Ministry of Environment

National Environmental Protection Agency

Romania's Greenhouse Gas Inventory 1989-2015

National Inventory Report

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- Annex 3: Gherghiţa Nicodim (ME), Evelina Dascălu (ME), Pompilia State, Sorin Deaconu, Adarciza Brulea, Luminiţa Olteanu;
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AD	Activity Data
AGB	Above Ground Biomass
ANMDM	National Agency for Medicines and Medical Devices
ANRE	Romanian Energy Regulatory Authority
APMCR	Romanian Association of Construction Materials Producers
AR	Afforestation/Reforestation
ASH	ASH content of the manure
AWMS	Animal Waste Management Systems
B_0	Maximum methane (CH4) 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

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
CS EF_s	Country Specific Emission Factors
CWPB	Centre Worked Pre-baked
DDLVRC	Directorate on Driving Licenses and Vehicles Registration Certificates
D	Deforestation
DE	Digestible Energy
DOC	Degradable Organic Carbon
DOC_F	Fraction of DOC Dissimilated
DOM	Dead Organic Matter
DS_{dom}	Fraction of Degradable Organic Component
dm	decimeter
DW	Dead Wood
EAF	Electric Arc Furnace
EB	Energy Balance
EC	European Commission
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
EU	European Union
EUROSTAT	Statistical Office of the European Communities
ERT	Expert Review Team

EU-ETS	European Union-Emission Trading Scheme
FAO	Food and Agriculture Organization
FOD	First Order Decay
FFN	National Forest Fund
FLRFL	Forest Land Remaining Forest Land
FM	Forest Management
FORLUC	Forest Land Use
GB	Gross Fat
GD	Governmental Decision
GE	Gross Energy Intake
G	Grams
Gg	Giga gram
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPG	Good Practice Guidance
GWP	Global Warming Potential
Ha	Hectares
HCFC	Fluorinated Gases
HFC_s	Hydro-fluorocarbons
ICAS	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
ICPIL	Research and Design Institute of Wood Industry
IE	Included elsewhere
IEA	International Energy Agency
INSEMEX Petrosani	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 GPG 2006	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories - 2006
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
KP	Kyoto Protocol
KP Supplement	Good Practice Guidance Arising from the Kyoto Protocol
KCA	Key Category Analysis
Kcal	Kilocalorie
Kg	Kilograms
Kj	Kilojoule
L	Level
L	liquid
LB	Loss in Biomass
LT	Litter
LTO	Landing/Taking Off
LULUCF	Land Use, Land Use Change and Forestry
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
NFI	National Forest Inventory
NGHGI	National Greenhouse Gas Inventory
NH_3	Ammonia
NIM	National Institute of Meteorology
NIR	National Inventory Report
NIS	National Institute for Statistics
NMVOC	Non-methane Volatile Organic Compound
NO	Not occured
NOx	Nitrogen Oxides
NS	National System for the estimation of anthropogenic emissions by sources and removals by skins of all greenhouse gases not controlled by the Montreal Protocol

NSCR	Non Selective Catalytic Reduction
NTPA - 011	Romanian Standard regarding wastewater treatment
PB	Gross Protein
PFC_s	Per-fluorocarbons
PRODCOM Codes	Codes of PRODucts of the European COMmunity
QA/QC	Quality Assurance/Quality Control
RAR	Romanian Automobile Register
Rev	Re-vegetation
RNP	Public National Forest Administration
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	Nitrogenous substances extractable
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
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
SY	Statistical Yearbook
T	Trend
t	tones
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
WA	Weighted arithmetic average
Wetlands Supplement	Supplement to the 2006 Guideliness 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
%	Percent

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 25th version of the National Inventory Report (NIR) submitted by Romania, covering the national inventories of GHG emissions/ removals for the period 1989-2015.

This inventory (comprising the current National Inventory Report and the associated CRF tables) represents the 2017 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 1999 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 2012-2013 they decreased; in 2014-2015 they slowly increased, following the economic activities level.

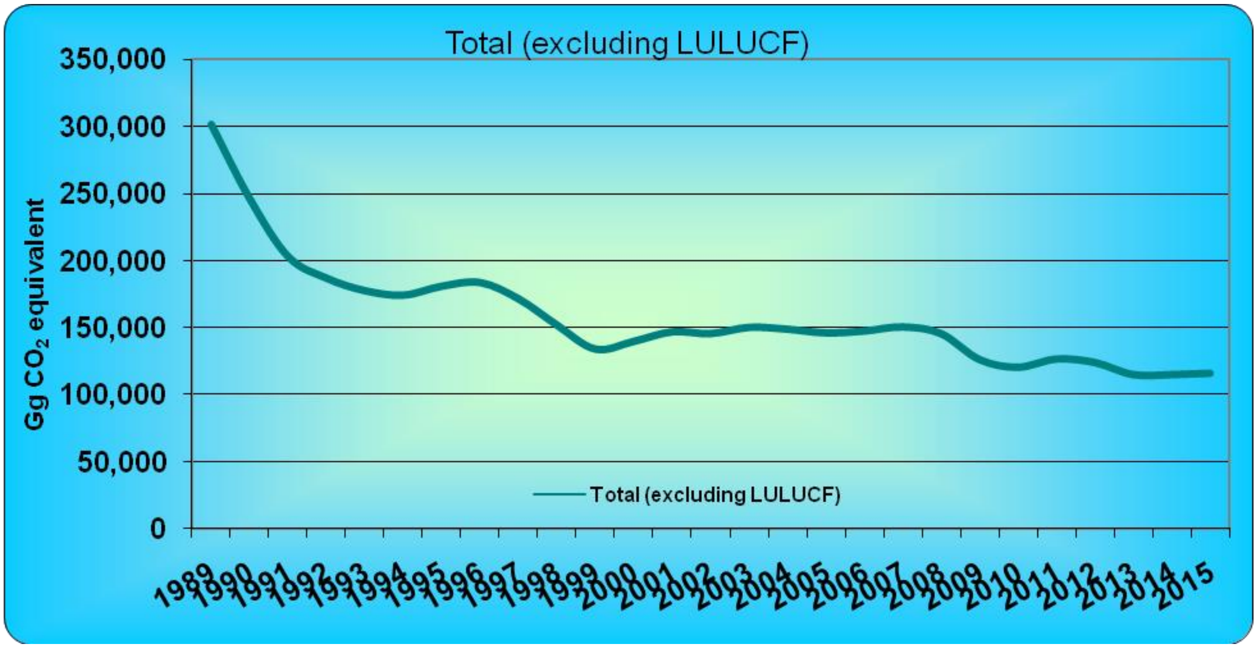
The largest contributor to the total national GHG emissions is CO_2, followed by CH_4 and N_2O. The share of each direct GHG in total emissions in 1989 and, respectively 2015, and the average share of each direct GHG in total emissions for 1989-2015 period are presented in the Table ES.1.

The total GHG emissions excluding LULUCF, in CO_2 equivalent, during 1989-2015 period, are presented in the Figure ES.1.

Table ES 1 Share of each direct GHG in total emissions in 1989, 2015, respectively 1989-2015 period

GHG	1989 (%)	2015 (%)	Average share for 1989-2015 period (%)
CO_2	69.12%	67.01%	68.50%
CH_4	23.29%	25.42%	24.33%
N_2O	6.11%	6.12%	6.16%
HFCs	0.00%	0.0141%	0.3482%
PFCs	1.48%	0.01%	0.64%
SF_6	0.00%	0.00045%	0.01557%
NF_3	0.00%	0.00%	0.00%

Figure ES 1 The total GHG emissions in CO_2 equivalent during 1989-2015 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 1989–2015 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 6.0.1.1.

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 27% 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 2015 year, the forest land area accounted for approximately 7 001,1 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 25th 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 2017 National Greenhouse Gas Inventory of Romania under the UNFCCC and the Kyoto Protocol.

For this submission, Romania prepared the CRF tables and database containing emissions/ removals estimates and background data for 1989-2015 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

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 and the GD no. 38/2015 on the organization and functioning of the Ministry of Environment, Waters and Forests 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), presently, 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 Urgecy Ordinance no. 9/2016 and in the Governmental Decision no. 284/2016.

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 estimating 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 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and IPCC good practice guidance, 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 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, is 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 the studies:

- in 2012, “Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations” 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, “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 “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, “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”.

❖ 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 of the studies:

- 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”;
- in 2013, “Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation”;

- in 2014, “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology”, “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology” and “Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology”.

❖ based on 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)”, Denkstat improved the system of administrating the HFCs, PFCs and SF_6 data and information.

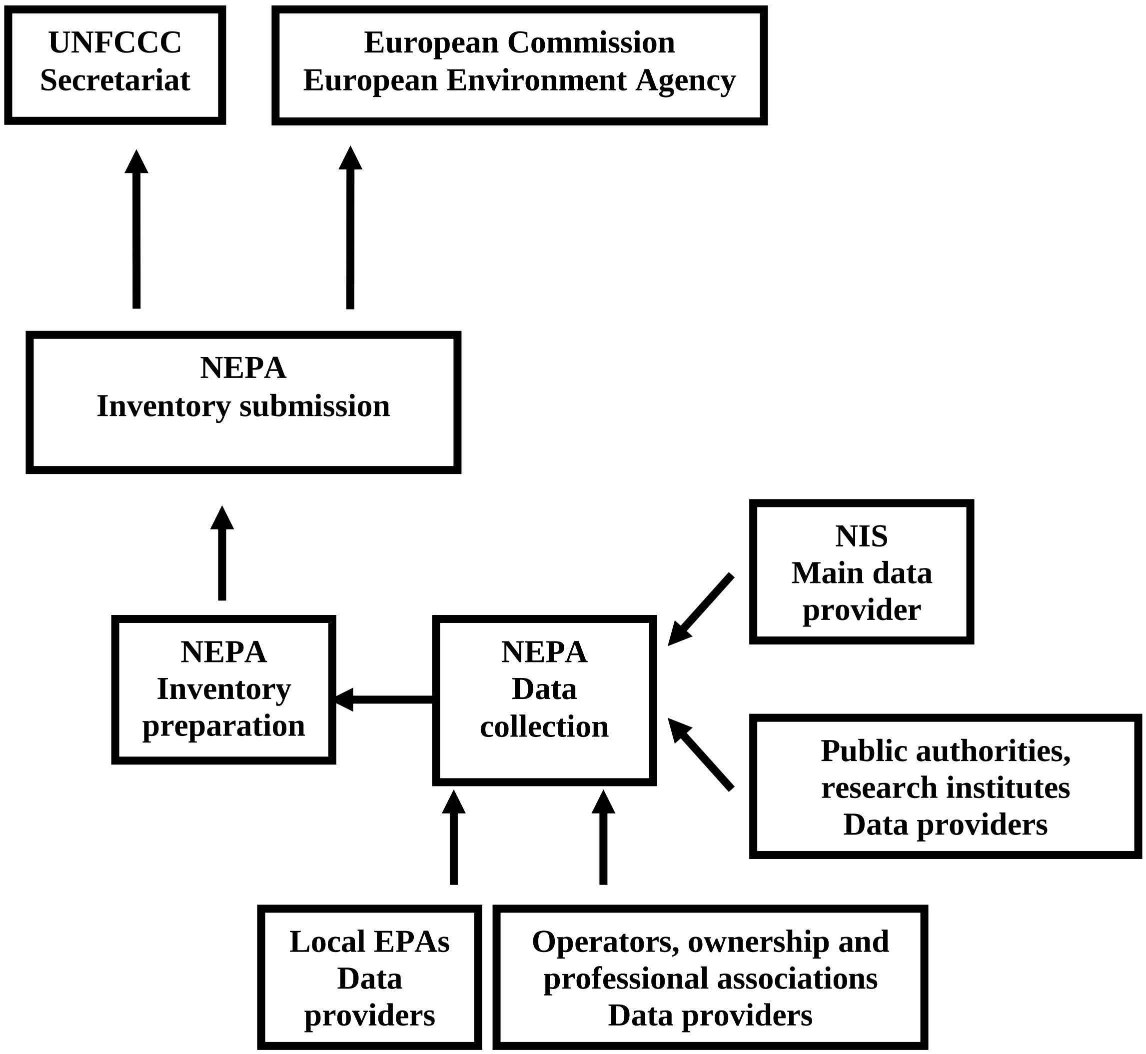
❖ the “Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO_2) and other greenhouse gas emissions” study was carried out in 2011 by the Institute for Studies and Power Engineering (ISPE); specific elements comprise:

➢ 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 and Climate Change officially considers, approves and 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;
- Ministry of Environment Order (MoEO) no. 1376/2008 for approving the Procedure on NGHGI reporting and the modality for answering to the observations and questions raised following the NGHGI review;
- MoEO no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI;
- MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels;
- MoEO no. 1602/2014 on approving the Quality Assurance and Quality Control Plan associated to the National Greenhouse Gas Inventory;

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

B. Ensure sufficient capacity for timely performance of the 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:
  - o appropriate working space and facilities have been provided;
  - o the necessary IT equipment has been procured through the support of study “Environmental Integrated Informational System”;
  - o 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;
  - o 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;
  - o 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);
  - o 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.

❖ 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	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

No.	Activity	Period/ Deadline	Persons subject to training	Responsible persons	Documents to be considered
	(NS) and the Greenhouse Gas Inventory (NGHGI)				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
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 (CO2) 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
					GPG 2003), IPCC 1996
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	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

No.	Activity	Period/ Deadline	Persons subject to training	Responsible persons	Documents to be considered
	improvement plan				

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;
- 2017 submission of the NGHGI constitutes the 25th 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;

- 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 team/activities relevant to the NIA and NS/NGHGI administration;
    - coordinating the QA/QC activities;
    - 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 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;
- QA/QC plan is intended to ensure the fulfillment of the NGHGI principles in Romania.

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.

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;
- results are presented in NIR, within:
  - Chapter 1, at general level;
  - Annex 1.
- KCA is used for prioritize efforts for improving the quality of the NGHGI-the relevant implemented and future studies refers mainly to the use of higher Tier methods on 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, “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 2013, “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)” and “Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation”;
- in 2014, “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology”, “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology” and “Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology”.

o 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:
  - the studies:
    - in 2011, “NGHGI LULUCF both under the UNFCCC and KP obligations”;
    - in 2012, “Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations” and “Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations”;
    - in 2013, “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 “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, “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”.
  - 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;
- 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, "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 2013, "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)" and "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation";
  - in 2014, "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology" and "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology".
- 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 “Environmental Integrated Informational System” study by the SC Asesoft International SA-SC Team Net International SA-SC Star Storage SRL consortium, based on a contract with NEPA;
- ❖ 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 the studies:
    - ▪ in 2011, “NGHGI LULUCF both under the UNFCCC and KP obligations”;
    - ▪ in 2012, “Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations” and “Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations”;
    - ▪ in 2013, “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 “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, “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”.

- 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 for 2015, both excluding and including the LULUCF;
- ❖ based on national (NIS, "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", "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)", "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N2O emissions estimation", "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology", "NGHGI LULUCF both under the UNFCCC and KP obligations", "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations", "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 "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", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology" and "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" studies), 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), and 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:
  - NEPA's/MEWF's work;
  - on the studies implemented:
    - 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" and "NGHGI LULUCF both under the UNFCCC and KP obligations";
    - in 2012, "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations";
    - in 2013, "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)", "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation", "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 "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, "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology", "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology" and "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".

    - 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;
- ❖ 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, "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" and "NGHGI LULUCF both under the UNFCCC and KP obligations";
    - in 2012, "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations";
    - in 2013, "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)", "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation", "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 "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, "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and

Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology", "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology" and "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".

  - 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 and 2016, 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;
  - 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.
- 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);
- 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 and 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.

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.

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, "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation”;

- in 2014, the studies “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology”, “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology” and “Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology”.

Based on 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)”, 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.

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.

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 provisions of the Governmental Decision no. 1570/2007 establishing the national inventory arrangements and national system, as ulteriorly modified and completed, to those in the MoEO no. 1602/2014 on approving the Quality Assurance and Quality Control Plan associated to the National Greenhouse Gas Inventory and to those in other relevant legal provisions in place (as previously presented), NEPA represents the competent authority responsible with the implementation of the QA/QC activities under the NGHGI.

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 correctness and consistency of choosing the AD, EF and methods used along the entire time series;
- ❖ checking the trends for identifying the outliers and re-analyze the values;
- ❖ 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,
  - "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";
  - "NGHGI LULUCF both under the UNFCCC and KP obligations".

- in 2012,
  - "Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations";
  - "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations".
- in 2013,
  - "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)";
  - "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation";
  - "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";
  - "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:
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology";
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to

allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology";

- "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology";
- "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".

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,
    - "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 2013,
    - "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)";
    - "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation";
    - "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";
    - "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,
    - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to

allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology";

- "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology";
- "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology";
- "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".

Additionally, in 2012 and 2016, 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.

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.

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;
- training of NEPA and data providers representatives through several training instruments;
- using a cross-checking QC approach within MECC;
- 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,
    - "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";
    - "NGHGI LULUCF both under the UNFCCC and KP obligations".
  - in 2012,
    - "Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations";
    - "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations".
  - in 2013,
    - "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)";
    - "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation";

  - "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";
  - "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,
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology";
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology";
  - "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology";
  - "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".

- 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 (attached as Annex 6.1.4) administered by the NGHGI coordinator.

Treatment of confidentiality issues

Due to the confidentiality clause assigned to some activity data on Industrial Processes 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 2015, 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, "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 2013, “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)” and “Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation”;
- in 2014, “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology”, “Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology” and “Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology”.

➢ 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:

- the studies:
  - in 2011, “NGHGI LULUCF both under the UNFCCC and KP obligations”;
  - in 2012, “Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations” and “Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations”;
  - in 2013, “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 “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, “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”.
- 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 “Environmental Integrated Informational System” study by the SC Asesoft International SA-SC Team Net International SA-SC Star Storage SRL consortium, based on a contract with NEPA.

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.

Activities were carried out mostly at MEWF, ISPE, ICAS and Denkstat, as contractors of studies:

- 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";
  - "NGHGI LULUCF both under the UNFCCC and KP obligations".
- in 2012,
  - "Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations";
  - "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations".
- in 2013,
  - "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)";
  - "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation";
  - "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";

  - "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,
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology";
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology".
  - "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology";
  - "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".

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 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).

NEPA 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;
- ❖ 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;
- ❖ worksheets and interim calculations for category estimates and aggregated estimates and any recalculations of previous estimates;
- ❖ 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 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 and Wetlands 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
LULUCF	National Institute for Statistics through Statistical Yearbook

Sector	Data sources
	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 work and the implementation by ISPE, ICAS and Denkstat, of the studies:
  - 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”;
    - “NGHGI LULUCF both under the UNFCCC and KP obligations”.
  - in 2012,
    - “Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations”;
    - “Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations”.
  - in 2013,

  - "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)";
  - "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation";
  - "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";
  - "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,
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology";
  - "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology";

    - "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology";
    - "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".
- 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, "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 2013, "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)";

- in 2014, "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology" and "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology".

- 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:

- the studies:
  - in 2011, "NGHGI LULUCF both under the UNFCCC and KP obligations";
  - in 2012, "Determination of emission/removal factors for the forest and for conversions from/to forest land associated pools both under UNFCCC and KP obligations" and "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations";
  - in 2013, "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 "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, "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".

➢ 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 "Environmental Integrated Informational System" study by the SC Asesoft International SA-SC Team Net International SA-SC Star Storage SRL consortium, based on a contract with NEPA.

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 was conducted for every year of the characterized period.

The results of the key category analysis for 1989 and 2014 are presented in NIR within:

❖ Chapter 1, at general level;

❖ Annex 1.

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 2015, both excluding and including the LULUCF sector; it is based on national (NIS, "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", "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)", "Determination of the biodegradable content industrial wastes amount and of sludge amount from wastewater treatment, deposited in managed landfills (for the period 1989-2012) and in unmanaged landfills (for the period 1950-2012). Determination of incinerated wastes

type/amount and of parameters specific to their incineration, for the period 1989-2012. Wastes incineration N_2O emissions estimation", "NGHGI LULUCF both under the UNFCCC and KP obligations", "Compilation of the 2013 National Greenhouse Gas Inventory Land Use, Land-Use Change and Forestry Sector both under the UNFCCC and KP obligations", "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 "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", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the categories Lime production, Glass production and Ammonia production, according to the IPCC 2006 methodology", "Elaboration and documentation of values for the parameters relevant to the National Greenhouse Gas Inventory Sector Industrial Processes and Product Use, values to allow for the implementation of the higher tier greenhouse gas emissions calculation methods for the category Iron and steel production, according to the IPCC 2006 methodology", "Estimation of methane emissions from industrial wastewater according to the IPCC 2006 methodology" and "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" studies), 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), and default AD and EFs uncertainty sources.

Considering the 2015 and 2016 NGHGI and the Tier 1 method:

❖ the total NGHGI uncertainty for 2014 excluding LULUCF was 11.2%, while including LULUCF was 18.1%;

❖ the uncertainty introduced into the trend in total national emissions, for 2014, was 1.3% when considering excluding LULUCF criteria and 5.7%, including LULUCF.

Considering the 2017 NGHGI and the Tier 1 method:

- the total NGHGI uncertainty for 2015 excluding LULUCF was 11%, while including LULUCF was 17.5%;
- the uncertainty introduced into the trend in total national emissions, for 2015, was 1.5% when considering excluding LULUCF criteria and 5.9%, including LULUCF.

Based on data and information associated with the 2017 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 1989-2015 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

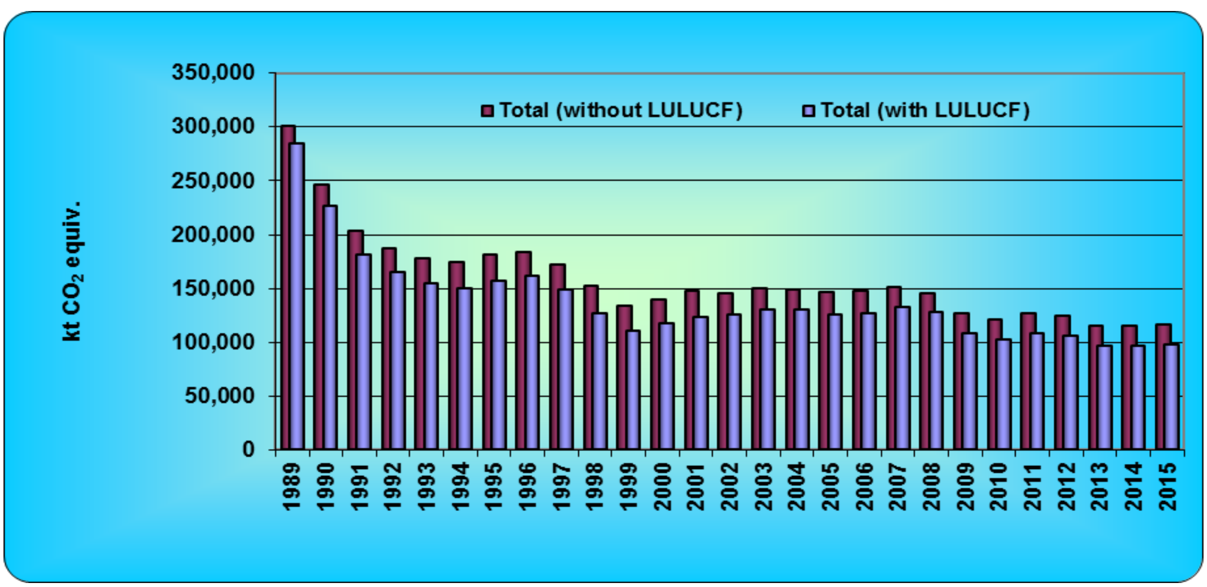
2.1 Description and interpretation of emissions trends for aggregated GHG emissions

The total GHG emissions in 2015, excluding removals by sinks, amounted to 116,426.73 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 with 61.37% in 2015 in comparison to 1989 while the net GHG emissions/ removals (taking into account the CO_2 removals) decreased with 65.56%. Based on these observations, there is a great probability for Romania to meet the commitments to reduce the GHG emissions in the first commitment, 2008-2012.

Figure 2.1 Trends of the aggregated GHG emissions



The emissions trend reflects the changes in this period characterized by a process of transition to a market economy. The emissions trend can be split in three parts: the period 1989-1999, the period 1999-2008 and the year 2010.

The decline of economic activities and energy consumption in the period 1989-1992 had directly caused the decrease of the total emissions in that period. With the entire economy in transition, some energy intensive industries reduced their activities and this is reflected in the GHG emissions reduction. Emissions have started to increase until 1996, because of the economy revitalization. Considering the starting of the operation of the first reactor at the Cernavoda nuclear power plant (1996), the emissions decreased again in 1997.

The decrease continued until 1999. The increased trend after 1999 reflects the economic development in the period 1999-2008. The limited decrease of GHG emissions in 2005, compared with 2004 and 2006 levels was caused by the record-breaking hydrological year positively influencing the energy produced in hydropower plants. Due to the economic crisis, the emissions have significantly decreased in 2013 comparing with 2008.

