020 by 25% in comparison with the 1990 level. In this context the 15 million Euros Romanian contribution planned for the fast start financing mechanism will be used for energy efficiency and transport infrastructure projects with a view to develop climate change mitigation policy, efficiency of natural resources use and the European integration of the Republic of Moldova.

16 OTHER INFORMATION

There is no other relevant information which needs to be reported.

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