2.1.1 Description and interpretation of emissions trends by gas

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: 69.12% CO_2, 23.29% CH_4, 6.11% N_2O, 1.48% PFCs. In 2015, the shares of GHG emissions were: 67.01% CO_2, 25.42% CH_4, 6.12% N_2O, 0.01% PFCs. The F gases started to be used as substitutes for ODS in refrigerating and air conditioning systems since 1995. In 2015, the contribution of these gases to the total GHG emissions is negligible: 1.41% HFCs and 0.04% 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 including LULUCF	CO_2 excluding LULUCF	CH_4 excluding LULUCF	N_2O excluding LULUCF	HFCs	PFCs	SF_6
1989	208,314.33	190,746.51	70,195.76	18,402.29	0.16	4,446.00	0.47
1990	170,747.62	150,033.00	57,237.02	15,478.14	0.18	2,808.43	0.47
1991	141,044.14	118,476.30	48,537.67	11,023.02	0.29	2,577.81	0.52

Year	CO_2 including LULUCF	CO_2 excluding LULUCF	CH_4 excluding LULUCF	N_2O excluding LULUCF	HFCs	PFCs	SF_6
1992	130,628.30	107,661.50	43,931.21	10,747.58	0.45	1,794.74	0.49
1993	122,120.28	97,841.13	42,381.13	11,425.77	0.73	1,870.78	0.52
1994	120,104.28	94,268.09	41,727.55	10,692.42	1.20	1,979.03	0.74
1995	125,458.82	100,398.51	41,951.55	11,344.97	2.53	2,354.07	0.98
1996	128,789.65	104,697.78	41,838.10	10,901.72	4.72	2,347.88	1.54
1997	120,005.11	95,471.62	38,874.95	10,512.71	10.36	2,341.19	1.41
1998	103,932.31	77,286.15	36,633.17	9,326.44	23.88	2,285.99	1.51
1999	88,200.24	62,973.54	35,167.55	8,869.32	39.73	2,082.71	1.70
2000	92,958.04	68,413.68	36,117.73	9,333.07	70.82	1,674.72	8.68
2001	98,492.35	73,082.70	38,029.41	9,228.04	112.87	1,367.16	14.33
2002	98,576.14	76,239.00	37,665.15	8,528.94	168.16	985.46	12.10
2003	103,051.07	81,403.51	37,715.37	9,215.33	228.75	304.54	10.54
2004	101,801.59	81,008.85	36,403.59	10,494.37	293.93	153.86	14.10
2005	99,585.26	77,646.45	36,068.39	10,320.98	368.91	95.28	15.67
2006	102,367.15	80,033.90	35,715.81	9,185.81	484.20	64.06	24.13
2007	106,449.07	86,313.98	34,515.50	9,189.75	665.63	28.18	29.88
2008	103,112.28	83,074.11	33,730.50	7,987.46	946.95	17.87	33.83
2009	86,113.59	65,889.86	32,161.61	7,317.08	924.42	8.16	47.03
2010	82,265.52	61,925.86	30,046.66	7,535.11	982.46	9.13	60.71
2011	88,455.72	67,806.55	29,525.66	7,858.60	1,092.14	12.72	47.83
2012	85,888.55	66,107.12	30,128.10	7,146.12	1,197.29	7.43	50.76
2013	76,954.06	56,877.26	29,767.54	7,305.79	1,298.44	6.15	57.20
2014	77,195.56	57,093.25	29,748.15	7,038.28	1,373.08	6.34	51.78
2015	78,013.49	57,911.19	29,592.00	7,125.64	1,636.76	6.57	52.27

Carbon dioxide (CO_2) – the most significant anthropogenic greenhouse gas is the carbon dioxide. The decrease of CO_2 emissions (from 208,314.3267 Gg in 1989 to 78,013.49 Gg in 2015) 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 2015 by 57.84% compared with the levels 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 2015 decreased with 61.28% in comparison with the level in the base year.

Fluorocarbons and SF_6 (HFCs, PFCs, SF_6) – The PFCs emissions generated in the production of the primary aluminium are reported for the entire analyzed period (1989-2015) and have decreased with 99.85% in 2015 comparing with the level in 1989.

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), except for CO emissions, which strongly increased staring with 1995, due to the raise of the amount of the firewood used in households.

The 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.

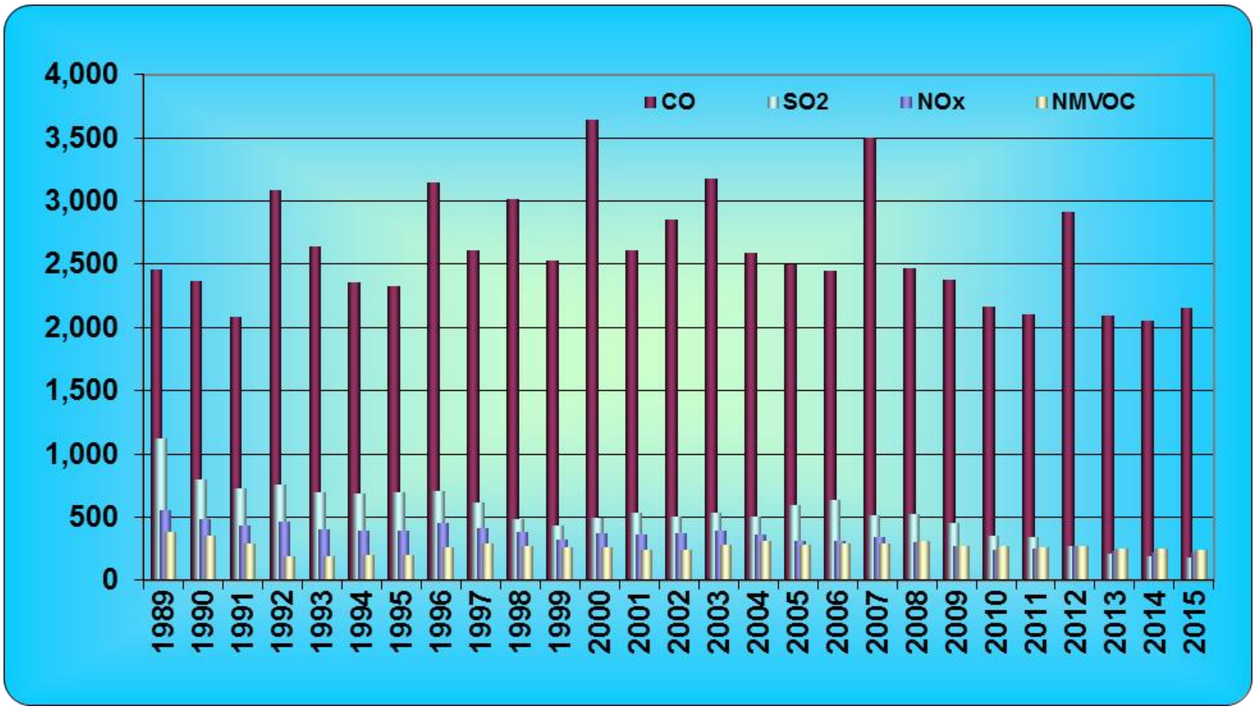
The indirect GHG emissions trends are presented in Figure 2.2.

Table 2.2 Indirect GHG emissions levels [kt]

Year	NO_x	CO	NMVOC	SO_2
1989	553.10	2457.72	388.09	1120.61
1990	486.57	2369.46	352.71	802.18
1991	429.22	2082.17	290.28	725.61
1992	461.09	3089.31	195.41	759.69
1993	403.90	2636.10	193.78	694.65
1994	393.53	2355.34	198.31	688.67
1995	391.55	2331.67	203.27	696.85
1996	455.36	3146.10	260.44	706.95
1997	414.97	2612.67	289.77	612.73
1998	384.22	3018.25	271.40	488.76
1999	323.65	2524.62	261.54	436.33
2000	375.56	3643.84	264.89	490.78
2001	359.18	2608.40	242.60	535.10
2002	369.30	2850.32	245.91	508.53
2003	389.85	3175.06	283.51	537.61
2004	358.26	2588.90	309.01	508.35
2005	317.15	2500.59	286.84	594.42
2006	313.94	2452.76	291.40	632.27
2007	342.31	3496.78	293.47	515.49
2008	299.98	2465.60	312.19	521.07
2009	269.47	2379.72	275.32	450.63
2010	244.66	2168.76	274.61	354.88
2011	250.09	2102.89	262.63	344.99
2012	272.79	2909.50	269.14	273.37
2013	231.37	2099.06	255.99	215.22

Year	NO_x	CO	NMVOC	SO_2
2014	222.73	2050.34	251.46	185.75
2015	223.65	2154.66	246.38	178.72

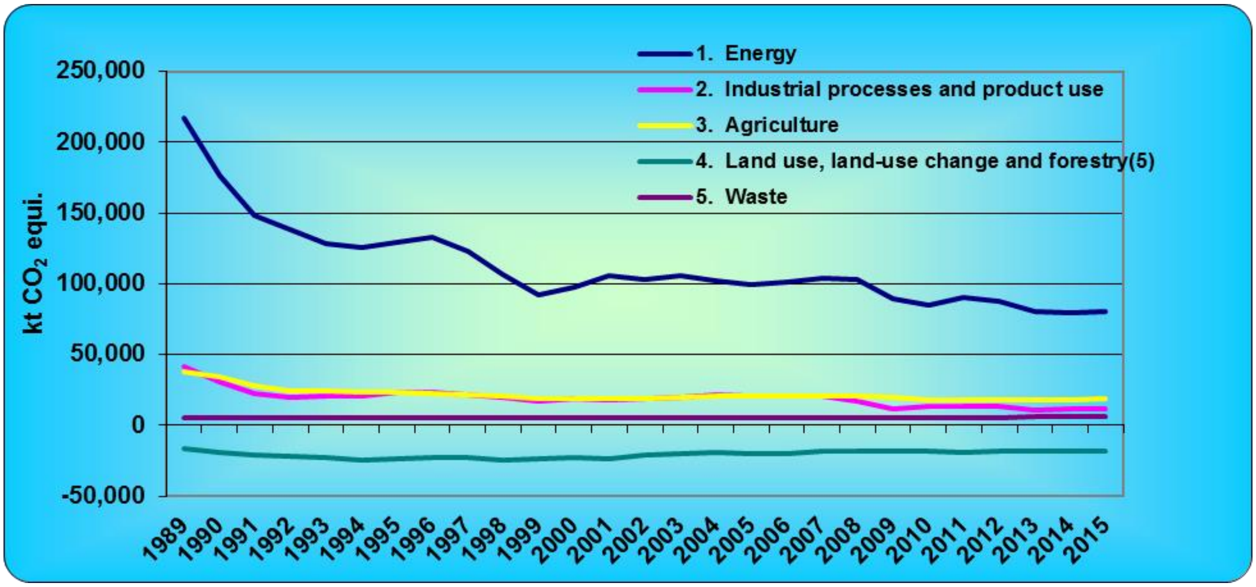
Figure 2.2 Indirect GHG emissions trends [kt]



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 68.80% of the total national GHG emissions in 2015. The GHG emissions resulted from the Energy sector decreased with 63.07% compared with the base year.

Industrial processes and product use - contributes to total GHG emissions with 10.20%. A significant decrease of GHG emissions was registered in this sector 71.61% decreases in 2015 compared to the level in 1989 due to the decline or the termination of certain production activities.

Agriculture - GHG emissions have also decreased. The GHG emissions in 2015 are 50.38% lower in comparison with the 1989 emissions due to:

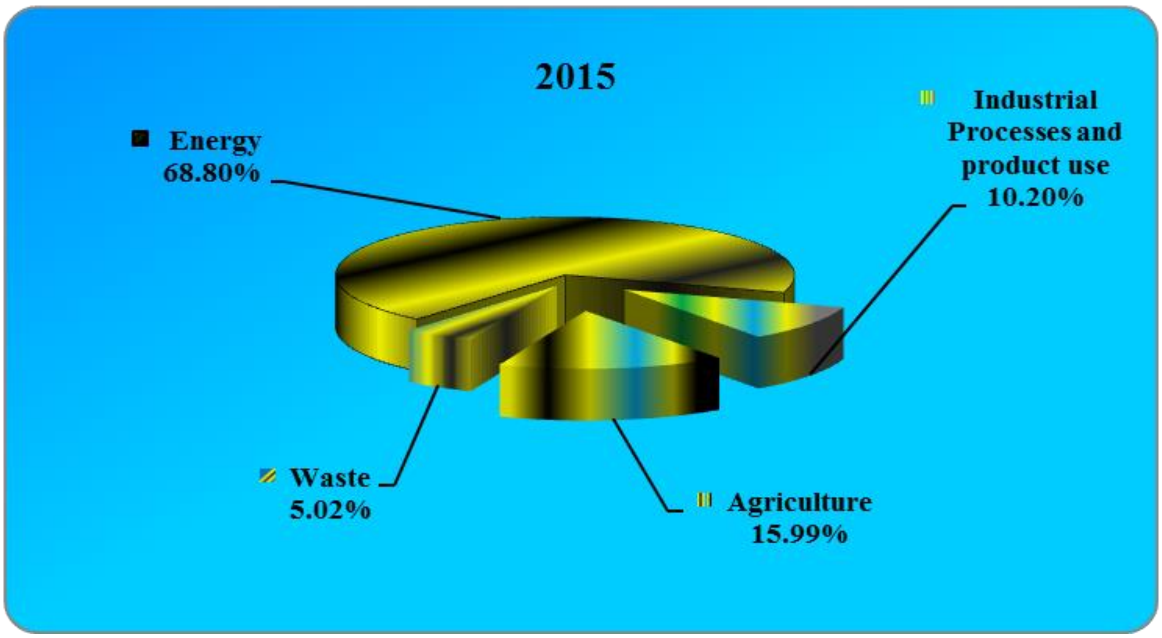
- the decline of livestock;
- the decrease of rice cultivated area;
- the decrease of crop productions level;
- the decline of N synthetic fertilizer applied amounts.

In 2015, 15.99 % of the total GHG emissions resulted from the agriculture sector.

LULUCF - The net GHG removals/emissions level is 11.83% higher in 2015 in comparison with the level in the base year.

Waste sector - emissions have increased in 2015 with 13.78% in comparison with the level in 1989. The contribution of the waste sector to the total GHG emissions in 2015 is 5.02%.
The participation of sectors to GHG emissions (excluding LULUCF) is presented in the next figure.

Figure 2.4 Sectorial GHG emissions in 2015 [%]



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)

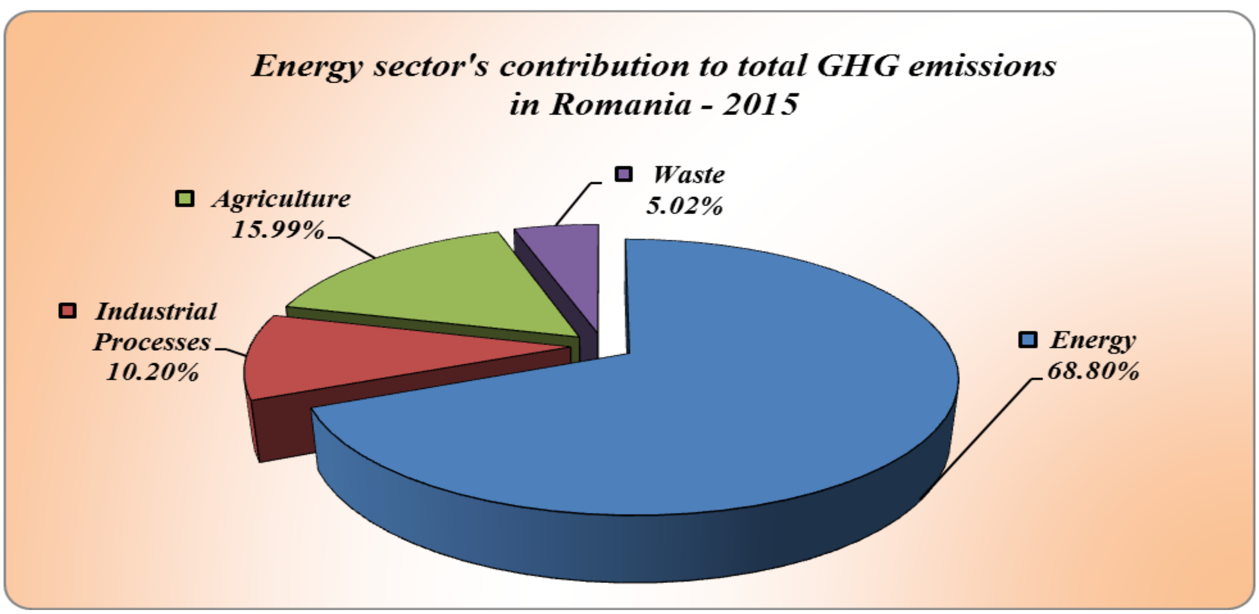
3.1 Overview of the sector

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.

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 2015, the Energy sector was responsible for about 68.80% of the total GHG emissions 116,426.72 kt CO_2 equivalent.

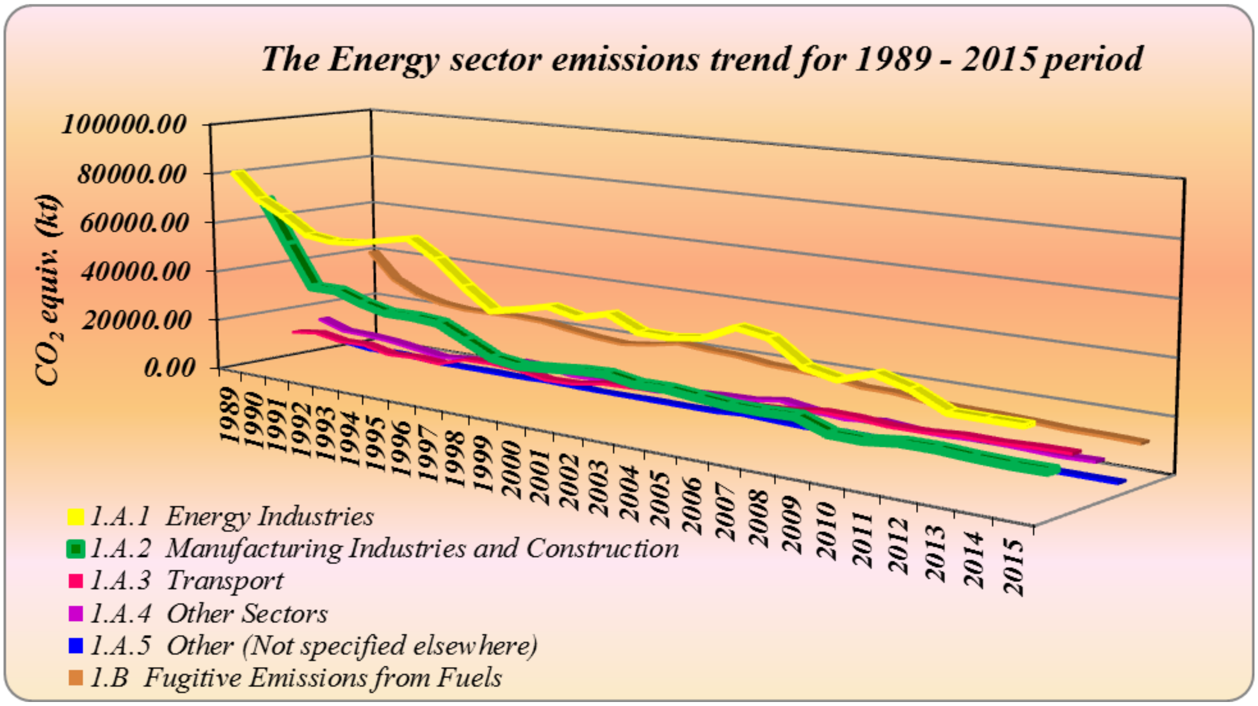
Figure 3.1 The contribution of Energy Sector to the total GHG emissions in Romania, 2015



Emission trends

In 2015, emissions from the Energy sector have decreased by 63.58% (80,098.16 kt CO_2 equivalent compared to 219,899.51 kt CO_2 equivalent in 1989, base year).

Figure 3.2 The energy sector emission trend for the period 1989-2015



The emissions trend reflects the changes in this period characterized by a process of transition to a market economy.

The emissions trend can be split in two parts: the period 1989-1996 and the period 1996-2004. The decline of economic activities and energy consumption in the period 1989-1992 had directly caused the decline in total emissions in that period. With the entire economy in transition, some energy intensive industries reduced their activities and this is reflected in the GHG emissions reduction.

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.

The firewood consumption in households increased in 2008 due to the increase of the inhabitable space in the rural area (according to the Energy Balance).

The decreased fuel consumptions, especially in industry, are due to the decrease of economic activities level in the second semester of 2008.

Available energy resources totaled, in 2011, 44.5 million tons of oil equivalent (tep), increasing with 2.08 thousands tons , compared to 2010.

Final energy consumption in 2011 was preserved, overall, the same level as in 2010, slight increases were recorded in agriculture and forestry (10.7%) and transport (+4.0%).

Exports of energy (including bunkers), of 4.163 million tons, compared to 2009 increased by 2.7%.

Electricity consumption in 2011 was, with 1506 GWh (2.4%) more higher than in 2010.

Consumption of energy production plants in 2011 was higher than 2010 with 1502 thousand toe (+15.7%).

Coal accounts for 54.5% in the consumption of energy production plants and 14.7% hydrocarbons.

In 2012, energy resources and primary energy production decreased slightly (- 2.4% and -1.3%) compared with 2011.

Imports of energy products increased slightly (+0.4%) compared to last year while final energy consumption remained at the same level as the previous year.

Available energy resources amounted, in 2012, 43.4 million tons equivalent petroleum (Toe), down 1.055 million toe (-2.4%) from the previous year, mainly due to lower primary energy production.

The decrease in oil resources (-6.8%) was accompanied by, among other things, the resources of the coal decrease (-5.4%) and natural gas (-0.7%).

Primary energy resources in 2012 were 41.728 million tonnes of oil equivalent, down with 70 toe the previous year. Of primary energy resources:

- Coal (excluding coke) 7846 mii toe 8298 mii toe in 2012 compared to 2011 (-5.4%);
- Oil: 9.718 million toe in 2012 compared to 10.426 million toe in 2011 (-6.8%);
- Gas utilizable s: 12.582 million toe in 2012 compared to 12.676 million toe in 2011 (-0.7%);
- Import coke from 470 ktoe in 2012 compared to 505 thousand toe in 2011 (-6.9%);
- Hydroelectric, wind, solar photovoltaic and nuclear power: 4101mii toe in 2012 compared to 4.286 million toe (-4.3%).

Primary energy production in 2012 of 27.1 million toe, had a slight decrease (-353 toe, representing -1.3%) compared to 2011, but continued to maintain a significant share in total energy resources, representing 62.5% of them.

Were all decreased production of primary energy carriers, except natural gas production increased 0.5% from the previous year.

Imports of energy products increased slightly (+0.4%) compared to last year, the decrease oil and gas imports was offset by increased imports of products petroleum and coal (including coke) with 13.8% and 12.2%.

Final energy consumption in 2012 remained at the same level as in 2011, increases in agriculture and forestry (15.2%), households (2.7%) and transport (0.7%) were offset by declines in industry and the tertiary sector.

Total final energy consumption in industry (including construction), which accounts for approximately 30% of total final energy consumption was down compared to the year previous (-4.2%). In transport, the increase in consumption in road transport (+2.2% since 2011) consumption shortfall recorded in other types of transport.

Energy exports (including bunkers) of 3.798 million toe, fell to 8.8% in 2011.

Gross inland consumption of energy per capita in the year 20 12 was 1736 kg oil equivalent.

Industry (including construction and energy) still holds the largest share in structure of electricity consumption (57.9%), followed by the population (23.1%).

Consumption for power plants in 2012 was lower than in 2011 with 722 ktoe (-6.5%).

For power plants have been used 10.341 million toe, this consumption is included fuel for electricity generation in the nuclear plant. The share of coal consumption in thermoelectric energy consumption for production in 2012 was 56.1%, down from 2011 when it was 58.6%.

An opposite trend was gazoaze oil consumption, whose share increased in 2012 to 14.5% compared to 13.7% as were in use for the production energy plants in 2011.

In 2013, industry (including construction and energy sector) still holds the largest share in structure of electricity consumption (56.1%), followed by the population (23.9%).

Exports of energy (including bunkers), compared to 2012 increased by 2.7%; total consumption of public lighting decreased with 12.7% compared to previous year; the coal consumption share in 2013, was 48.7% from the thermoelectric energy consumption compared to 56.1% in 2012.

In 2014, energy resources and primary energy production decreased slightly (- 2.4% and -1.3%) compared with 2012 and imports of energy products decreased slightly (-14%) compared to last year while final energy consumption decreased (-3.9%) compared with 2012.

The primary energy resources were of 40.235 million tonnes of oil equivalent in 2014, an increase of 991 000 toe over the previous year.

In 2015, emissions from the Energy sector have decreased by 54.64% (80,098.16 kt CO_2 equivalent to 2015 compared to 176,586.2756 kt CO_2 equivalent in 1990).

In 2015, emissions from the Energy sector have increased with 0.33% (80,098.16 kt CO_2 equivalent to 2015 compared to 79,835.39 kt CO_2 equivalent in 2014).

According to the Energy Balance, the final energy consumption in 2015 increased with 160 thousand toe (+0.7%) in comparison with 2014. The final consumption in industry, with a share of 29.4% in the final energy consumption) decreased with 18 thousand toe (-0.3%) in comparison with 2014; the largest consumer in industry is the metallurgy branch which increased its consumption with 7.4%, instead, the chemical industry decreased in energy consumption with 14.7%.

Exports of energy (including bunkers), compared to 2014 increased with 288 thousands toe (5.0%).

Consumption of renewable and other fuels increased by 15.6 %, mainly due to increased consumption of biomass (+ 18.3 %) compared to 2014.

Industry (including construction and energy sector) still holds the largest share in structure of electricity consumption (56.1%), followed by the population (23.9%).

The primary energy resources were of 40.235 million tonnes of oil equivalent in 2014, an increase of 991 000 toe over the previous year.

There were increases at coal production (+ 5.9%) but decreased production of hydro, wind and photovoltaic electricity over the previous year (-3.9%), as well as oil production (-1, 2%).

The weight of coal consumption in the consumption for the production of thermoelectric energy was 48.1% and 17.9% for the hydrocarbon gases consumption, increasing by 2.7% over the previous year.

Consumption of liquid hydrocarbons remained at the same insignificant weight (0.2%) as in 2014.

In 2015, the available energy resources totaled 42.2 million tonnes of oil equivalent (toe), increasing by 484 000 toe (+ 1.2%) over the previous year. This was mainly due to increased imports of energy products.

From primary energy resources, the resource represented by imported petroleum products had the largest increase (716 000 toe, + 31.4%); This, together with the oil resources (which grew by 142 thousands toe, representing + 1.2%) had a share of about 36% in total primary energy resources; Significant declines were recorded at the natural gas resources usable (-407 000 toe, representing -3.7%) (Source - Romanian National Institute for Statistics).

Table 3.1 Shares of GHG emission categories within the Energy sector, in 2015

Energy sector-categories	**Percentages for 2015**
Energy industries	37.11
Manufacturing Industries and Construction	15.55
Transports	19.64
Other sectors	12.96
Other	0.58
Fugitive emissions	14.17

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 2015 Energy sector

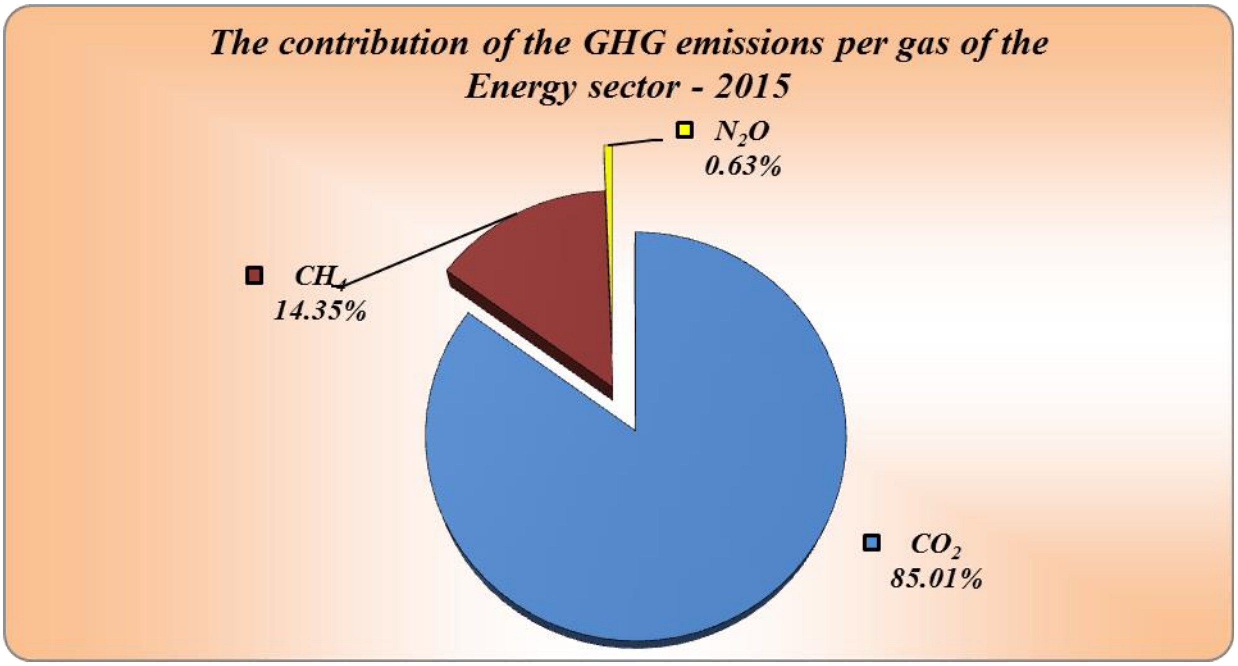


Table 3.2 Status of emissions estimation within the Energy Sector for 2015

IPCC category-Energy Sector	Emissions estimation status		
	CO_2	CH_4	N_2O
1AA 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	✓	✓	✓

IPCC category-Energy Sector	Emissions estimation status		
	CO_2	CH_4	N_2O
1.A.2.d. Pulp paper and print	✓	✓	✓
1.A.2.e. Food processing, beverages and tobacco	✓	✓	✓
1.A.2.f.	✓	✓	✓
1.A.2.g Other (as specified in table 1.A(a)s2)	✓	✓	✓
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	✓	✓	✓
1B Fugitive Emissions from Fuels			
1.B.1.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

IPCC category-Energy Sector	**Emissions estimation status**		
	CO_2	**CH_4**	**N_2O**
1.B.2. Oil and Natural Gas			
1.B.2.a. Oil	✓, NO	✓	✓
1.B.2.a.i. Venting oil	✓, NO	✓	NA
1.B.2.a.ii. Flaring oil	✓, NO	✓	✓
1.B.2.a.iii.1. Exploration	✓, NO	✓	NA
1.B.2.a.iii.2. Production and upgrading	✓, NO	✓	NA
1.B.2.a.iii.3. Transport	✓, NO	✓	NA
1.B.2.a.iii.4. Refining and storage	✓, NO	✓	NA
1.B.2.a.iii.5. Distribution of oil products	NO	NO	NO
1.B.2.a.iii.6. Other	✓, NO	IE	NA
1.B.2.b. Natural Gas	✓	✓	✓
1.B.2.b.i. Venting gas	✓	✓	NA
1.B.2.b.ii. Flaring gas	✓	✓	✓
1.B.2.b.iii.1. Exploration	IE, NO	IE	NA
1.B.2.b.iii.2. Production	✓, NO	✓	NA
1.B.2.b.iii.3. Processing	NO,IE	IE	NA
1.B.2.b.iii.4. Transmission	✓, NO	✓	NA
1.B.2.b.iii.5. Distribution and storage	✓, NO	✓	NA
1.B.2.b.iii.6. Other	NO	✓	NA
1.B.2.d.Other	✓, NO	✓	NA
1.D. Memo items			
1.D.1. International Bunkers			
1.D.1.a. Aviation	✓	✓	✓
1.D.1.b. Marine	✓	✓	✓
1.C.2. Multilateral Operations	NE	NE	NE
1.C.3. CO_2 Emissions from Biomass	✓	NA	NA
1.A.B. Fuel Combustion – Reference Approach	✓		

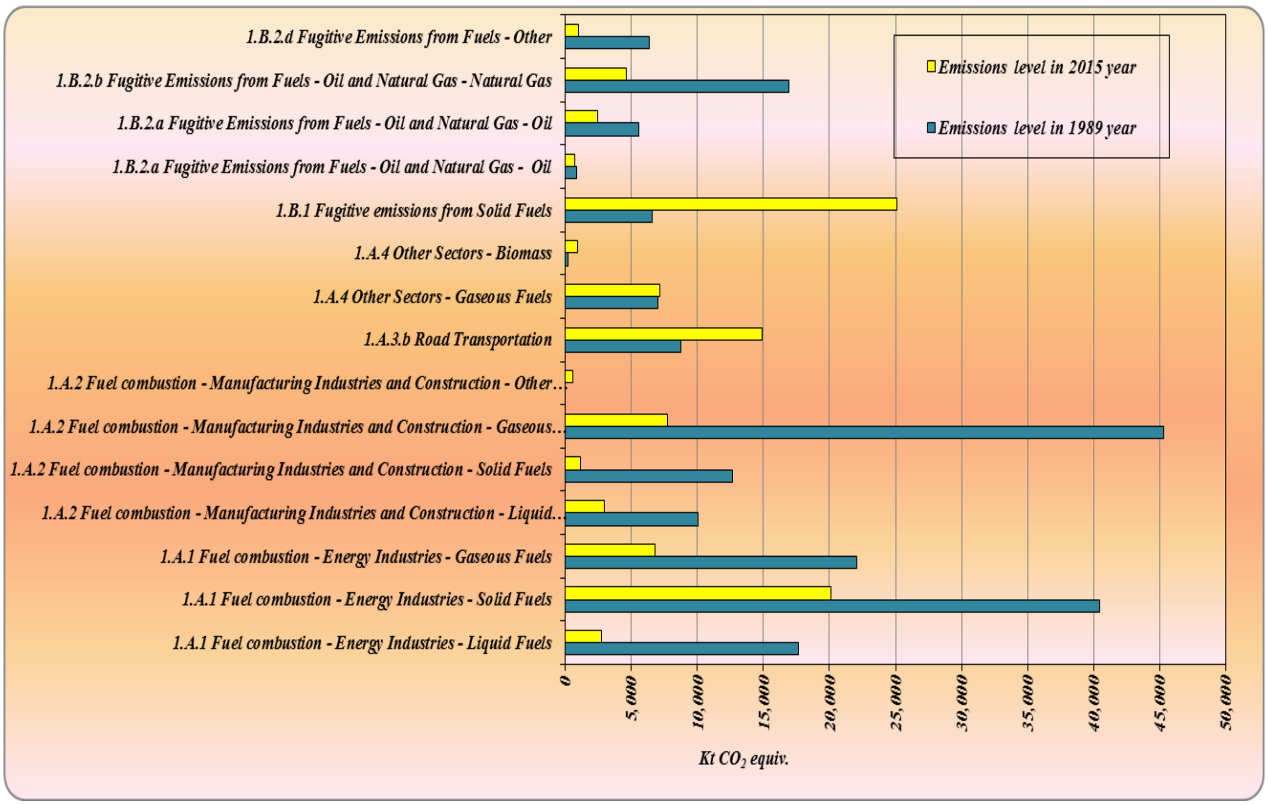
3.1.1 Key sources

Table 3.3 Key categories overview - Energy 2015

Key categories	GHG	Criteria	Contribution in total GHG emissions [%]
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	LT	2.33%
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	LT	17.27%
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	LT	5.82%
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	LT	2.55%
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	LT	0.98%
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	LT	6.62%
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	LT	0.50%
1.A.3.b Road Transportation	CO_2	LT	12.80%
1.A.4 Other Sectors - Gaseous Fuels	CO_2	LT	6.12%
1.A.4 Other Sectors - Biomass	CH_4	LT	0.80%
1.B.1 Fugitive emissions from Solid Fuels	CH_4	LT	21.57%
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	LT	0.62%
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	LT	2.13%

Key categories	GHG	Criteria	Contribution in total GHG emissions [%]
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	LT	3.98%
1.B.2.d Fugitive Emissions from Fuels - Other	CH_4	LT	0.84%

Figure 3.4 Key categories, both by level and trend criteria, overview – Energy Sector, 2015



3.2 Fuel combustion (CRF 1.A)

3.2.1 Comparison of the sectorial 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, 2007-2015 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 2007–2012, 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 Comparisonof the sectorial approach with the reference approach

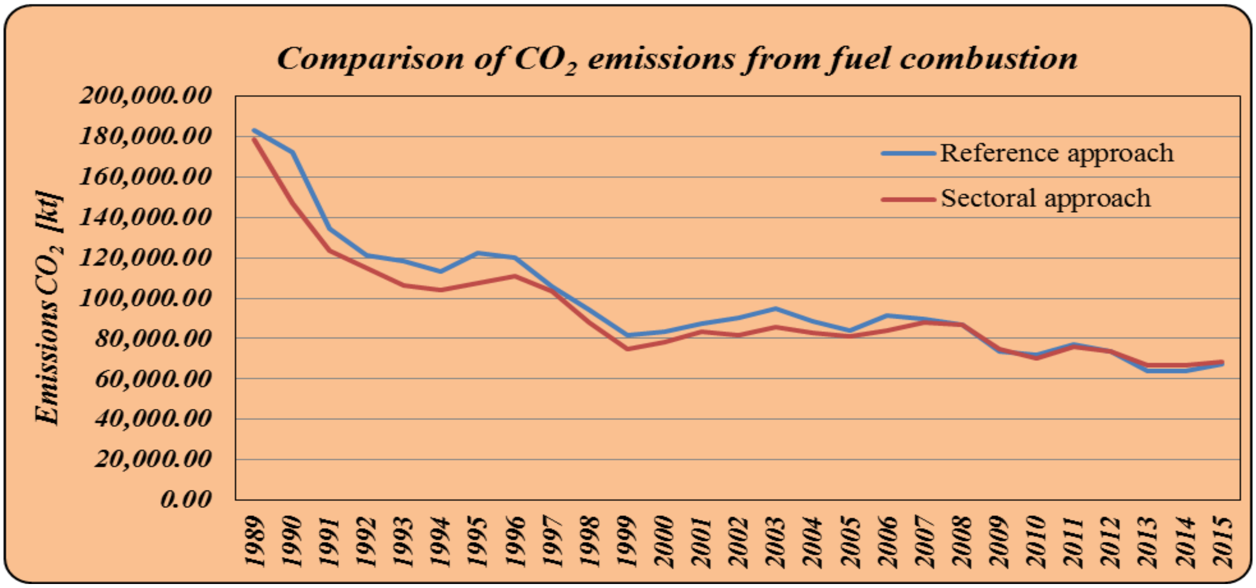


Figure 3.6 Comparisonof the sectorial approach with the reference approach – liquid fuels

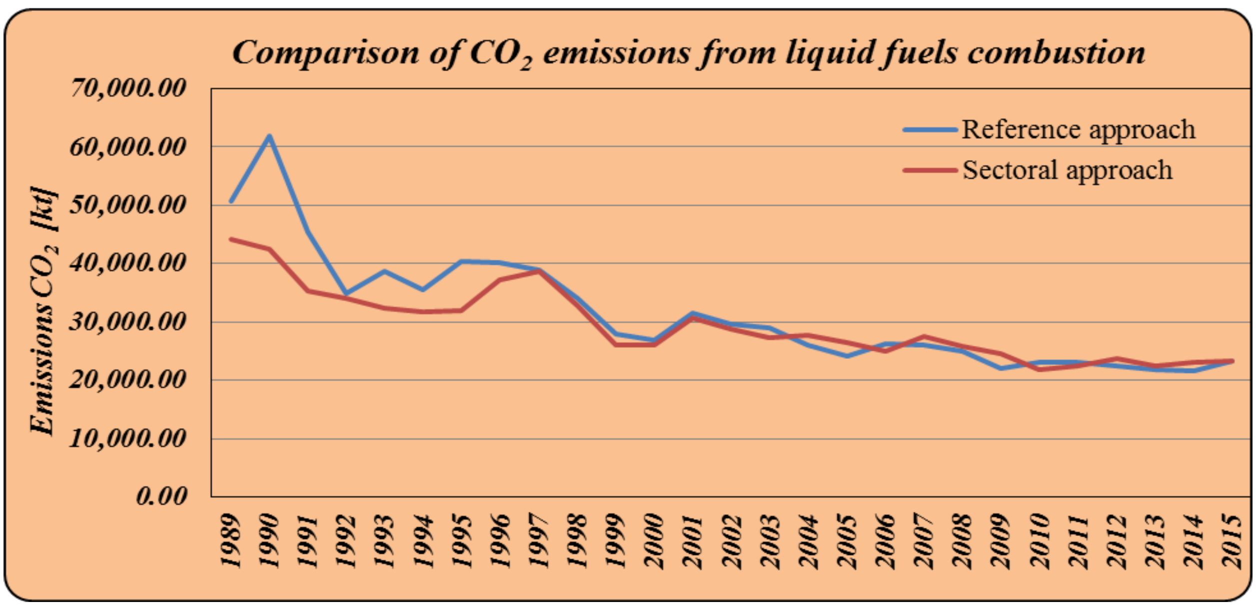


Figure 3.7 Comparisonof the sectorial approach with the reference approach – solid fuels

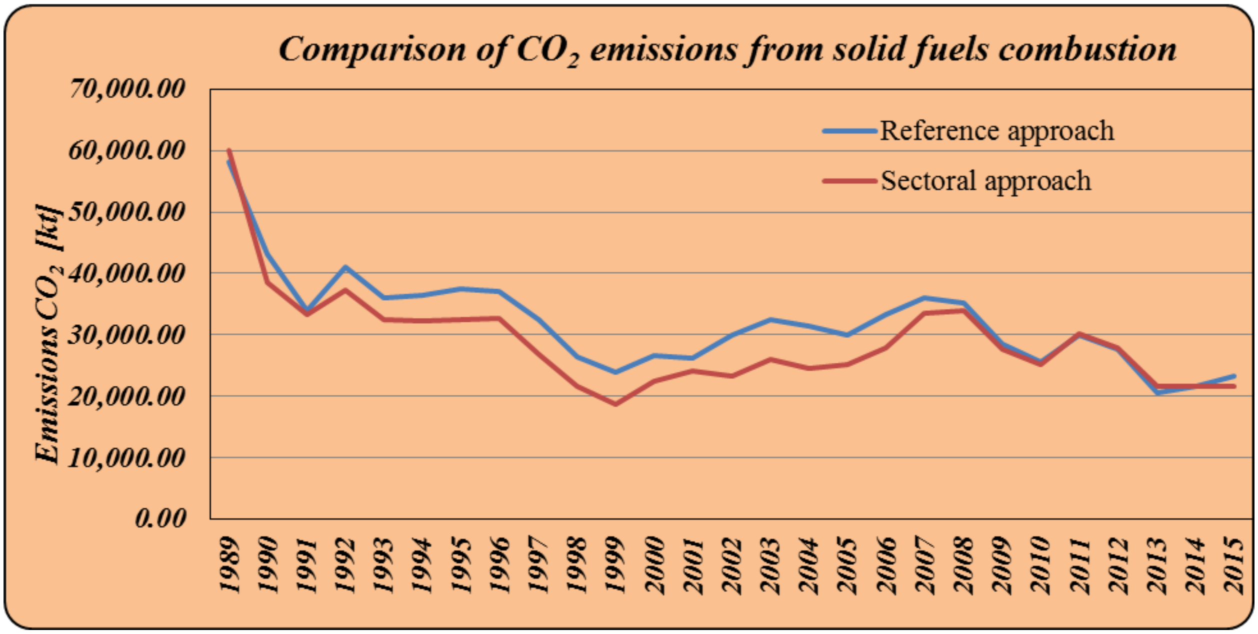
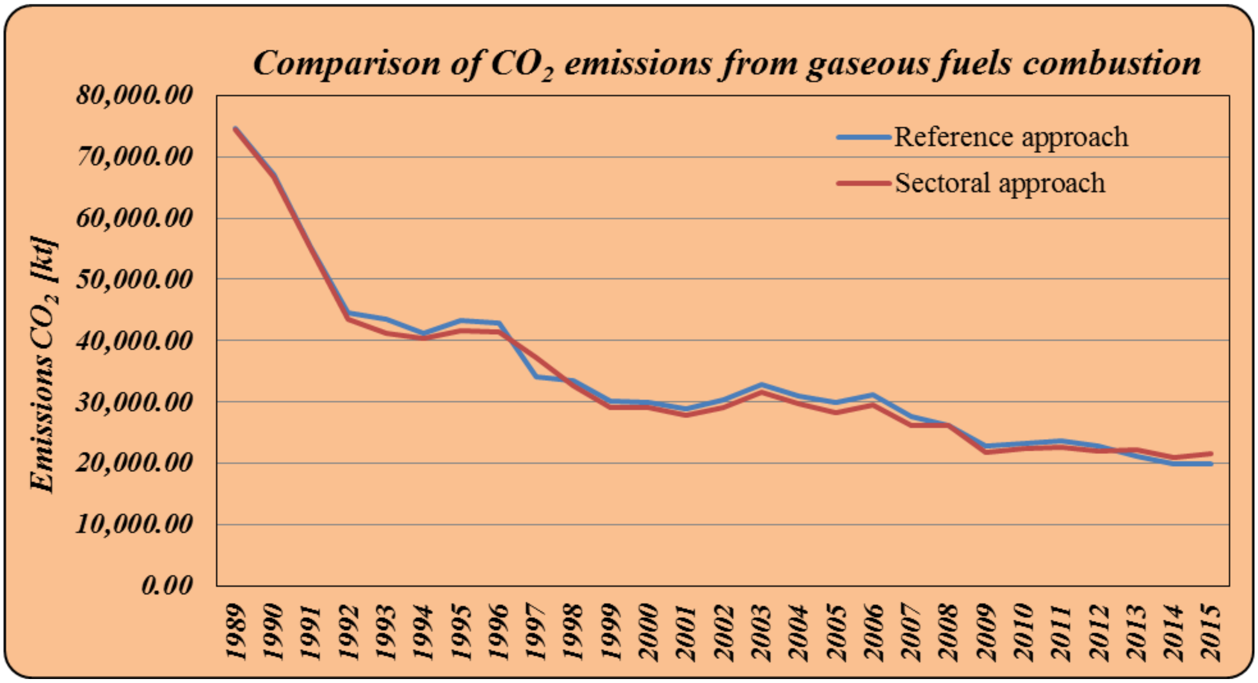


Figure 3.8 Comparisonof the sectorial approach with the reference approach – gaseous fuels



Explanation of Differences

A comparison between the RA and the SA indicates differences in both the energy consumption data and CO_2 emissions, -2.7 % in terms of energy consumption and, -0.22 % in terms of CO_2 emissions for 2015.

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 1A1b, 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 1A1b 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.

The difference between the two approaches is influenced by the usage of the EU-ETS activity data in 1.A.1.a category for period 2007-2015. This correction is not implemented in the RA.

A reason for the RA-SA differences is the subtracting of the quantities of coal from 1.A.2.a category, 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.

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 county 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 (2007-2012 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. For 2015 the determined values of NCVs and CO_2 CSEFs determined for 2014 were used.

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.

3.2.2 International Bunkers fuels(CRF 1.D.1)

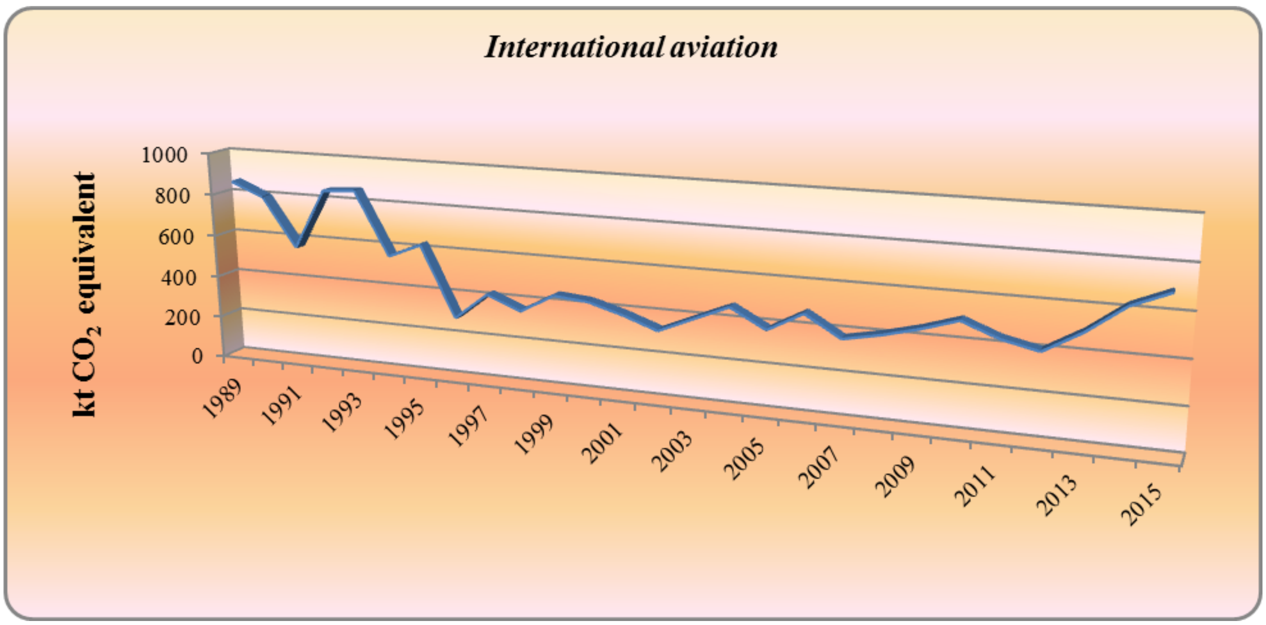
The International Bunkers category comprise data and information on the fuels and the emissions resulting from international air and marine transport of passengers and cargo. These GHG related data and information are also subject to the inventory and they are reported, but the GHG emissions are not 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).

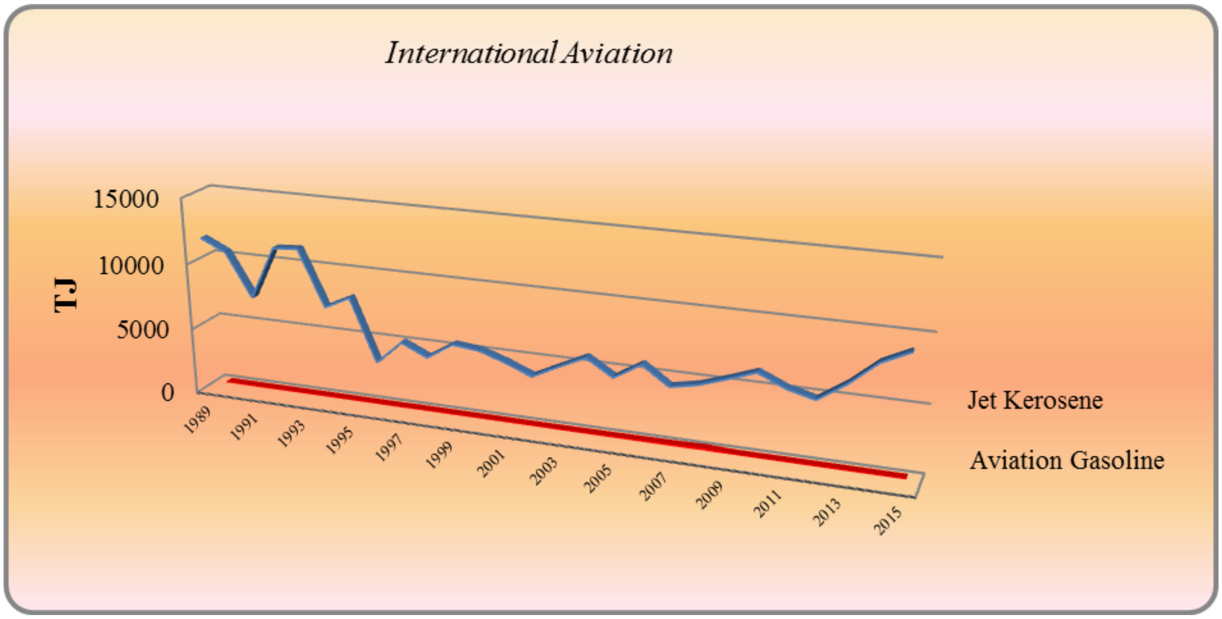
In 2015 the emissions from International Aviation Subsector represent 0.04 % of total emissions from the transport sector (15,730.41 kt CO_2 equivalent).

Figure 3.9 GHG emissions from International Aviation Subsector



In 2015 the emissions from the International Aviation subsector have decreased by 20.15 % compared to the base year 1989 due to the fuel consumption has decreased.

Figure 3.10 Fuel consumption associated with the International Aviation Subsector, 1989-2015 period



The Tier1 and Tier 2 method was used and are presented in section 3.2.9.2.2.

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 IPCC 2006 methodology vol 2, chapter 3 Table 3.6.9, page 3.70 (see Annex 3.3).

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

The activity data for international navigation are provided through the IEA/Eurostat Questionnaire; emission factors values used are both country specific and default, provided through the IPCC 2006.

In 2015 the emissions from International Navigation Sub-sector represent 0.85% of total emissions from the transport sector (15,730.41 kt CO_2 equivalent).

Figure 3.11 The GHG emissions from International Navigation Subsector

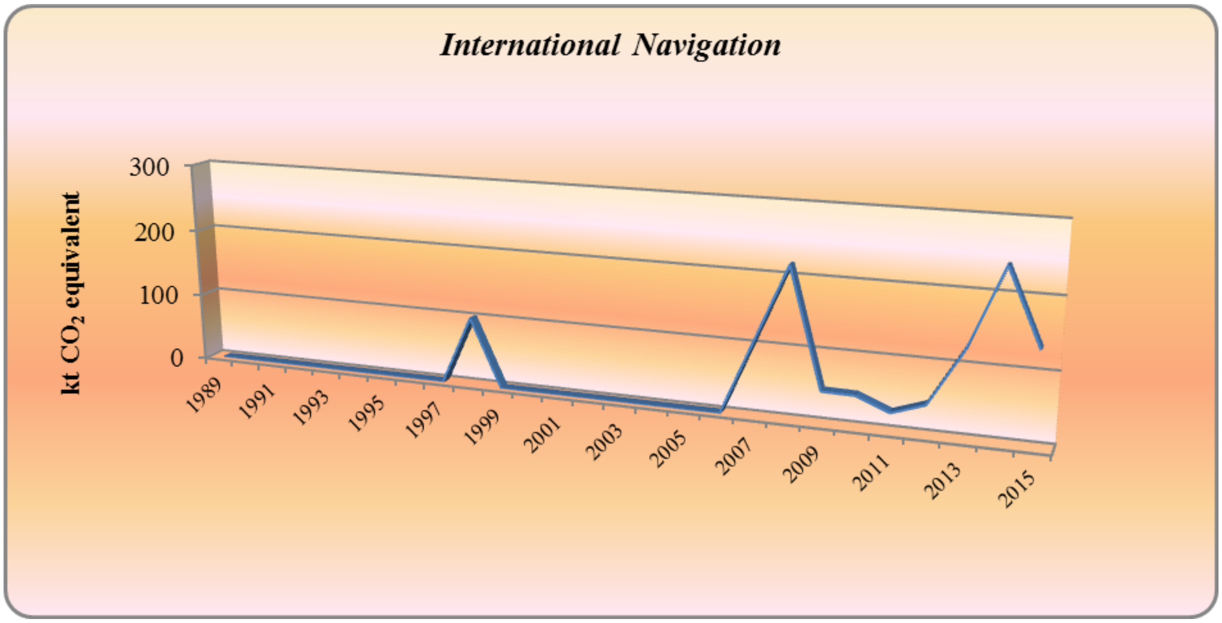
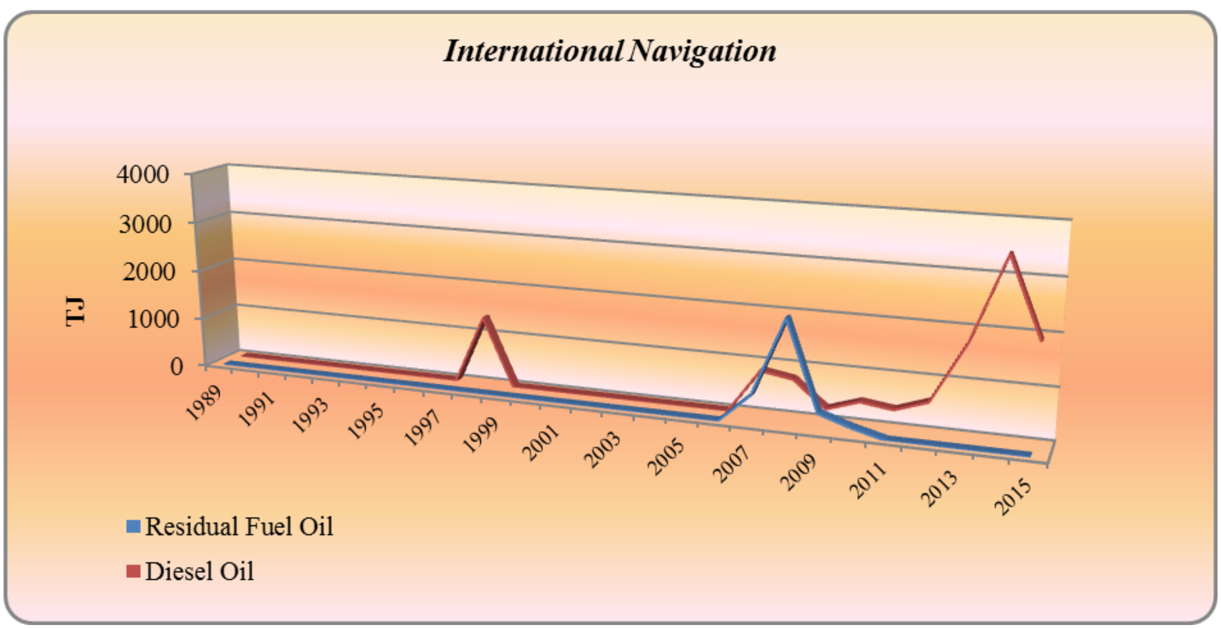


Figure 3.12 Fuel consumption associated with the International Navigation Subsector, 1989-2015 period



In the period 1989-1997 and1999-2005 is not provided fuel consumption by NSI. In 1998 it is fuel consumption and appears peak of graphic. In 2006 increases fuel consumption by 2007 when we have again peak of graphic. Starting with year 2008 decreases fuel consumption implicitly the emissions value.

In the 2015 year, the fuel consumption level associated with the International Navigation category descreased by 44.30% compared with the one associated with 2014.

The Tier1 and Tier 2 method was used and are presented in section 3.2.9.4.2.

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 (2007-2012 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. For 2015 the determined values of NCVs and CO_2 CSEFs determined for 2014 were used.

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 IPCC 2006GL 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;

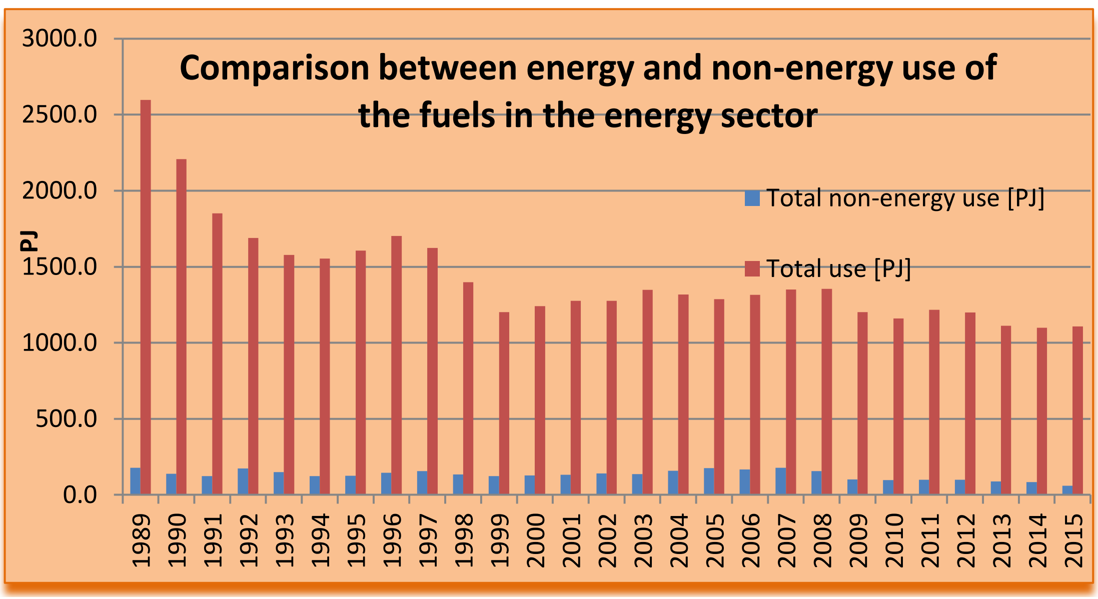
- Lubricants, Naphta, Refinery gas, Other kerosene, Gas Diesel-Oil, Petroleum Coke, Residual Fuel Oil, Other products, White spirit: the carbon was presumed that is fully emitted and not stored, having the full oxidation during use;
- Paraffin Waxes: the fraction of carbon stored is 0.8, the rest of 0.2 being emitted.

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	177.9	2595.90	6%
1990	138.1	2206.67	6%
1991	124.1	1851.91	7%
1992	174.4	1689.54	10%
1993	148.9	1578.16	9%
1994	124.3	1554.78	8%
1995	126.0	1605.60	8%
1996	144.7	1702.54	9%
1997	155.4	1622.96	10%
1998	134.9	1397.57	10%
1999	123.2	1201.87	10%
2000	128.9	1240.47	10%
2001	131.6	1276.88	10%
2002	141.2	1277.03	11%
2003	137.1	1348.17	10%
2004	158.3	1317.45	12%
2005	176.8	1286.94	14%
2006	168.2	1316.23	13%
2007	178.2	1350.72	13%
2008	156.4	1355.43	12%
2009	100.5	1200.68	8%

Year	Non-energy use [PJ]	Apparent energy consumption incl. non-energy use [PJ]	[%]
2010	96.8	1160.65	8%
2011	99.6	1217.68	8%
2012	100.4	1200.37	8%
2013	87.5	1111.56	8%
2014	84.40	1099.33	8%
2015	60.61	1108.52	5%

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

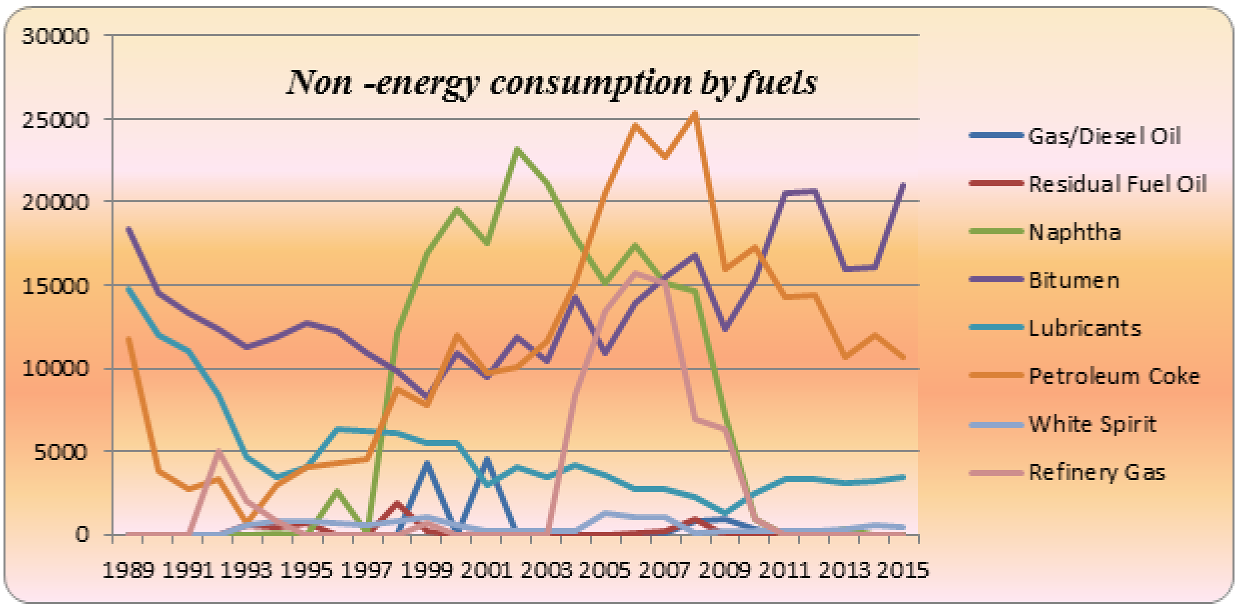


There are some fluctuations of the reported consumption of some of the fuels during the time series – unstable trends in the exports imports, or production.

The non-energy use of fuels is an average of 11% from the total apparent energy consumption during the period 1999-2008, and arround 8% for the rest of the years. 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 2015 the share of the non-energy use of the fuels in total consumption is about 5%.

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.

Figure 3.14 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***

  The recalculations are mainly in 2013 and 2014 from the coke_oven_coke moved in transformation from the iron&combustion, as reported in the Energy Balance, and accounted as non-energy consumption.

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 80,098.16 kt CO_2 equivalent in 2015.

Within the fuel combustion sector, 43.2% of the CO_2 equivalent emissions correspond to Energy Industries category, 18.1% of the CO_2 equivalent emissions correspond to 1.A.2 Manufacturing Industries and Construction, 22.9% of the CO_2 equivalent emissions correspond to 1.A.3 Transport, 15.1% of the CO_2 equivalent emissions correspond to 1.A.4 Other Sectors and less than 0.67% from the CO_2 equivalent emissions correspond to 1.A.5 Other (Not specified elsewhere).

It is observed that Energy Industries are the main source of GHG emissions from fuel combustion with 29,721.92 kt CO_2 equivalent of the emissions in 2015. 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, 2012-2014, 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 2013 in comparison with 2012, in the energy industries, with 16 per cent; the variation between 2014 and 2013 is much lower, by only -0.15%.

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

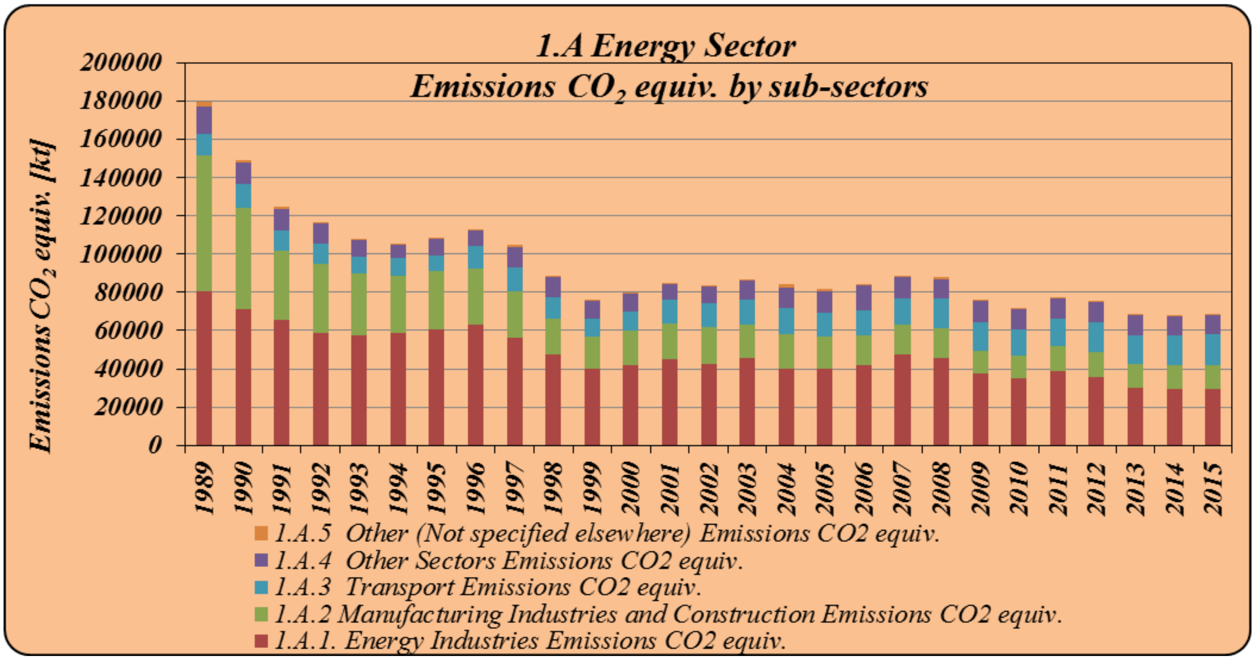
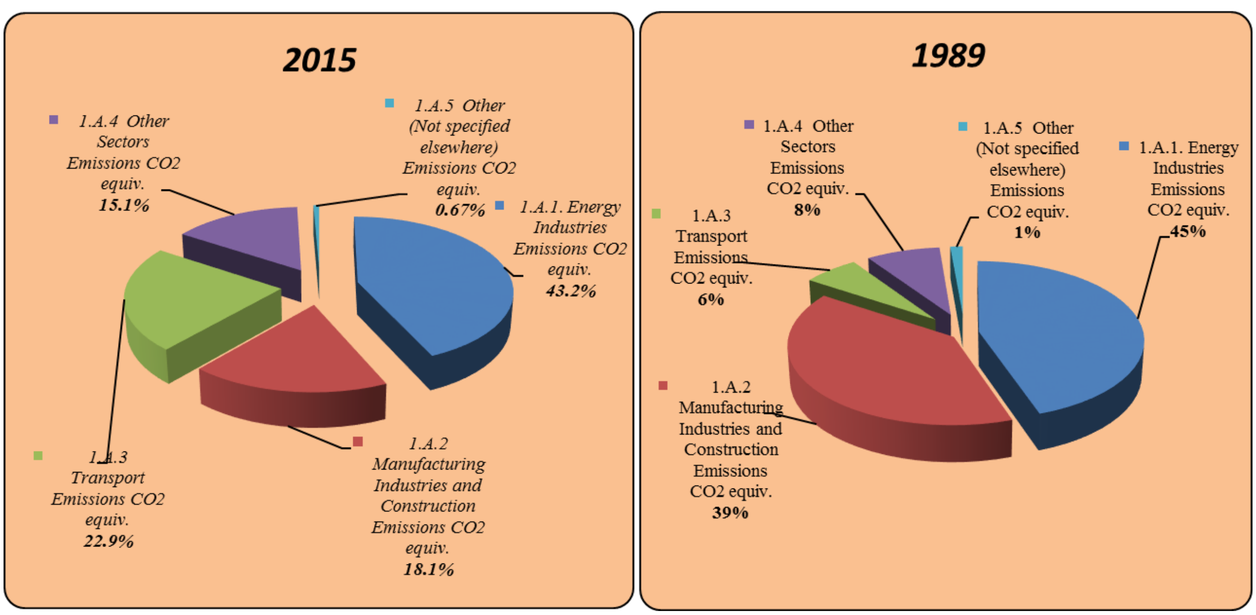


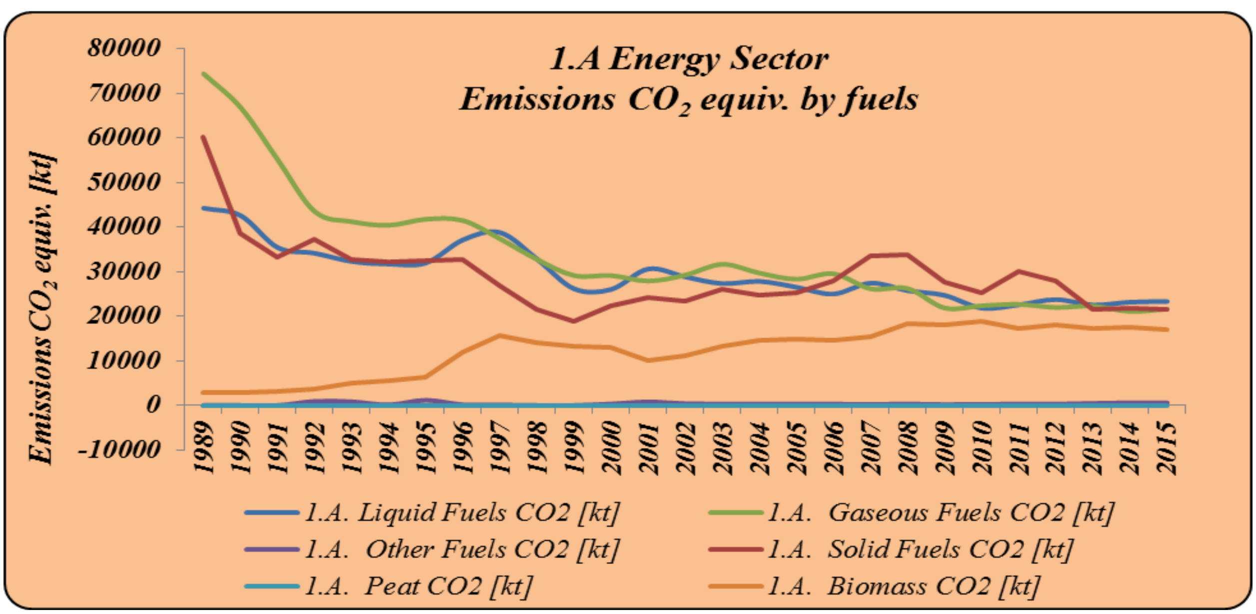
Figure 3.16 Base year and current year comparison in respect to the contribution of Fuel Combustion Activities Subsector categories emissions in total Subsector emissions



In 2015 a increase of the GHG emissions is observed in 1A1 Energy Industries where the CO_2eq decreased with 0.04 % in comparison with 2014, in 1.A.2 Manufacturing Industries and Construction with 0.97% and 1.A.4 Other sectors decreased with 3.14% and 1.A.3 Transport has an increased trend, the CO_2equiv. emissions being higher with 0.84% than in 2014. 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 increase trend in 2015 in comparison with 2014, with less than 1%.

Manufacturing industry and construction is the sector which changed drastically – compared to 1989, the emissions being decreased from 39% to 18.1% in 2015. The same, the transport sub-sector has a substantial modification in the contribution to the overall energy emissions, rising from 6% in the base year up to 22.9% in 2015.

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



In the period 2006-2012 the main contribution to CO_2 emissions was from solid fuels, having a pick in 2007-2008. In 2015 the contribution of the liquid fuel was about 28%, solid 26%, gaseous 26%.

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 2005–2007, 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.

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 2011-2014 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 2013 and 2014 the country specific emission factors determined from the EU-ETS operator reports for the previous year, 2012, 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.

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.
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 1990-2014. 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.

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.

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.

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, 2007-2012, 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 liquis and solids and presented in ANNEX 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 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 2007-2015.

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 (listed above).

Also, the contry specific emission factor 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 (Tiers 3 according to the Methodology for monitoring GHG emissions of operators participating in the ETS).

General approach for the greenhouse gas emission factors

CO_2 greenhouse gas

For the 1989–2006 period

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

For the 2007-2014 period

- ❖ **Solid Fuels**, EFs calculated as weighted arithmetic average (WA), on each year of 2007–2014 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 2007–2014 period, ALL EU-ETS reported category activities, oxidation included, are used.
- ❖ **Gaseous fuels**, EFs calculated as weighted arithmetic average (WA) on each year of 2007–2014 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.

For the years 2015, the country specific CO_2 emission factors associated to the 2014 value determinations for the available fuels, are used.

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).

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

EF [t/TJ]	**Year**						
Type of Fuel	**2007**	**2008**	**2009**	**2010**	**2007-2010 WA EFs**	**2011**	**2012**
Lignite	103.45	100.24	98.32	97.01	99.89	94.75	94.46
Natural gas	55.29	55.69	55.49	55.64	55.52	55.52	55.58
Refinery gas	55.32	54.05	58.11	57.93	56.38	57.42	56.90
Other bituminous coal	93.24	94.34	95.20	94.88	94.74	91.80	90.50
Coke_Oven_Coke	92.92	84.33	92.89	92.65	91.22	95.16	93.99
Transport diesel	74.00	72.35	74.04	72.75	73.29	72.92	73.56
Residual fuel oil	78.58	76.83	77.97	79.69	78.16	79.49	79.48
Heating and other gasoil	74.46	77.87	74.45	73.66	74.19	73.31	74.08
Petroleum Coke	-	94.34	91.85	94.02	93.63	98.50	96.83
Industrial Wastes						83.50	83.81
Sub-bituminous coal	93.75	92.79	93.93	92.93	93.32	92.70	93.81

Table 3.5 (continued) Country-Specific CO_2 emission factors for stationary combustion, without oxidation included, from ETS verified reports

EF [t/TJ]	**Year**		
Type of Fuel	**2013**	**2014**	**2015**
Lignite	95.86	97.95	97.95

EF [t/TJ]	**Year**		
Type of Fuel	**2013**	**2014**	**2015**
Natural gas	55.59	55.59	55.59
Refinery gas	57.90	57.40	57.40
Other bituminous coal	92.18	93.14	93.14
Coke_Oven_Coke	93.54	108.28	108.28
Transport diesel	70.66	69.62	69.62
Residual fuel oil	78.50	79.23	79.23
Heating and other gasoil	76.11	73.63	73.63
Petroleum Coke	92.80	92.73	92.73
Industrial Wastes	89.53	92.34	92.34
Sub-bituminous coal	93.81	93.56	93.56

The EFs having the oxidation included are calculated as the total sum of the verified CO_2 emissions divided by the total amount of the respective energetic fuel consumption, 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.

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

EF Ox [t/TJ]	**Year**						
Type of Fuel	**2007**	**2008**	**2009**	**2010**	**2007-2010 WA EFs**	**2011**	**2012**
Lignite	98.44	94.55	91.51	88.66	93.47	86.41	86.93
Natural gas	54.80	55.65	55.31	55.48	55.30	55.52	55.58
Refinery gas	54.89	56.04	58.11	57.71	56.77	57.42	56.90
Other bituminous coal	92.97	93.43	95.19	97.87	94.31	91.08	90.02
Coke_Oven_Coke	92.06	84.46	92.97	92.65	91.11	95.16	93.99
Transport diesel	73.95	73.43	74.22	73.29	73.74	72.92	73.56

EF Ox [t/TJ]	Year						
Type of Fuel	**2007**	**2008**	**2009**	**2010**	**2007-2010 WA EFs**	**2011**	**2012**
Residual fuel oil	78.09	76.89	78.00	79.71	78.04	79.49	79.48
Heating and other gasoil	74.36	78.50	74.65	73.67	74.30	73.29	74.08
Petroleum Coke	-	94.52	91.85	94.02	93.73	98.50	96.83
Industrial Wastes	-	-	-	-	-	83.50	83.81
	93.75	92.79	92.57	92.05	92.86	91.97	93.30

Table 3.6 (continued) Country-Specific CO_2 emission factors for stationary combustion, oxidation included, from ETS verified reports

EF [t/TJ]	Year		
Type of Fuel	**2013**	**2014**	**2015**
Lignite	88.84	90.70	90.70
Natural gas	55.59	55.59	55.59
Refinery gas	57.90	57.40	57.40
Other bituminous coal	91.79	92.78	92.78
Coke_Oven_Coke	95.16	108.28	108.28
Transport diesel	70.66	69.62	69.62
Residual fuel oil	78.50	79.23	79.23
Heating and other gasoil	76.11	73.63	73.63
Petroleum Coke	92.80	92.34	92.34
Industrial Wastes	89.53	92.34	92.34
Sub-bituminous coal	93.52	92.54	92.54

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

Fuel Type	EF CO_2 t/TJ (including oxidation factor)	EF CO_2 t/TJ (excluding oxidation factor)	Carbon Content t/TJ
Lignite	93.47	99.89	27.24
Natural gas	55.30	55.52	15.14
Refinery gas	56.77	56.38	15.38
Other bituminous coal	94.31	94.74	25.84
Coke oven coke	91.11	91.22	24.88
Transport diesel	73.74	73.29	19.99
Residual fuel oil	78.04	78.16	21.32
Heating and other gasoil	74.30	74.19	20.23
Petroleum Coke	93.73	93.63	25.54
Motor Gasoline*	71.62	71.62	19.53
Sub-bituminous coal	92.86	93.32	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* category, 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 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 1A1b 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
1A1a	***Electricity and heat production***	**90,25**	
1A1 a - i	Electricity production	99,66	Nominal installed thermal power plants > 20 MWt reporting
1A1 a – ii	Electricity and heat production		
1A1 a - iii	Heat production	73,47	
1A1 b	Petroleum refining	74,15	Emissions from fuel combustion only
1A1 c	Manufacture of solid fuels and other industries		Nominal installed thermal power plants > 20 MWt reporting
1A2	***Manufacturing industry and Construction***	**60,60**	
1A2 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
1A2 b	Non-ferrous metals (aluminum)		Nominal installed thermal power plants > 20 MWt reporting
1A2 c	Chemical	74,44	Nominal installed thermal power plants > 20 MWt reporting
1A2 d	Pulp, Paper and Print	90,43	Fuel combustion for the installations having production

CRF Category	Main activity	Share of the EU-ETS reporting to the EB [%]	Reporting Plants
			capacity greater than >20 tones/day and nominal installed thermal power plants > 20 MWt reporting
1A2 e	Food Processing, Beverages and Tobacco	15,10	Nominal installed thermal power plants > 20 MWt reporting
1A2 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 88.88 t/TJ, coke_oven_coke – CO_2 CS EF 95.2 t/TJ, lower than the limit of the range, Heating and other gasoil – CO_2 CS EF 76.1 t/TJ – higher than the range. Also, in 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. CO_2 Emission factors:

- In the EU-ETS reports, the reported coal in 1.A.1a was separated in lignite and sub-bituminous coal by the calorific power. The criteria used to separate these types of coal was the range for the calorific power of lignite and sub-bituminous coal provided in the IEA Statistic Manual. As consequence, the CO_2 CSEF for Sub-bituminous coal was determined and the CO_2 CS EF for lignite was modified accordingly.
- For the all fuels reported in the EU-ETS reports for 2013 and 2014, the CO_2 CSEFs were determined and used in the estimation of the CO_2 emissions in the categories where the corresponding consumption was reported.
- Further to the implementation of the 2006 IPCC Guidelines, the CO_2 CS EFs were modified in accordance with the reporting on the EU-ETS reports in the new categories 1.A.2.f and 1.A.2.g.

2. Net calorific values: the fuels which have determined or modified the CO_2 CS EF as above, the net calorific values were updated or determined, too.

3. Activity data:

- The usage of the EU-ETS data in 1.A.1.a category: the deployed procedures to establish the cause for differences between ETS consumption and the Energy Balance consumption in this category are still ongoing. Being that the EU ETS reports are verified by accredited verifiers, the corresponding data have a higher degree of credibility. Thus, in 1.A.1.a the corresponding EU-ETS data were used on the ETS period (2007-2015), and for the fuels having a higher consumption in ETS than in the Energy Balance. This consumption was corrected with a factor determined as a weighted average of share of the ETS CO_2 emissions on 1.A.1.a category, in 2014, for the selected countries were detailed ETS data were available. In the the table bellow the correction factor determined during the technical review at EU level in 2016 is 95.45%.

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]		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Other bituminous coal	**ETS**	162	392	313	249	251	265	216	149	147
	EB	-	-	-	-	-	-	-	-	-
Lignite	**ETS**	32,115	33,220	29,071	28,109	34,859	31,815	22,731	23,577	25,018
	EB	31,964	33,186	30,198	28,182	34,356	30,403	23,209	23,447	25,179
Sub-bituminous coal	**ETS**	2,313	3,020	2,243	1,860	2,400	2,062	2,013	1,831	1,290
	EB	952	500	371	330	358	667	316	241	192
Residual Fuel Oil	**ETS**	333	232	390	200	192	136	43	36	47
	EB	304	232	387	208	170	111	48	31	41
Natural gas [TJ]	**ETS**	139,090	122,442	106,475	87,758	107,942	102,174	100,379	93,218	101,365
	EB	182,051	161,286	128,005	123,522	128,938	112,268	80,494	73,982	71,067
Transport diesel	**ETS**	0.02	0.33	0.50	0.31	0.37	0.31	0.42	0.30	0.28
	EB	5.00	3.00	2.00	3.00	3.00	9.00	11.00	20.00	11.00
Heating and other gas oil	**ETS**	0.17	0.16	2.54	2.68	0.01	0.01	0.02	0.23	0.27
	EB	14.00	12.00	21.00	14.00	19.00	14.00	8.00	1.00	1.00
Refinery gas	**ETS**	655.82	217.14	49.71	245.16	95.56	75.66	37.57	64.00	53.19
	EB	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Petroleum coke	**ETS**	-	-	-	-	62.82	123.18	111.48	113.56	103.35
	EB	-	-	-	-	-	-	-	-	-

The fuels which are taken into consideration in the category 1A1a from the EU-ETS report are the followings: other bituminous coal, lignite, sub-bituminous coal, residual fuel oil, natural gas, refinery gas, petroleum coke.

- 1.A.2.a - Further to some discussions with the National Institute for Statistics it was concluded that the used methodology in the Energy Balance to split the solid fuel consumption between combustion and processess conduct to the double accounting of the GHG emissions with the IPPU sector, 2.C.1 category. To solve the problem, the consumption considered in IPPU of coke_oven_coke, sub-bituminous coal and anthracite was subtracted from the corresponding sum of the consumption reported in transformation and combustion in iron & steel category in Energy Balance. Only the rest is considered as fuel combusted in 1.A.2.a – iron and steel category. The new figures looks like in the attached file.

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]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
1989	1076987.02	1,076,987.02	80157.25	80219.39	0.1	1.45	1.45	0.0	0.81	0.81	0.0
1990	618774.09	980,766.30	51205.36	70723.31	38.1	1.17	1.53	31.1	0.60	0.61	2.7
1991	547446.48	901,239.18	46412.59	65414.59	40.9	0.96	1.31	37.0	0.58	0.60	2.3
1992	805386.57	787,540.95	60436.49	58810.66	-2.7	1.08	1.06	-1.7	0.63	0.60	-4.3
1993	789952.17	769,066.79	59399.90	57494.24	-3.2	1.08	1.06	-1.9	0.60	0.57	-5.2
1994	800064.67	779,390.82	60210.66	58325.33	-3.1	1.10	1.08	-1.9	0.61	0.58	-5.1
1995	831651.32	809,008.87	62722.24	60641.14	-3.3	1.23	1.20	-1.8	0.64	0.61	-5.3
1996	867875.09	840,577.30	65269.10	62708.20	-3.9	1.24	1.21	-2.2	0.64	0.60	-6.4
1997	783655.70	762,064.13	58361.74	56310.50	-3.5	1.18	1.16	-1.8	0.56	0.52	-5.8
1998	671028.71	653,882.96	49033.89	47407.04	-3.3	0.93	0.92	-1.8	0.44	0.41	-5.9
1999	559867.68	545,997.85	41048.01	39763.54	-3.1	0.79	0.78	-1.8	0.38	0.36	-5.4
2000	579498.20	564,578.35	43304.09	41946.55	-3.1	0.81	0.79	-1.9	0.43	0.41	-5.2
2001	602687.36	586,999.77	46121.57	44692.89	-3.1	1.01	1.00	-1.5	0.49	0.46	-4.8
2002	581625.03	566,244.32	43626.99	42225.24	-3.2	0.81	0.79	-1.9	0.44	0.42	-5.2

Year	Changes at AD level [TJ]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
2003	623665.48	606,295.52	46842.99	45259.15	-3.4	0.83	0.81	-2.1	0.48	0.46	-5.4
2004	561708.93	542,504.88	41982.18	40194.93	-4.3	0.73	0.71	-2.6	0.43	0.40	-6.7
2005	553237.68	537,803.35	41507.82	40072.74	-3.5	0.71	0.70	-2.2	0.44	0.41	-5.3
2006	568945.16	549,986.56	43484.25	41719.43	-4.1	0.72	0.70	-2.6	0.49	0.46	-5.8
2007	552045.95	601,399.64	43791.85	47213.47	7.8	0.65	0.70	8.2	0.48	0.51	5.5
2008	533220.01	576,443.91	41611.31	45212.57	8.7	0.62	0.67	7.1	0.48	0.53	10.5
2009	452801.19	476,149.46	35102.23	37146.50	5.8	0.53	0.56	4.7	0.42	0.45	7.4
2010	426924.08	457,312.88	32131.73	34651.05	7.8	0.51	0.55	5.9	0.39	0.42	9.5
2011	469909.28	506,563.42	35407.20	38592.21	9.0	0.57	0.62	7.5	0.46	0.51	11.8
2012	426849.80	460,623.64	32429.48	35343.05	9.0	0.51	0.55	8.7	0.41	0.46	11.9
2013	340474.51	393,811.85	25345.80	29631.73	16.9	0.46	0.52	13.2	0.32	0.36	13.8
2014	335479.06	388,953.53	24951.71	29584.11	18.6	0.51	0.57	12.2	0.33	0.37	13.4

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]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
1989	1132803.17	1100073.55	70923.28	67975.07	-4.2	2.82	2.49	-11.6	0.40	0.35	-12.3
1990	1257378.24	853114.05	74477.73	51118.35	-31.4	2.30	1.64	-28.6	0.30	0.22	-26.7
1991	972210.56	591245.89	56308.89	34856.75	-38.1	1.47	0.98	-33.1	0.19	0.13	-29.0
1992	578874.22	574497.10	35207.98	34820.35	-1.1	1.65	1.61	-2.7	0.23	0.23	-2.8
1993	532271.63	524132.44	32117.40	31386.76	-2.3	1.50	1.42	-5.4	0.21	0.20	-5.8
1994	500814.32	494038.81	29633.81	29029.31	-2.0	1.21	1.14	-5.6	0.17	0.16	-6.0
1995	513092.36	501615.61	30188.81	29156.58	-3.4	1.49	1.38	-7.7	0.20	0.19	-8.4
1996	488517.71	482371.47	28925.84	28376.98	-1.9	1.21	1.15	-5.1	0.17	0.16	-5.3
1997	418749.72	402919.84	24840.71	23409.55	-5.8	1.17	1.02	-13.5	0.17	0.14	-14.3
1998	322907.48	309152.17	19600.47	18351.67	-6.4	0.97	0.83	-14.2	0.14	0.12	-14.7
1999	295974.61	285562.94	17881.82	16933.37	-5.3	0.90	0.79	-11.6	0.13	0.11	-12.2
2000	309572.13	300040.96	18760.16	17893.10	-4.6	1.04	0.94	-9.2	0.15	0.13	-9.7
2001	318366.38	313324.55	19497.05	19038.79	-2.4	1.02	0.97	-4.9	0.15	0.14	-5.2

Year	Changes at AD level [TJ]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
2002	334566.68	329126.93	20035.63	19541.77	-2.5	1.28	1.22	-4.3	0.18	0.17	-4.6
2003	317245.88	307344.73	18569.42	17667.27	-4.9	1.33	1.23	-7.5	0.18	0.17	-8.1
2004	300176.10	290042.74	18773.79	17844.21	-5.0	1.25	1.15	-8.1	0.18	0.16	-8.6
2005	286512.15	272300.38	18069.53	16742.88	-7.3	1.16	1.02	-12.2	0.17	0.14	-12.9
2006	282254.16	261591.26	17680.27	15756.61	-10.9	1.29	1.08	-16.0	0.18	0.15	-16.9
2007	273862.79	258118.09	17055.34	15583.86	-8.6	1.26	1.11	-12.5	0.18	0.16	-13.2
2008	277583.61	260738.32	17578.59	16067.79	-8.6	1.13	0.96	-14.9	0.16	0.13	-15.9
2009	210458.82	197421.00	13125.16	11915.26	-9.2	0.92	0.79	-14.1	0.13	0.11	-15.1
2010	210030.13	198598.18	12801.36	11750.61	-8.2	1.00	0.89	-11.4	0.14	0.12	-12.4
2011	226698.90	217129.31	14126.92	13227.07	-6.4	1.06	0.96	-9.0	0.15	0.13	-9.7
2012	235560.57	217481.69	14967.03	13274.35	-11.3	1.21	1.03	-14.9	0.17	0.14	-15.9
2013	225688.96	211494.06	13942.79	12607.90	-9.6	1.09	0.97	-11.2	0.15	0.13	-12.4
2014	223461.25	208152.98	13697.94	12272.26	-10.4	1.10	0.97	-11.8	0.15	0.13	-13.2

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]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
1989	242917.87	242917.87	14173.02	14177.80	0.0	17.74	17.74	0.0	0.19	0.19	0.0
1990	197799.02	196653.21	10953.94	10851.71	-0.9	17.03	16.69	-2.0	0.16	0.16	-1.1
1991	199634.37	198753.97	10789.26	10712.72	-0.7	12.26	11.99	-2.2	0.12	0.12	-1.1
1992	173070.73	172242.97	9934.81	9859.59	-0.8	12.67	12.42	-2.0	0.15	0.15	-0.8
1993	164802.04	164258.70	8434.93	8386.72	-0.6	13.44	13.28	-1.2	0.17	0.17	-0.5
1994	151640.60	151566.05	6852.35	6847.58	-0.1	12.86	12.84	-0.2	0.18	0.18	-0.1
1995	173391.91	173342.78	7886.34	7879.09	-0.1	14.29	14.28	-0.1	0.20	0.20	0.0
1996	215217.36	214869.54	7552.56	7517.49	-0.5	29.86	29.76	-0.3	0.40	0.40	-0.1
1997	283718.30	283427.91	9756.24	9727.69	-0.3	39.46	39.37	-0.2	0.53	0.53	-0.1
1998	271372.07	271333.79	9420.00	9419.51	0.0	35.21	35.20	0.0	0.49	0.49	0.0
1999	240699.42	240606.98	7961.73	7953.73	-0.1	33.06	33.03	-0.1	0.45	0.45	0.0
2000	241675.59	241617.08	8220.42	8218.01	0.0	32.18	32.17	-0.1	0.44	0.44	0.0
2001	207476.52	207438.24	7788.12	7787.99	0.0	22.89	22.88	0.0	0.32	0.32	0.0
2002	208764.18	208674.74	7859.27	7854.36	-0.1	23.43	23.41	-0.1	0.32	0.32	0.0

Year	Changes at AD level [TJ]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
2003	251950.51	251882.11	9281.90	9279.72	0.0	28.70	28.69	-0.1	0.39	0.39	0.0
2004	282045.47	281916.87	9899.46	9893.20	-0.1	34.87	34.83	-0.1	0.47	0.47	0.0
2005	289303.80	289259.25	10213.19	10213.43	0.0	35.53	35.51	0.0	0.48	0.48	0.0
2006	315712.98	315674.00	11959.44	11961.94	0.0	33.70	33.69	0.0	0.46	0.46	0.0
2007	287473.17	287450.56	10060.99	10068.37	0.1	35.30	35.29	0.0	0.48	0.48	0.0
2008	296644.15	296642.64	8888.61	8882.99	-0.1	44.67	44.67	0.0	0.60	0.60	0.0
2009	314681.31	314638.76	10110.12	10106.24	0.0	44.03	44.02	0.0	0.60	0.60	0.0
2010	305643.34	305619.60	9053.77	9058.74	0.1	45.44	45.44	0.0	0.61	0.61	0.0
2011	290421.98	290372.93	9187.50	9182.68	-0.1	40.80	40.79	0.0	0.55	0.55	0.0
2012	305236.54	305172.62	9695.94	9690.41	-0.1	42.54	42.53	0.0	0.58	0.58	0.0
2013	293800.68	293719.38	9362.02	9330.06	-0.3	40.80	40.78	0.0	0.55	0.55	0.0
2014	283043.76	283306.27	8885.05	8872.13	-0.1	41.10	41.04	-0.1	0.55	0.55	0.0

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

Year	Changes at AD level [TJ]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
1989	30015.39	30015.39	2468.35	2464.90	-0.1	0.17	0.17	0.0	0.03	0.03	0.0
1990	12972.73	12799.28	1232.12	1211.76	-1.7	0.13	0.12	-1.4	0.02	0.02	-1.4
1991	21422.45	21422.45	1283.36	1279.12	-0.3	2.22	2.22	0.0	0.05	0.05	0.0
1992	11673.00	11673.00	991.39	987.52	-0.4	0.37	0.37	0.0	0.02	0.02	0.0
1993	5814.66	5774.58	309.33	305.63	-1.2	0.54	0.54	-0.1	0.01	0.01	-0.6
1994	7504.84	7464.30	437.67	433.92	-0.9	0.54	0.54	-0.1	0.01	0.01	-0.6
1995	8901.62	8877.38	556.59	554.28	-0.4	0.84	0.84	0.0	0.01	0.01	-0.2
1996	6844.66	6828.82	276.06	274.45	-0.6	0.96	0.96	0.0	0.02	0.02	-0.2
1997	13633.68	13632.36	845.72	845.40	0.0	0.70	0.70	0.0	0.02	0.02	0.0
1998	10677.42	10671.48	698.33	697.66	-0.1	0.40	0.40	0.0	0.01	0.01	-0.1
1999	3609.43	3609.43	103.19	103.19	0.0	0.67	0.67	0.0	0.01	0.01	0.0
2000	3824.39	3824.39	238.11	238.11	0.0	0.45	0.45	0.0	0.01	0.01	0.0
2001	10580.73	10580.73	382.58	382.58	0.0	1.86	1.86	0.0	0.03	0.03	0.0
2002	9969.65	9968.28	268.32	268.19	0.0	1.99	1.99	0.0	0.03	0.03	0.0

Year	Changes at AD level [TJ]		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 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1		NGHGI 2016 v.4	NGHGI 2017 v.1	
2003	11263.98	11263.98	377.89	377.89	0.0	1.93	1.93	0.0	0.03	0.03	0.0
2004	22560.26	22560.26	1307.92	1307.92	0.0	1.64	1.64	0.0	0.03	0.03	0.0
2005	18969.26	18969.26	831.51	831.51	0.0	2.39	2.39	0.0	0.04	0.04	0.0
2006	14052.25	14052.25	502.65	502.65	0.0	2.21	2.21	0.0	0.03	0.03	0.00
2007	18880.95	18880.95	950.81	950.81	0.0	1.85	1.85	0.0	0.03	0.03	0.00
2008	16614.04	16614.04	811.68	811.68	0.0	1.70	1.70	0.0	0.03	0.03	0.00
2009	8582.60	8582.60	270.73	270.73	0.0	1.49	1.49	0.0	0.02	0.02	0.00
2010	8828.91	8828.91	267.81	267.81	0.0	1.56	1.56	0.0	0.02	0.02	0.00
2011	10022.13	10022.13	538.48	538.48	0.0	0.81	0.81	0.0	0.01	0.01	0.00
2012	10249.28	10249.28	558.37	558.37	0.0	0.82	0.82	0.0	0.02	0.02	0.00
2013	7927.67	7921.33	423.48	406.31	-4.1	0.67	0.67	0.0	0.01	0.01	-0.03
2014	7456.18	7531.18	401.52	385.25	-4.1	0.62	0.62	0.0	0.01	0.01	0.40

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 no necessary resources were available for these activities.

Emission Factors

Following the same procedure used until now, based on EU-ETS operators reporting, the country-specific CO_2 emission factors will be calculated and included in the next inventory submission.

In response of ERT recommendation, "Romania further investigate and elaborate on the non-energy use of fuels reported in the energy balance, which is not reported in the energy sector, and assess whether the country specific carbon storage factors are appropriate", Romania analysed the non-energy use of the fuels as activity data provided through the energy balances and used national values for net calorific power and country specific emission factors for the fuels reported under the EU-ETS.

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.

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

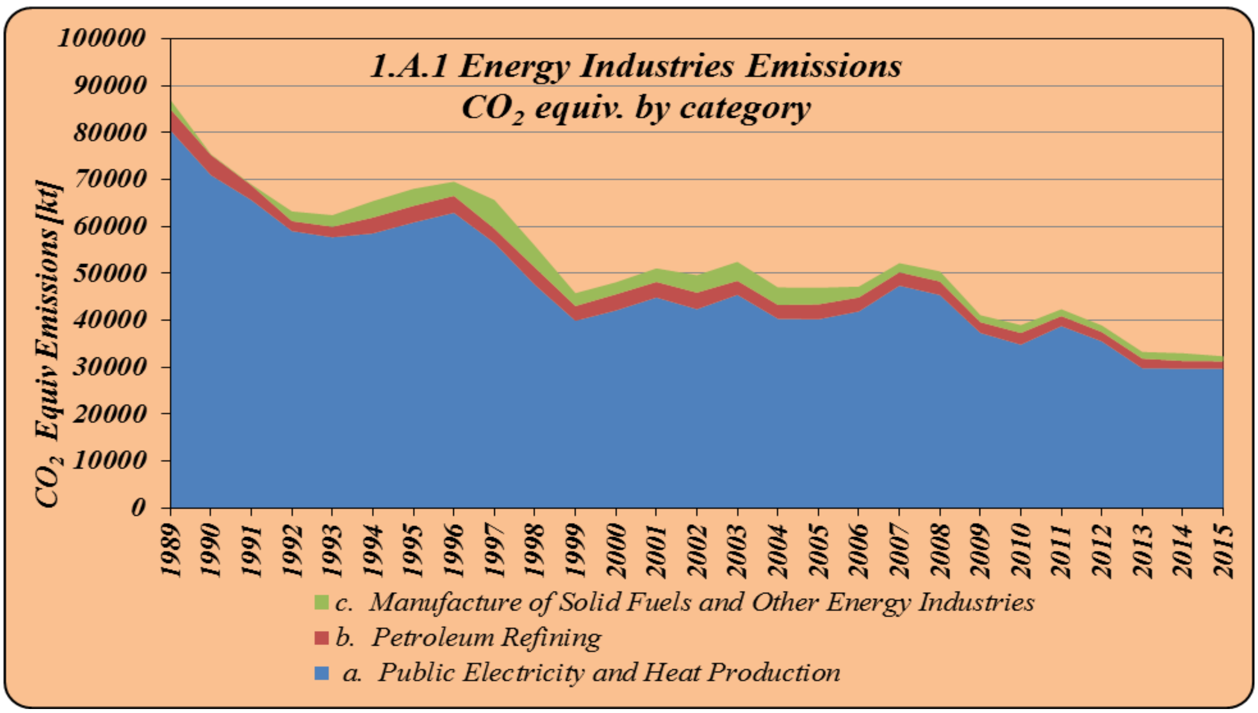
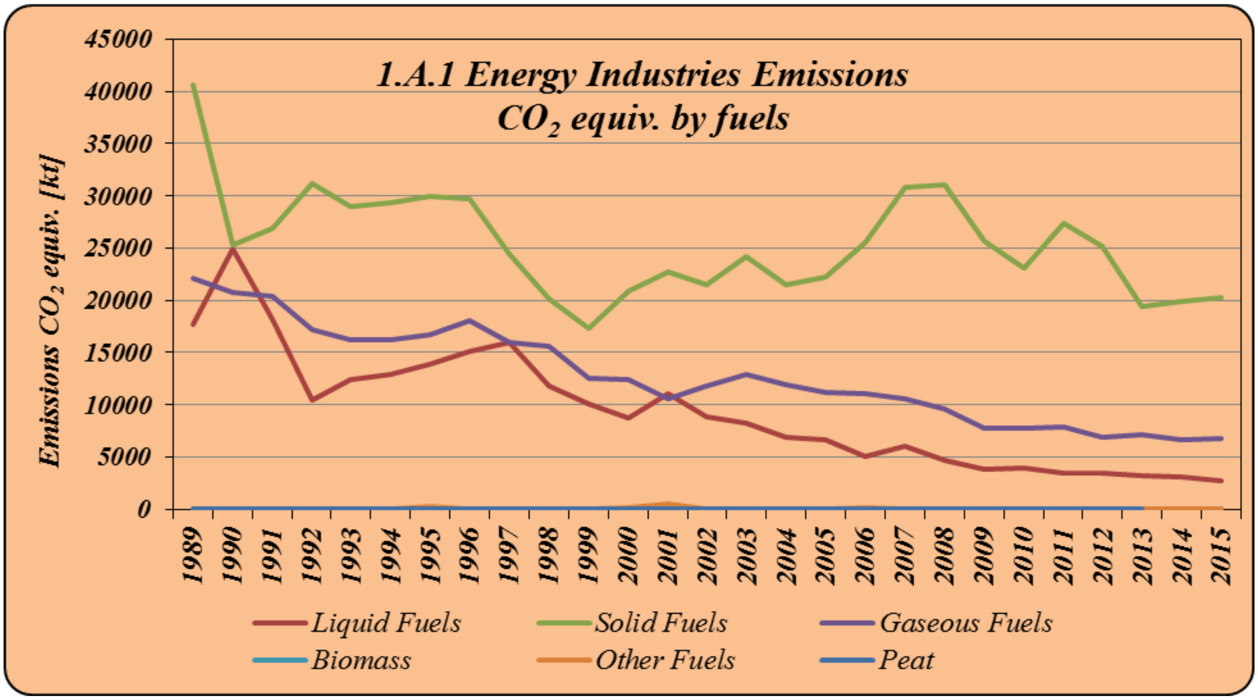


Figure 3.19 GHG emissions trend for the subsector 1.A.1 Energy industries by type of fuels



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% in the base year and a 43.2.% in 2015. For the last years of the time-series, 2014 and 2015, the share of the Energy Industries in the total Energy sector encountered a decreasing, having a share of 43.6% 2014 year and 43.2% in 2015 year.

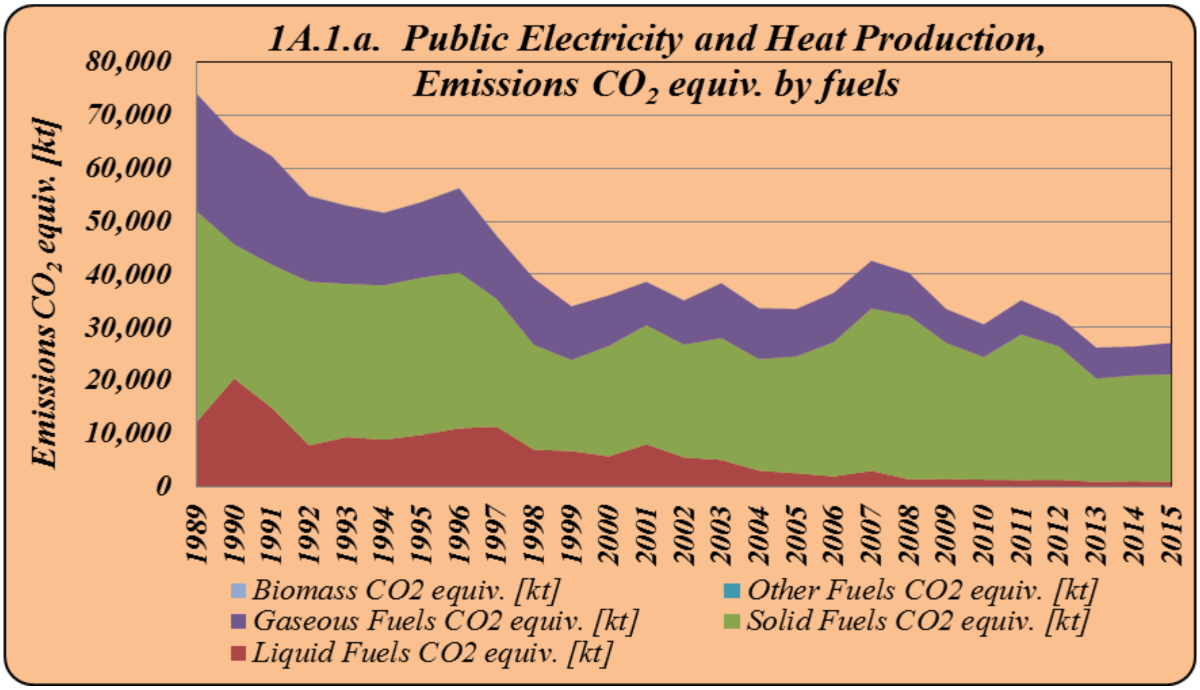
The contribution of this sub-sector to the 1.A. – Fuel combustion is, for the year 2015, about 68,747.68 kt CO_2 equiv. having the main contributor the activity category 1.A.1.a – Electricity and Heat Production with 27,114.87 kt CO_2 equiv.

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

3.2.5.1.1 Category description

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.).

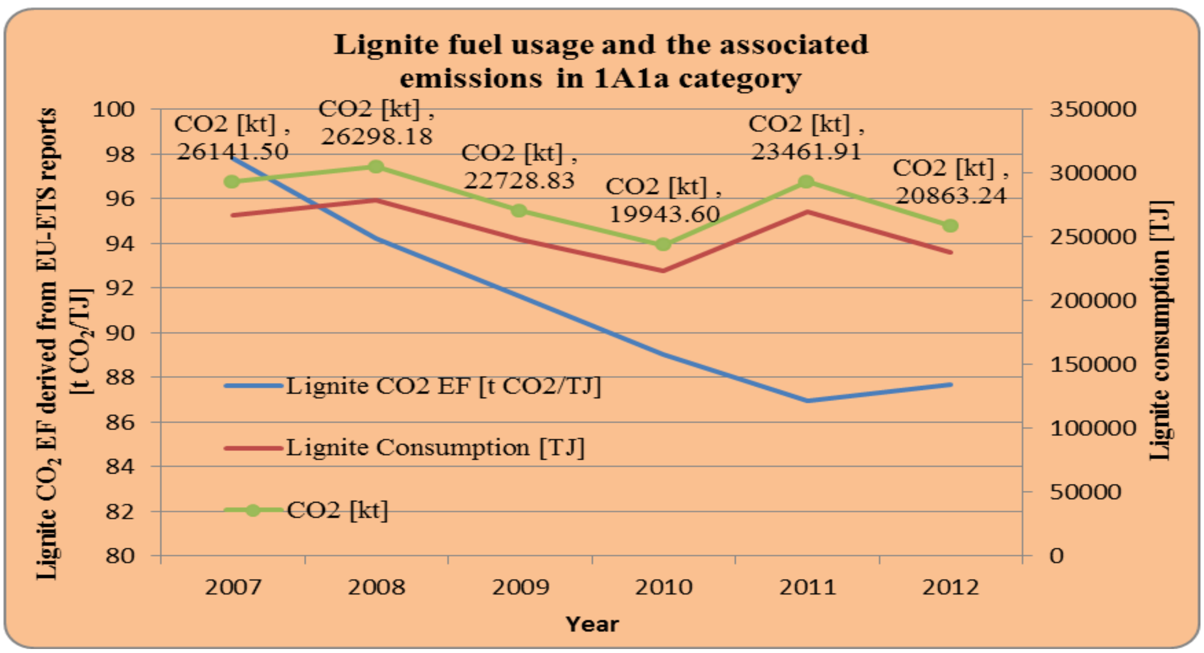
Figure 3.20 GHG emissions from 1.A.1.a Public Electricity and Heat Production



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. The share to the total of GHG emissions 1A – Fuel Combustion, for CRF category 1.A.1.a is 41.68% in the base year and 39.26% for the year 2015. The share of this activity category to the 1.A.1. - Energy Industry is 91.94% for the base year and 91.22% for the year 2015 (about 29,721.92 kt CO_2 equiv.). The most quantity of combusted fuel in this activity is from solid fuel (aprox. 77%), for the entire time-series, being supplied mostly from national resources. The usage of the liquid fuels drastically decreased in the last years of the analyzed period, to 10% in total fuels used. Small quantities of GHG emissions are from the combustion of biomass and other fuels (9.2 and 0.71 CO_2 kt equiv.).

The decreasing trend is observed for the all burned fuels, due to the fact that the demand of the energy slightly decreased in the 2014 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 bellow figure (for 2013, 2014 and 2015 the situation related to the lignite usage in the EU-ETS is not yet analyzed, this activity being scheduled to be undertaken in the following period, as soon as the necessary resources will be available for these activities).

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



3.2.5.1.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels without analyze on EU-ETS reporting, or large combustion plants, are used. For the fuels reported in this activity category and having determined Country Specific Emission Factors, Tier 2 methodology is used.
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 1.B - Fugitive Emission Sector.
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

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

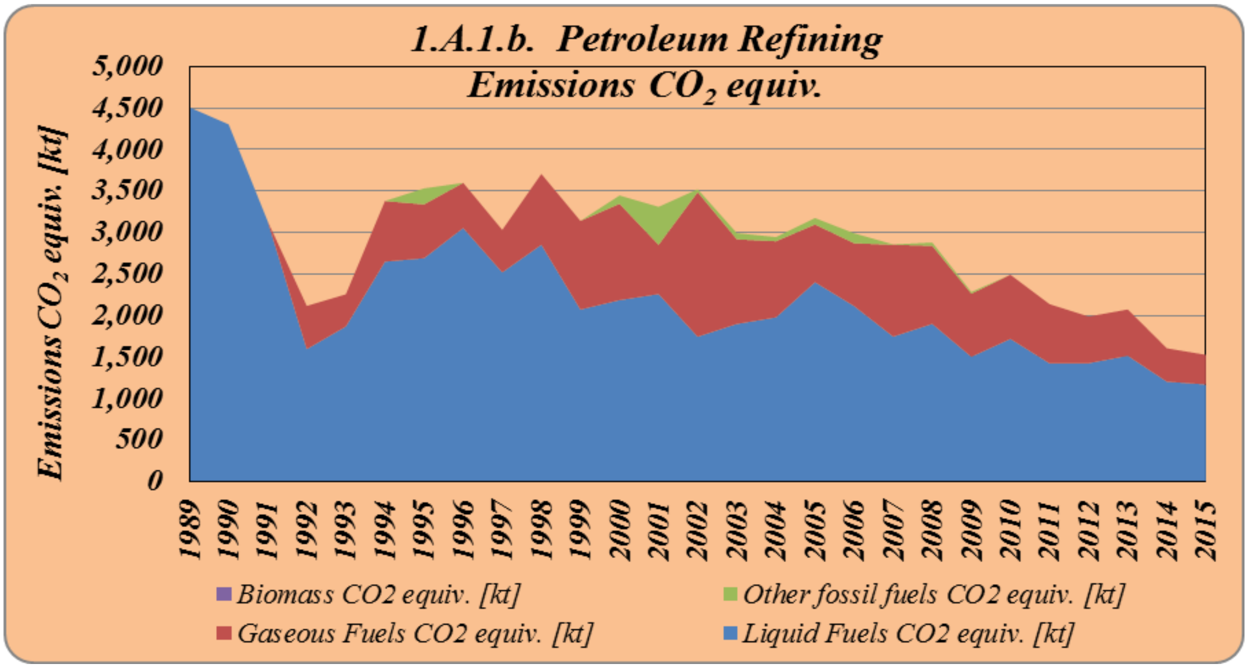
It is planned to take into consideration the emissions from the operators reporting on EU-ETS (having their reports verified by accredited verifiers) in order to achieve a hire tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.

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

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.).

3.2.5.2.1 Category description

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



The share in total GHG emissions 1.A – fuel Combustion of this activity is 2.51% for the year 1989 and 1.57% for the year 2015. The main fuels reported are liquids which are: Refinery gas, Transport diesel and Residual fuel oil, together with natural gas having a contribution about 1,169.2 kt CO_2 equiv. in 2015.

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 having determined Country Specific Emission Factors, Tier 2 methodology is used. 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 1.B - Fugitive Emission Sector. 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

No recalculations were performed for this submission.
See the Chapter 3.2.4.5 for more details.

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

It is planned 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. See the Chapter 3.2.4.6 for more details.

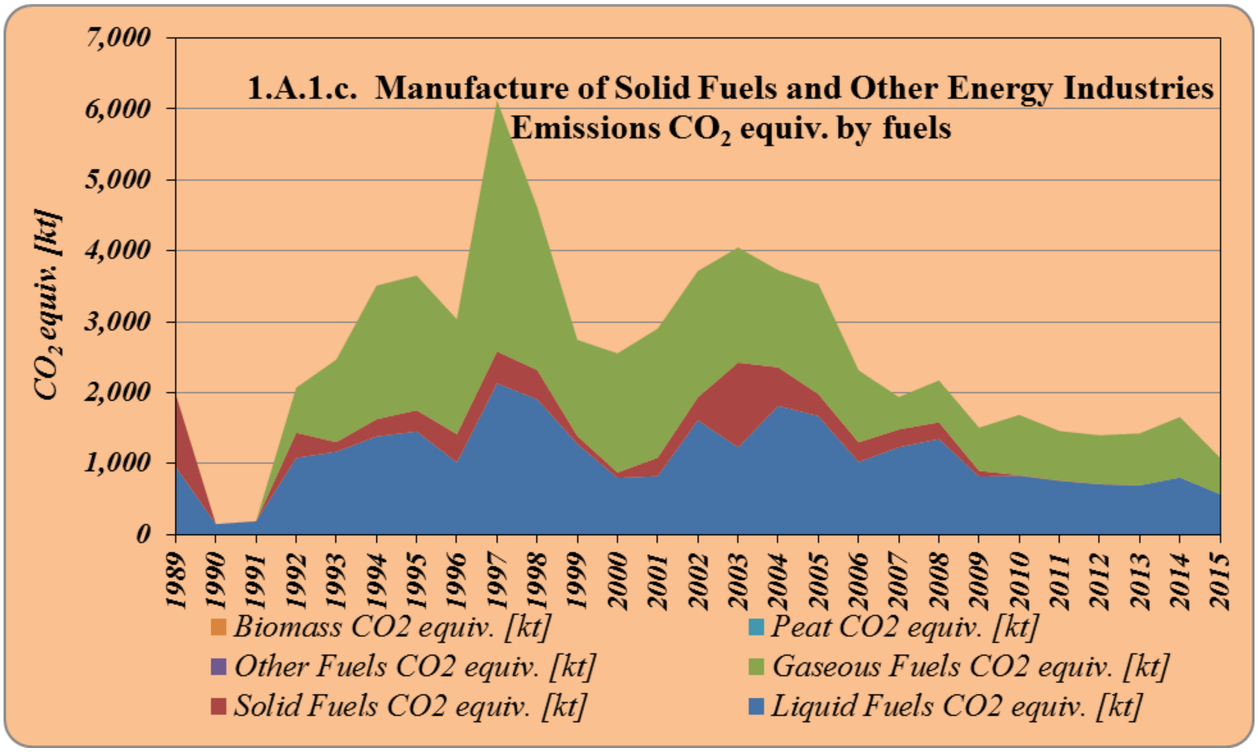
3.2.5.3 Manufacture of Solid Fuels and Other Energy Industries (CRF 1.A.1.c.)

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.).

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



The share in total GHG emissions - sector 1A, is 1.57% for the year 2015, starting to a share of 1.10% in the base year, 1989. The emissions from this activity decreased by 45.40% compared to base year. 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.

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 having determined country specific emission factors, 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 corresponding with that Used in Main Activity Plants (net). 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 1.B - Fugitive Emission Sector. 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

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

It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the chapter 3.2.4.6 for more details.

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 fuels and other fossil, 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.).

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

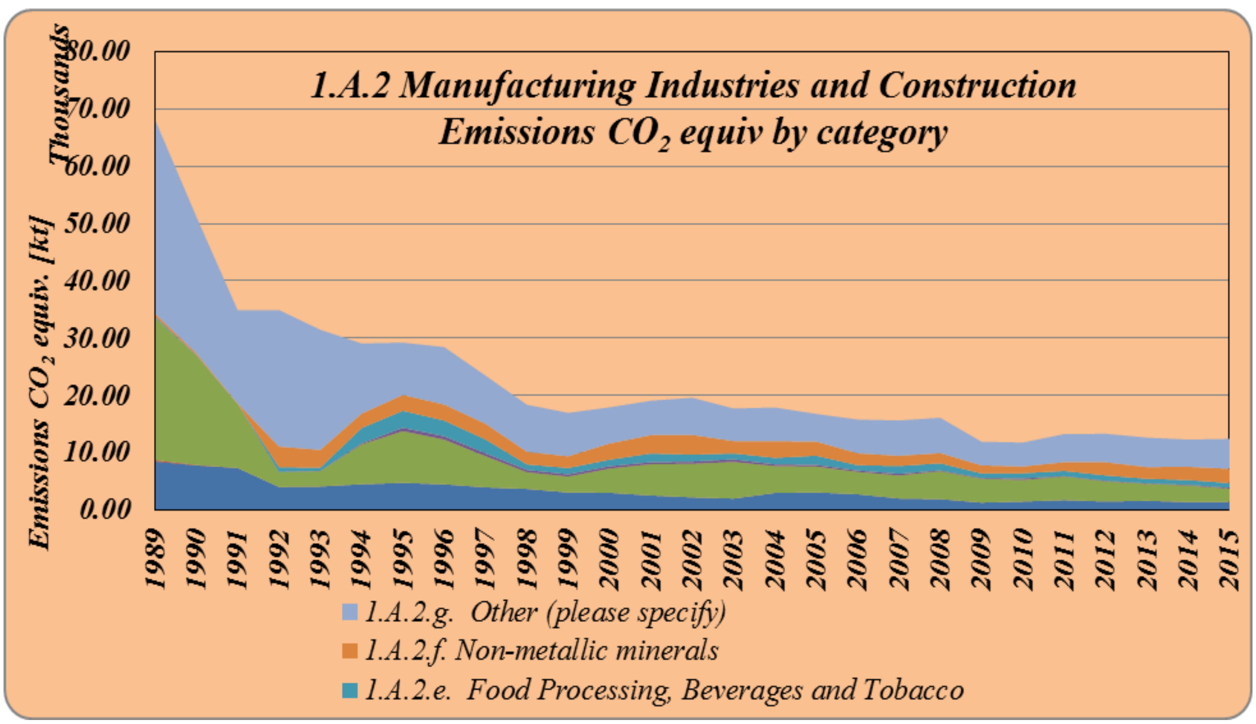
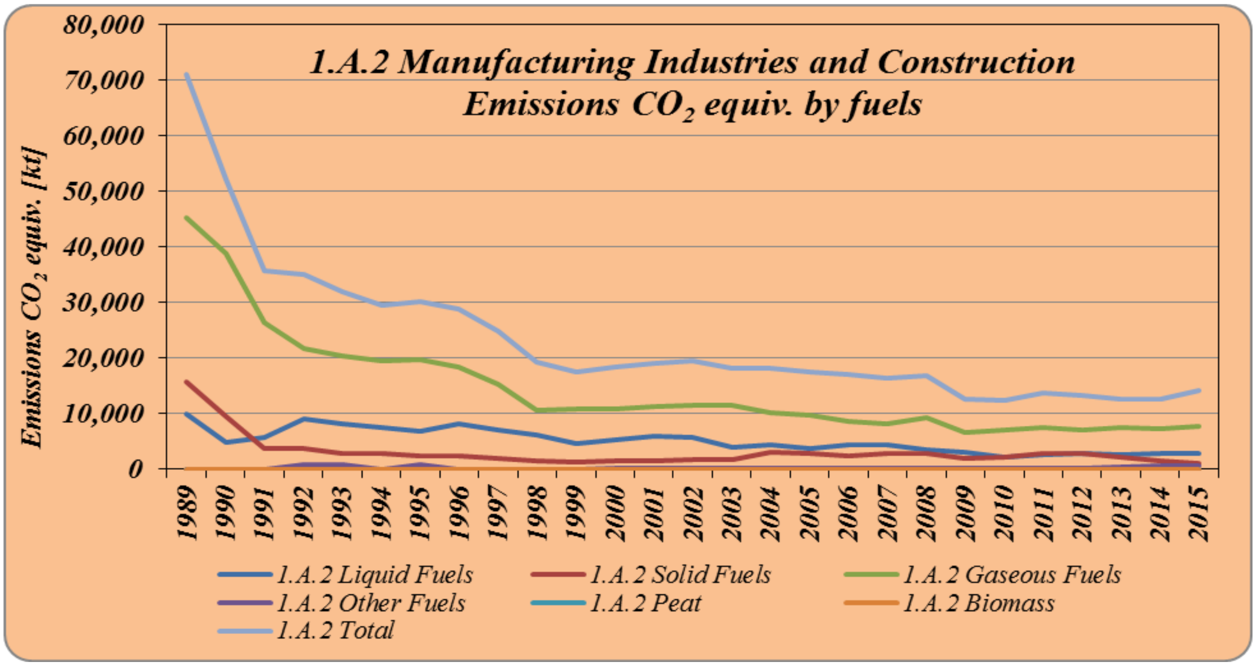


Figure 3.25 GHG emissions trend for the subsector 1.A.2. Manufacturing Industries and Constructions by fuels



The subsector Manufacturing Industries and Construction was responsible in 2015 for 18.1% of the total Energy Sector GHG emissions (about 12,455.83 kt CO_2 equivalents).

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

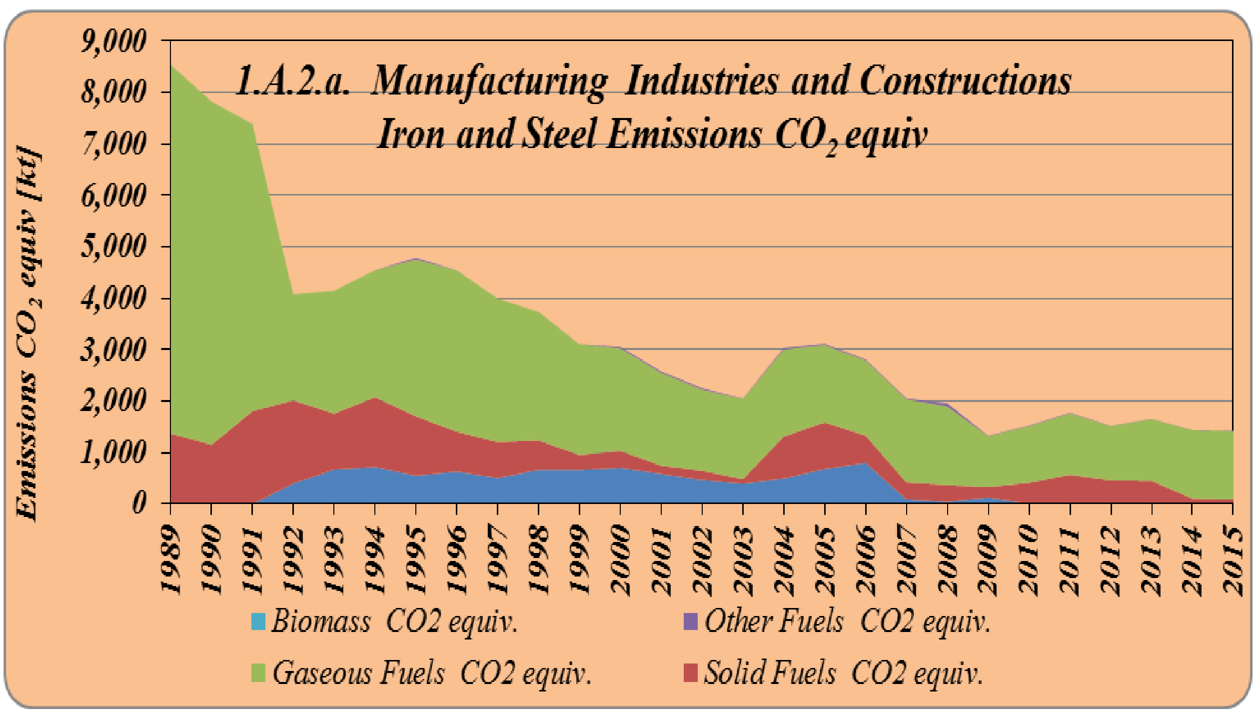
- ***Energy Use in the Petrochemical Sector***
- ***Energy Use in Transformation Sector, autoproducers:***
  - Auto producer Electricity Plants
  - Auto producer CHP Plants
  - Auto producer Heat Plants.
- ***Energy Sector - Blast Furnaces (Energy)***
- ***Industry Sector:***
  - Iron and Steel;
  - 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

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



The share of the total CO_2 equiv. emissions of the 1.A.2.a category to the 1.A.2 sub-sector, is 12.53% from the base year, to 11.44% - current year, 2015. The contribution of this category is about 1,425.11 kt CO_2 equiv., in 2015.

3.2.6.1.2 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.

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 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 1.B - Fugitive Emission Sector.

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

No recalculation due to the activity data chages are made. See the Chapter 3.2.4.5 for more details.

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

It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.

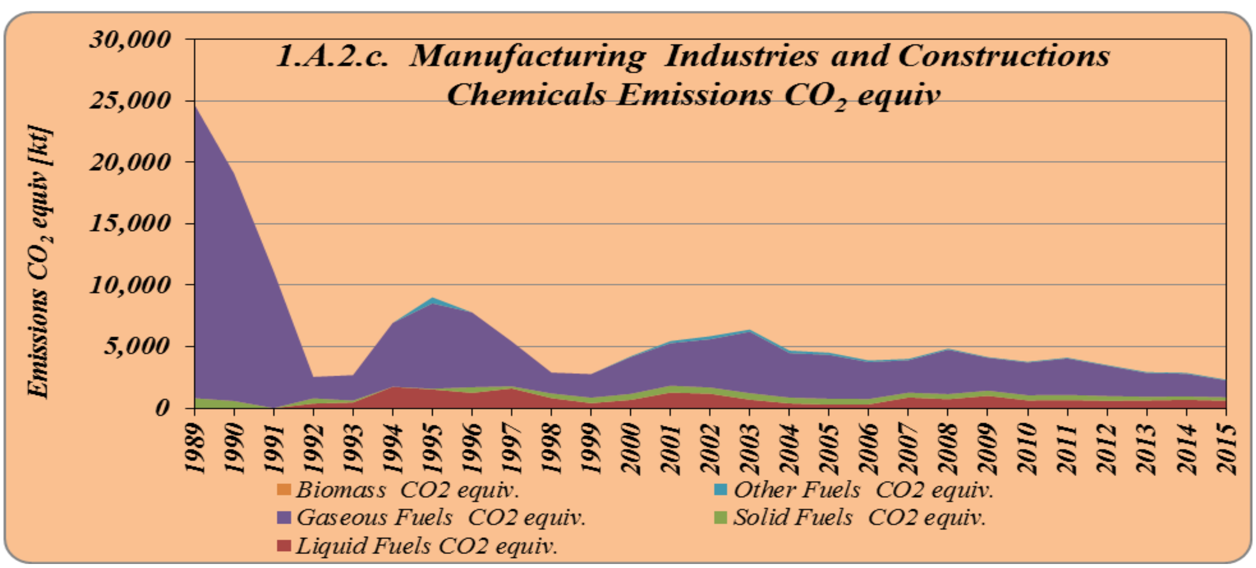
3.2.6.2 Fuel combustion, Manufacturing Industries and Construction, Non-Ferrous metals (CRF 1.A.2.b)

This activity category mostly is included in the 1.A.1.a Iron and steel reporting. The Energy Balance provided fuel consumption only on 1989, 1990, 2007 years. For the rest of the time-range the notation key is IE – included elsewhere.

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

3.2.6.3.1 Category description

Figure 3.27 GHG emissions from 1.A.2.c – Chemicals, by fuels



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 – 36.30% to 18.67% - current year, 2015. The contribution of this category is about 2,325.29 kt CO_2 equiv., in 2015.

3.2.6.3.2 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, 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 corresponding with that used in industry (net).

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 1.B - Fugitive Emission Sector.

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

No recalculations were performed for this submission.

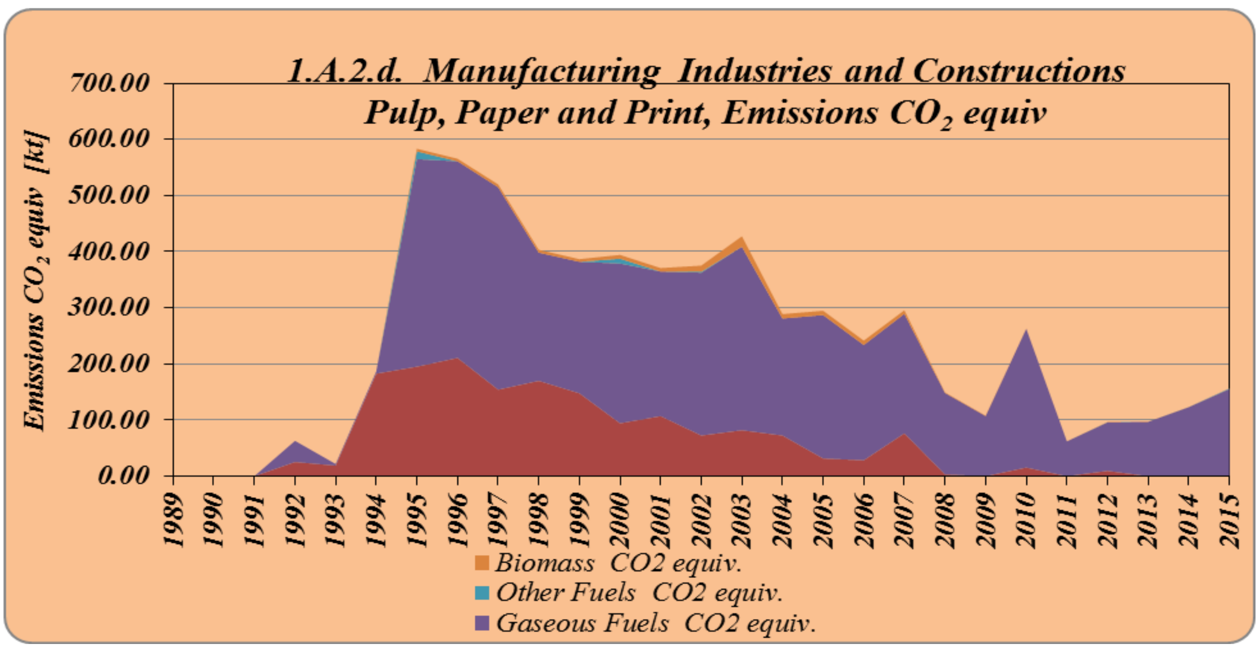
3.2.6.3.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.

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

Figure 3.28 GHG emissions from 1.A.2.d – Pulp, Paper and Print, by fuels



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 1.26% - in the current year, 2015. The contribution of this category is about 156.41 kt CO_2 equiv., in 2015.

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.).

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.
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 industry (net).
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 1.B - Fugitive Emission sector. 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

No recalculations for the specific activity data change were made in this category. For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

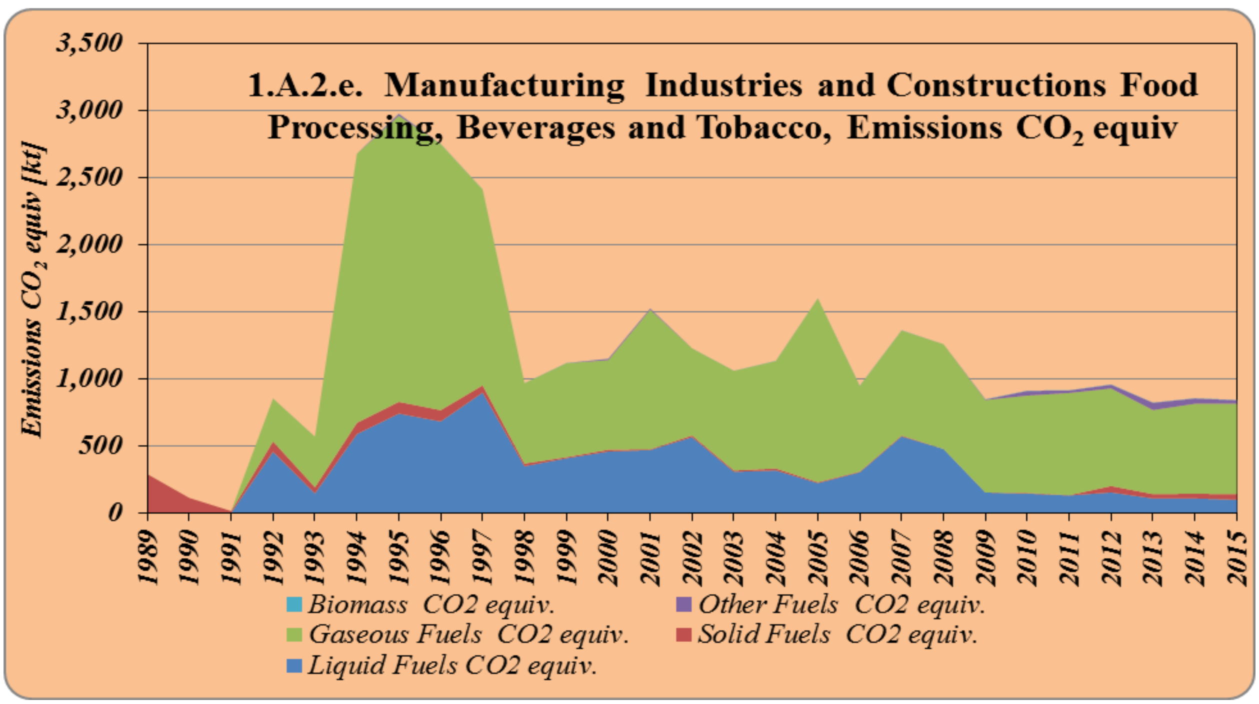
3.2.6.4.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.

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

Figure 3.29 GHG emissions 1.A.2.e – Food Processing, Beverages and Tobacco, by fuels



The share of the total GHG emissions of the 1.A.2.e category to 1.A.2 sub-sector is about 0.42% - base year to the 6.75%, current year, 2015. The contribution of this category is about 840.92 kt CO_2 equiv., in 2015. 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.

3.2.6.5.2 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, 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 corresponding with this activity. 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 1.B - Fugitive Emission Sector.

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

No recalculations due to the activity data change were made. 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

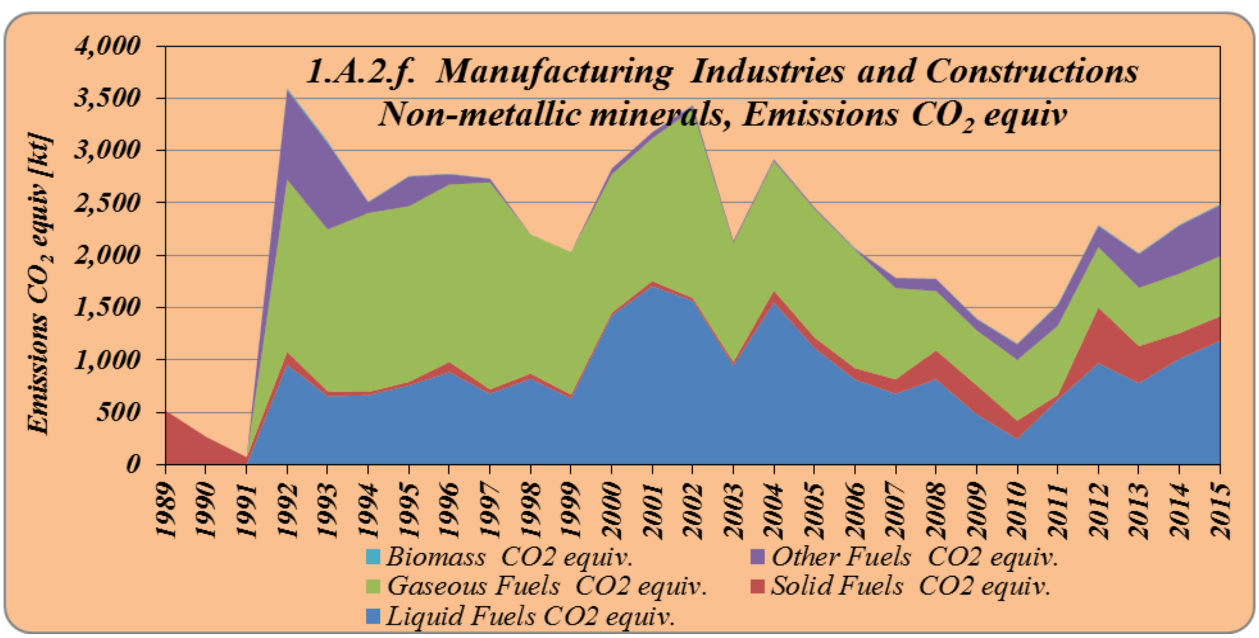
It is planned to take into consideration the emissions from the operators reporting on EU-ETS (having their reports verified by accredited verifiers) in order to achieve a hire tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.

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 gaseous fuels. It is observed a main contribution of the natural gas usage as fuel in this activity category, mostly on the period 1991 - 2000. The share of the total GHG emissions of the 1.A.2.f category to the 1.A.2 sub-sector is about 19.97%, current year, 2015. The contribution of this category is about 2,487.67 kt CO_2 equiv., in 2015.

Figure 3.30 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 without analyze on EU-ETS reporting are used. For the fuels reported in this activity category having determined Country Specific Emission Factors, 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 corresponding with this activity. 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 1.B - Fugitive Emission Sector.

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

No recalculations were performed due to the activity data changes in the non-metallic minerals activity 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

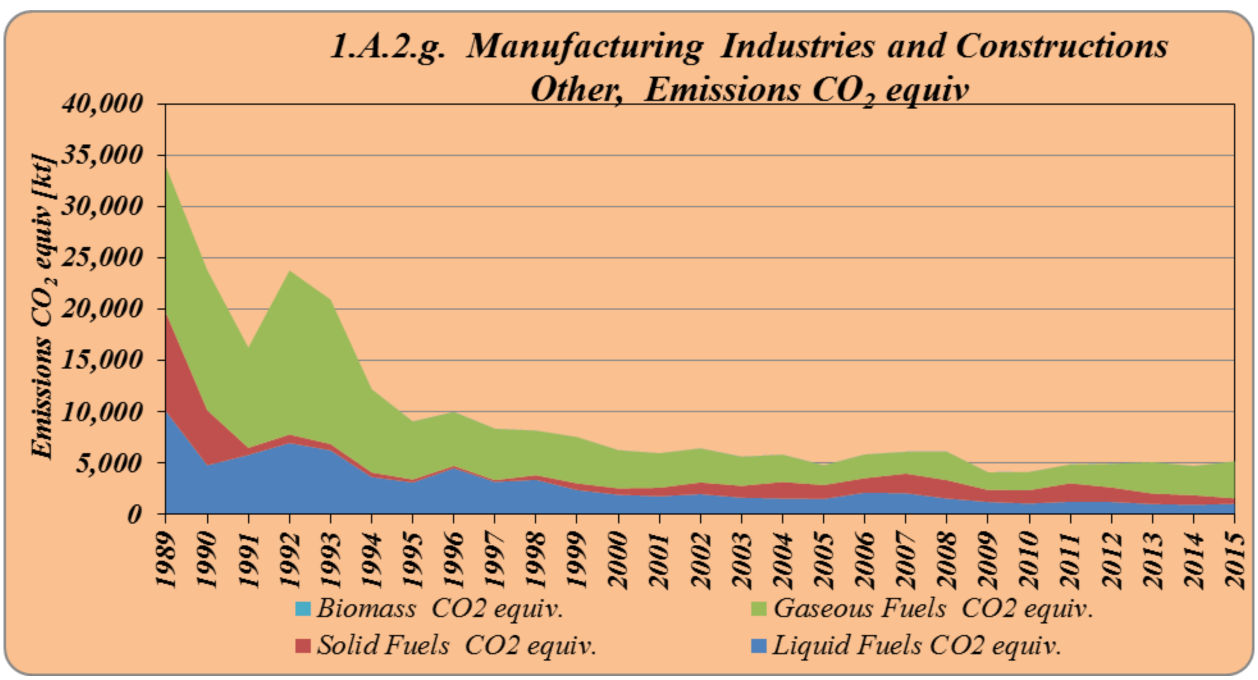
It is planned to take into consideration the emissions from the operators reporting on EU-ETS (having their reports verified by accredited verifiers) in order to achieve a higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.

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 41.91%, in 2015, the contribution of this category being about 5,220.55 kt CO_2 equiv.

Figure 3.31 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 without analyze on EU-ETS reporting are used. For the fuels reported in this activity category having determined Country Specific Emission Factors, 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 corresponding with this activity. 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 1.B - Fugitive Emission Sector.

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

No recalculations were performed due to the activity data changes in the non-metallic minerals activity 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

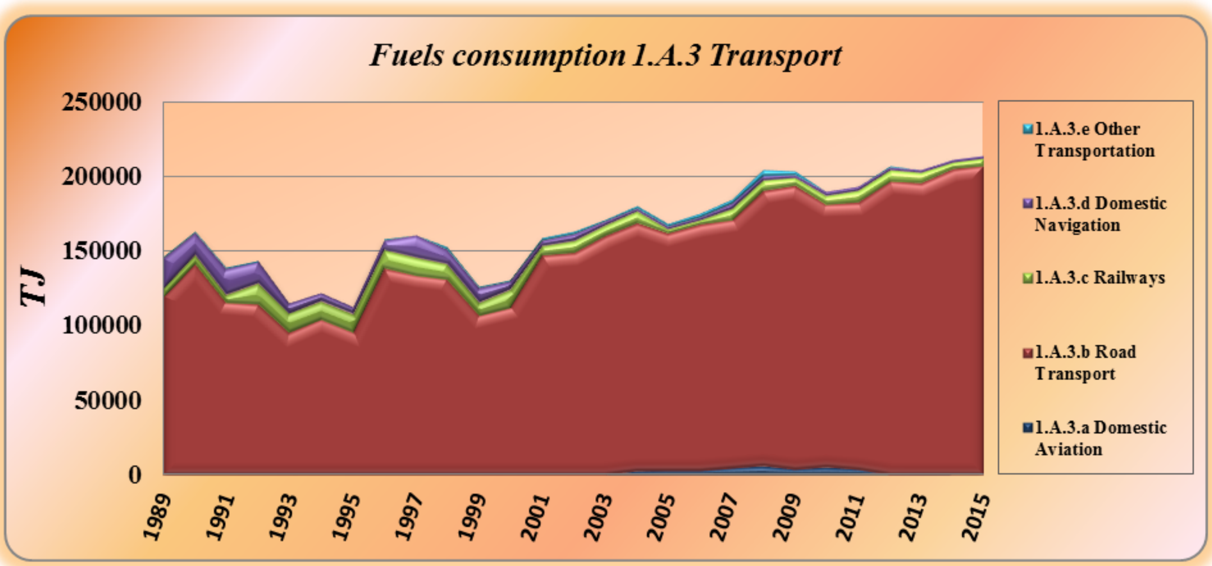
It is planned to take into consideration the emissions from the operators reporting on EU-ETS (having their reports verified by accredited verifiers) in order to achieve a higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.

3.2.7 Transport (CRF 1.A.3.)

3.2.7.1 Category description

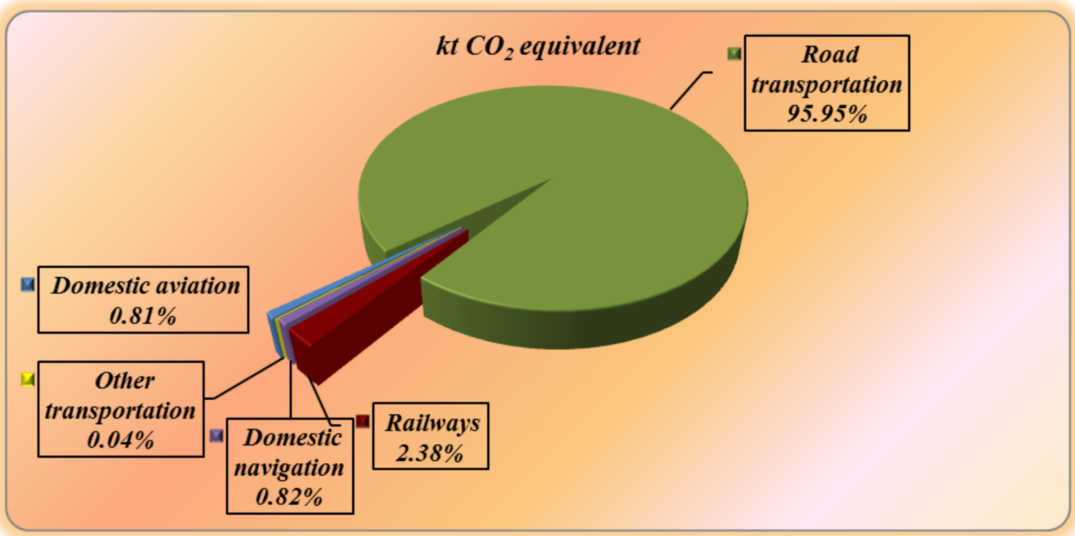
The IPCC source category for transport covers all types of mobile sources including also the range of characteristics that affect the emission factors and consequently the emissions. Those are compiled in five categories, according to the source. The direct GHG emissions originating from transport are 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.

Figure 3.32 Contribution of each category to total fuel consumption in Transport Subsector



In 2015 year, the emissions from transport categories accounted for 15,730.41 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, 20.46% represents transport emissions.
This sector includes emissions from road transportation, domestic aviation, railways, domestic navigation and other transportation.

Figure 3.33 The contribution of the emissions from different categories of Transport Subsector in 2015

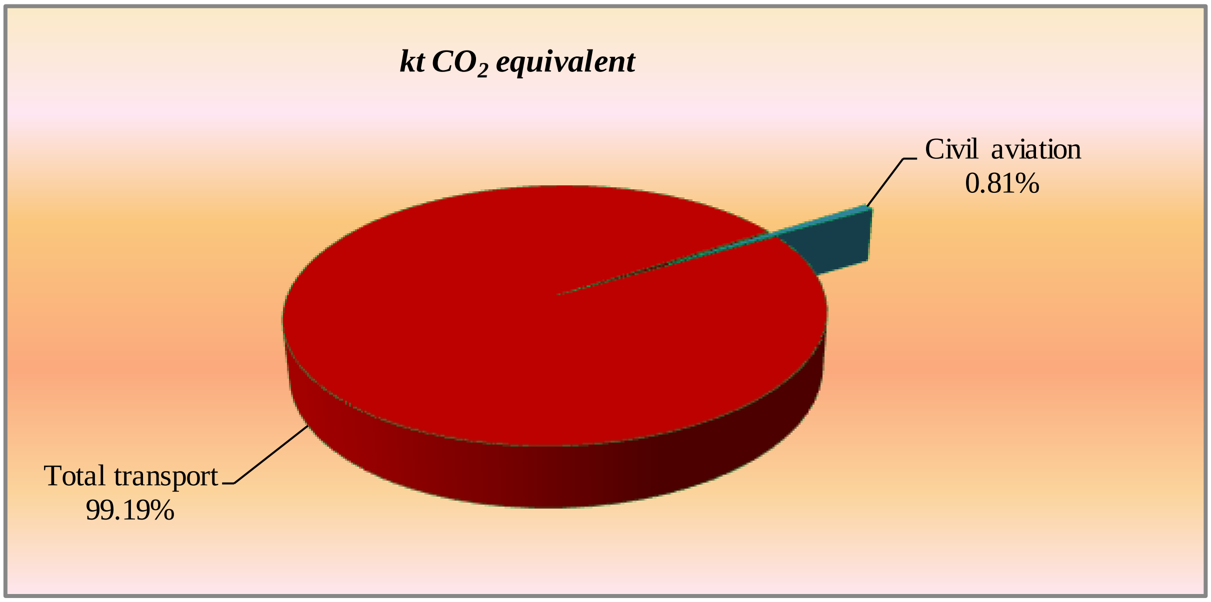


3.2.7.2 Civil Aviation (CRF 1.A.3.a)

3.2.7.2.1 Category description

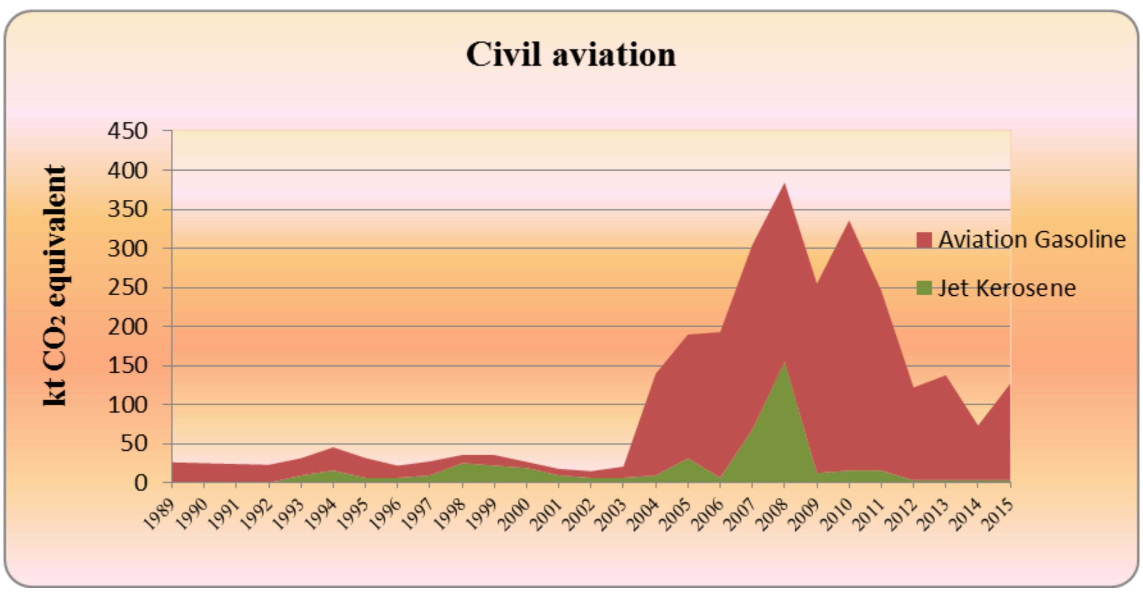
The emissions from the Aviation Subsector come from combustion of fuels of jet kerosene and aviation gasoline.
Aircraft emit carbon dioxide, methane and nitrous oxide, as well as carbon monoxide, non-methane volatile organic compounds, sulphur dioxide, and nitrogen oxides.
In 2015 year, the civil aviation related emissions represents 0.81% of total emissions from the transport sector (15,730.41 kt CO_2 equivalent).

Figure 3.34 The contribution of Civil Aviation emissions in total GHG emissions from Transport subsector



Greenhouse gas emissions from aviation are low in comparison to emissions from the transport sector but show an increase from 1989 to 2015.

Figure 3.35 GHG emissions Trend from 1A3a – Civil Aviation



In the period 1989-2003 emissions remains broadly constant, the fuel consumption being constant. Starting with 2004 in Civil Aviation Subsector due to the economic development of the country more flights took place, and therefore fuel consumption and, implicitly, emissions, increased. In the 2005-2015 period increases and decreases of emissions due to fluctuations in the number of flights operated took place.

3.2.7.2.2 Methodological issues

Methodology

The GHG emissions from Civil Aviation category are calculated according to IPCC 2006 provision. For the 1989-2003 period a Tier 1 method was applied as (no LTO data were available); for 2004-2015, a Tier 2 method was 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 IPCC 2006-Volume 2, chapter 3.6.1.1, page 3.59.

Tier 2 method

The 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 2006 IPCC (vol.2, ch 3.6.1.2, table 3.6.4, page 3.64.) for Tier 1 and Tier 2 methods, were 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, N_2O emissions factor for domestic and international aviation are default according to 2006 IPCC methodology, Table 3.6.5,pag 3.6.4, chapter 3, vol 2.

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

For Tier 2 the values of CH_4, N_2O emissions factor for Domestic and International Aviation are default according to 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 IPCC 2006 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 according to IPCC 2006 Guidelines.

The values of CO, NMVOC emission factors are default and in according to IPCC 1996 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 — 2009 and in according to

1996 IPCC Guidelines. Determination of values emission factors and emissions were in according to 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 1989-2015 period IEA/Eurostat Questionnaire data were used.

2004-2006 period, fuelconsumption data were not available, they being collected through extrapolations based on 2007 year fuel consumption data and LTO data on 2004-2007 period; 2007-2015 period it use IEA/Eurostat Questionnaire.

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 3.36 Fuel consumption(Aviation gasoline) for Civil Aviation -1.A.3.a

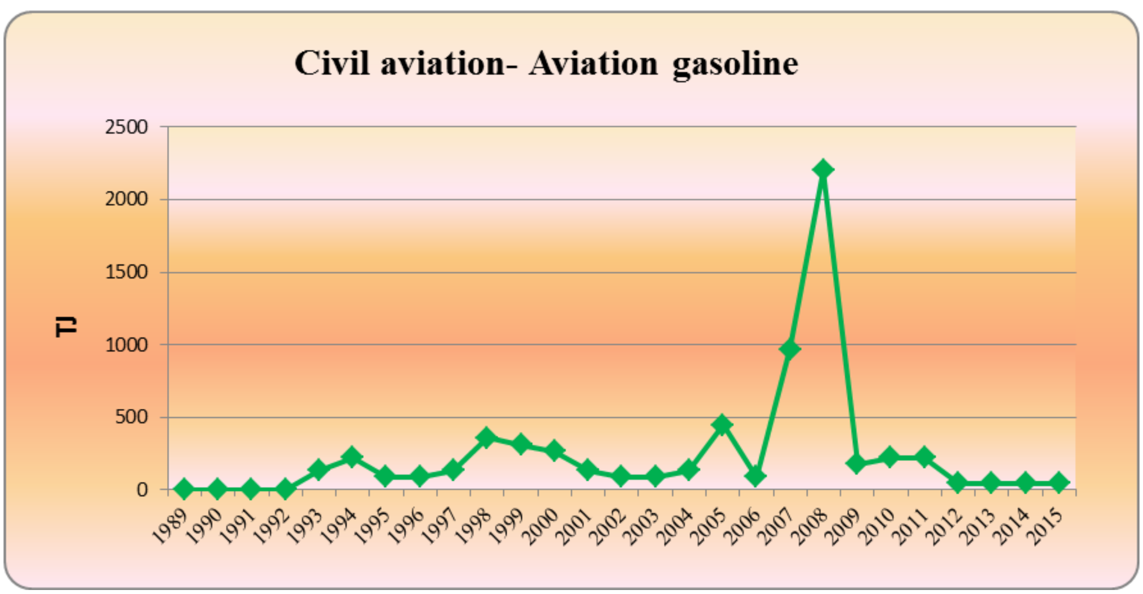
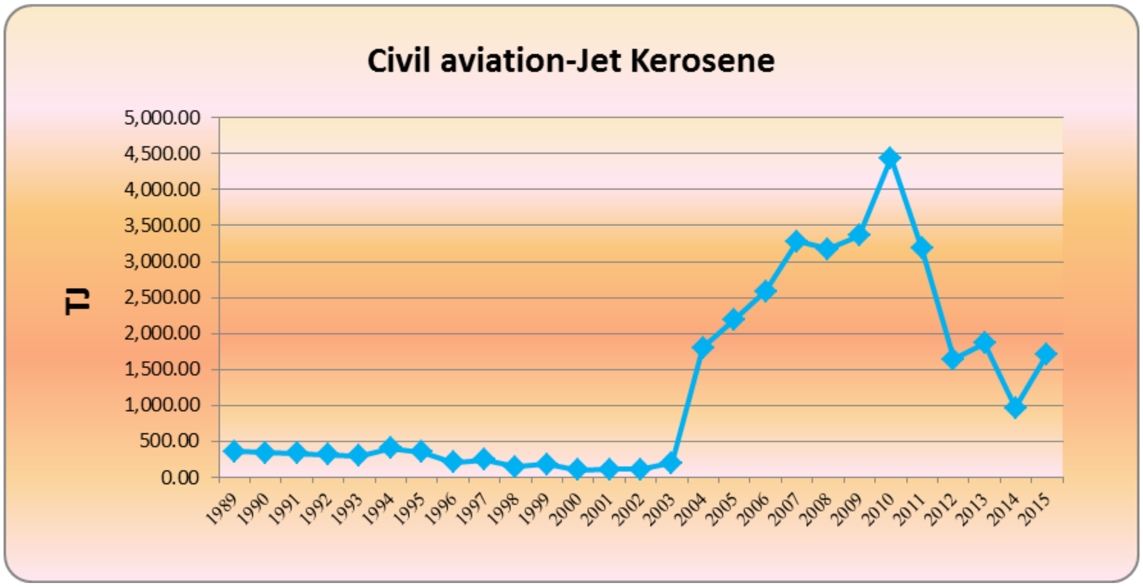


Figure 3.37 Fuel consumption(Jet Kerosene) for Civil Aviation -1.A.3.a



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 3.2.8 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 3.2.8 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 3.2.8 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.

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 Fugitive emissions 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 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

In order to improve the emissions estimates quality some important recalculations were made:

- ***emissions:***
  - ✓ Civil Aviation (1.A.3.a. Jet Kerosene) category: the CO_2 emission values for Jet Kerosene for 2004 - 2014 period have been updated due to transcription error in CRF Reporter

Table 3.13 Effects of data changes on CO_2 emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CO_2 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	362.883	362.88	25.946	25.95	0.00
1990	347.810	347.81	24.868	24.87	0.00
1991	333.503	333.50	23.845	23.85	0.00
1992	319.197	319.20	22.823	22.82	0.00
1993	438.492	438.49	31.152	31.15	0.00
1994	633.927	633.93	44.992	44.99	0.00
1995	441.808	441.81	31.456	31.46	0.00
1996	305.158	305.16	21.685	21.69	0.00
1997	382.757	382.76	27.167	27.17	0.00
1998	501.479	501.48	35.321	35.32	0.00
1999	498.532	498.53	35.177	35.18	0.00
2000	375.755	375.76	26.466	26.47	0.00
2001	250.134	250.13	17.684	17.68	0.00
2002	207.080	207.08	14.673	14.67	0.00
2003	288.776	288.78	20.514	20.51	0.00
2004	1,934.577	1,934.58	138.122	138.39	0.20
2005	2,640.350	2,640.35	187.786	188.12	0.18
2006	2,674.302	2,674.30	190.689	191.08	0.20
2007	4,245.804	4,245.80	300.902	302.12	0.41
2008	5,374.302	5,374.30	387.538	380.97	0.00
2009	3,536.060	3,536.06	248.967	252.56	1.45
2010	4,660.490	4,660.49	328.610	332.90	1.30
2011	3,406.082	3,406.08	245.083	243.21	-0.77

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CO_2 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2012	1,692.076	1,692.08	121.406	120.92	-0.40
2013	1,910.216	1,910.22	135.327	136.51	0.88
2014	1,016.34	1,016.34	72.6822	72.60	-0.11

Table 3.14 Effects of data changes on CH_4 emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [Gg]		Difference [%]
	NGHGI 2016 v.4.	NGHGI 2017 v. 1	NGHGI 2016 v.4.	NGHGI 2017 v. 1	
1989	362.88	362.88	0.000181	0.000181	0.00
1990	347.81	347.81	0.000174	0.000174	0.00
1991	333.50	333.50	0.000167	0.000167	0.00
1992	319.20	319.20	0.000160	0.000160	0.00
1993	438.49	438.49	0.000219	0.000219	0.00
1994	633.93	633.93	0.000317	0.000317	0.00
1995	441.81	441.81	0.000221	0.000221	0.00
1996	305.16	305.16	0.000153	0.000153	0.00
1997	382.76	382.76	0.000191	0.000191	0.00
1998	501.48	501.48	0.000251	0.000251	0.00
1999	498.53	498.53	0.000249	0.000249	0.00
2000	375.76	375.76	0.000188	0.000188	0.00
2001	250.13	250.13	0.000125	0.000125	0.00
2002	207.08	207.08	0.000104	0.000104	0.00
2003	288.78	288.78	0.000144	0.000144	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [Gg]		Difference [%]
	NGHGI 2016 v.4.	NGHGI 2017 v. 1	NGHGI 2016 v.4.	NGHGI 2017 v. 1	
2004	1,934.58	1,934.58	0.001663	0.001663	0.00
2005	2,640.35	2,640.35	0.002227	0.002227	0.00
2006	2,674.30	2,674.30	0.002575	0.002575	0.00
2007	4,245.80	4,245.80	0.003884	0.003884	0.00
2008	5,374.30	5,374.30	0.004534	0.004534	0.00
2009	3,536.06	3,536.06	0.004011	0.004011	0.00
2010	4,660.49	4,660.49	0.005029	0.005029	0.00
2011	3,406.08	3,406.08	0.003400	0.003400	0.00
2012	1,692.08	1,692.08	0.001660	0.001789	7.77
2013	1,910.22	1,910.22	0.001758	0.001758	0.00
2014	1,016.34	1,016.34	0.001482	0.001482	0.00

Table 3.15 Effects of data changes on N_2O emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Difference [%]
	NGHGI 2016 v.4	NGHGI 2017 v. 1	NGHGI 2016 v.4	NGHGI 2017 v. 1	
1989	362.883	362.88	0.00073	0.00073	0.00
1990	347.810	347.81	0.00070	0.00070	0.00
1991	333.503	333.50	0.00067	0.00067	0.00
1992	319.197	319.20	0.00064	0.00064	0.00
1993	438.492	438.49	0.00088	0.00088	0.00
1994	633.927	633.93	0.00127	0.00127	0.00
1995	441.808	441.81	0.00088	0.00088	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Difference [%]
	NGHGI 2016 v.4	NGHGI 2017 v. 1	NGHGI 2016 v.4	NGHGI 2017 v. 1	
1996	305.158	305.16	0.00061	0.00061	0.00
1997	382.757	382.76	0.00077	0.00077	0.00
1998	501.479	501.48	0.00100	0.00100	0.00
1999	498.532	498.53	0.00100	0.00100	0.00
2000	375.755	375.76	0.00075	0.00075	0.00
2001	250.134	250.13	0.00050	0.00050	0.00
2002	207.080	207.08	0.00041	0.00041	0.00
2003	288.776	288.78	0.00058	0.00058	0.00
2004	1,934.577	1,934.58	0.00397	0.00397	0.00
2005	2,640.350	2,640.35	0.00144	0.00537	272.30
2006	2,674.302	2,674.30	0.00083	0.00545	557.85
2007	4,245.804	4,245.80	0.00274	0.00860	214.23
2008	5,374.302	5,374.30	0.00546	0.01096	100.74
2009	3,536.060	3,536.06	0.00152	0.00725	377.93
2010	4,660.490	4,660.49	0.00173	0.00953	451.71
2011	3,406.082	3,406.08	0.00133	0.00696	422.61
2012	1,692.076	1,692.08	0.00057	0.00347	507.47
2013	1,910.216	1,910.22	0.00057	0.00388	579.46
2014	1,016.34	1,016.34	0.00055	0.00210	283.71

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

Analysis will be continued with the collaborating institutions in order to have a fully correspondence concerning the quantities of the fuels.

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

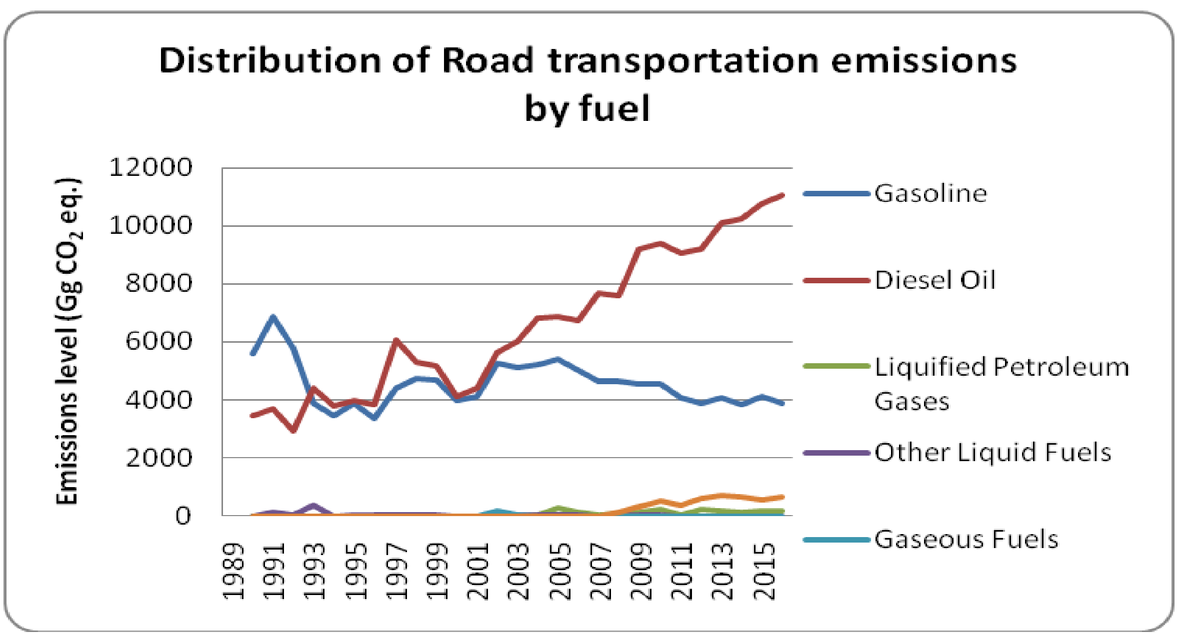
3.2.7.3.1 Category description

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.

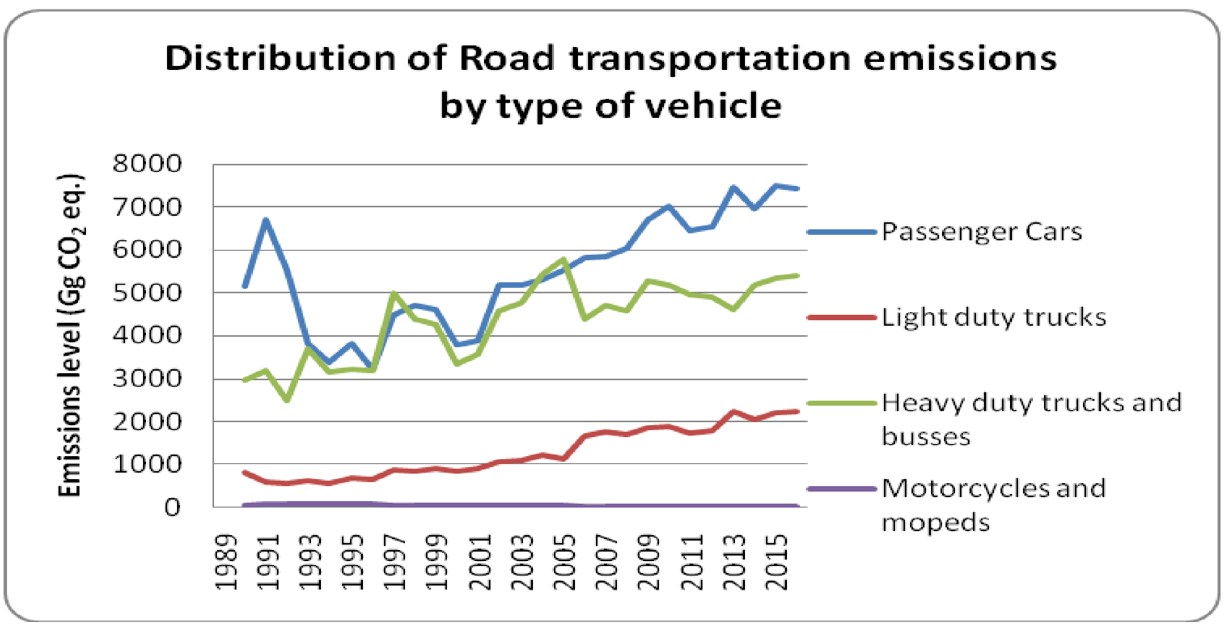
Exhaust emissions from road transport arise from the engines internal combustion of fuels such as gasoline, diesel, liquefied petroleum gas, other kerosene and natural gas.

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 2015.

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 67.73% compared to base year levels being 8998,90 kt CO_2equiv in 1989 and reached levels of 15,093.54 kt CO_2equiv in 2015. 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 2015, emissions from passenger cars contributed to 49.16% in total Road transportation emissions and heavy duty trucks and buses with 35.86%.

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

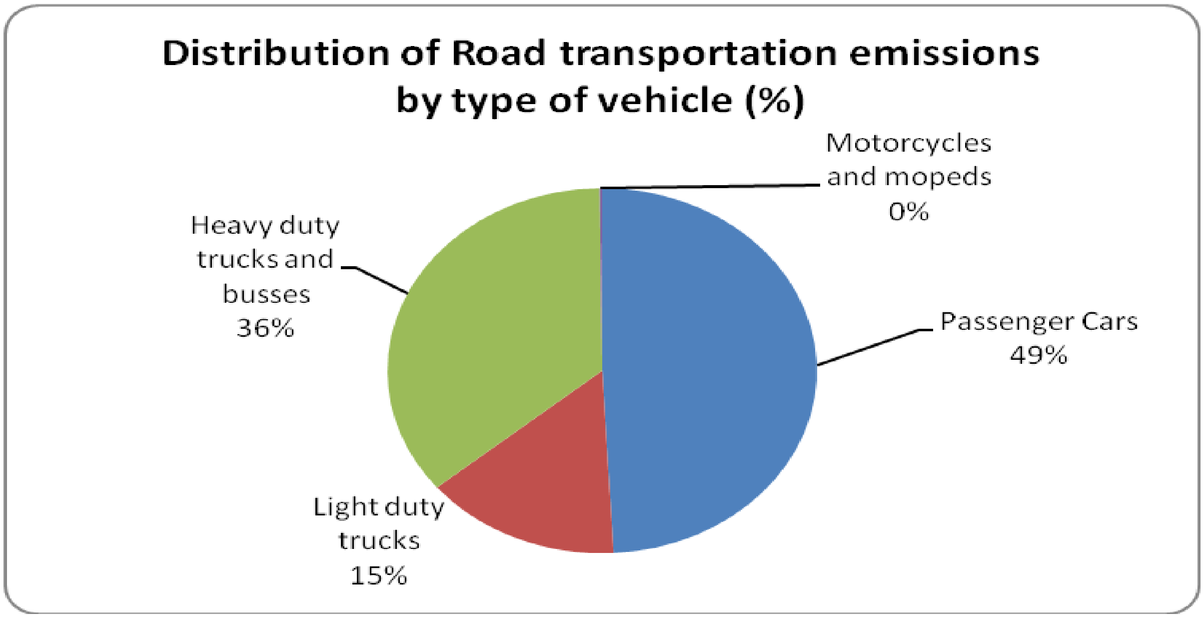
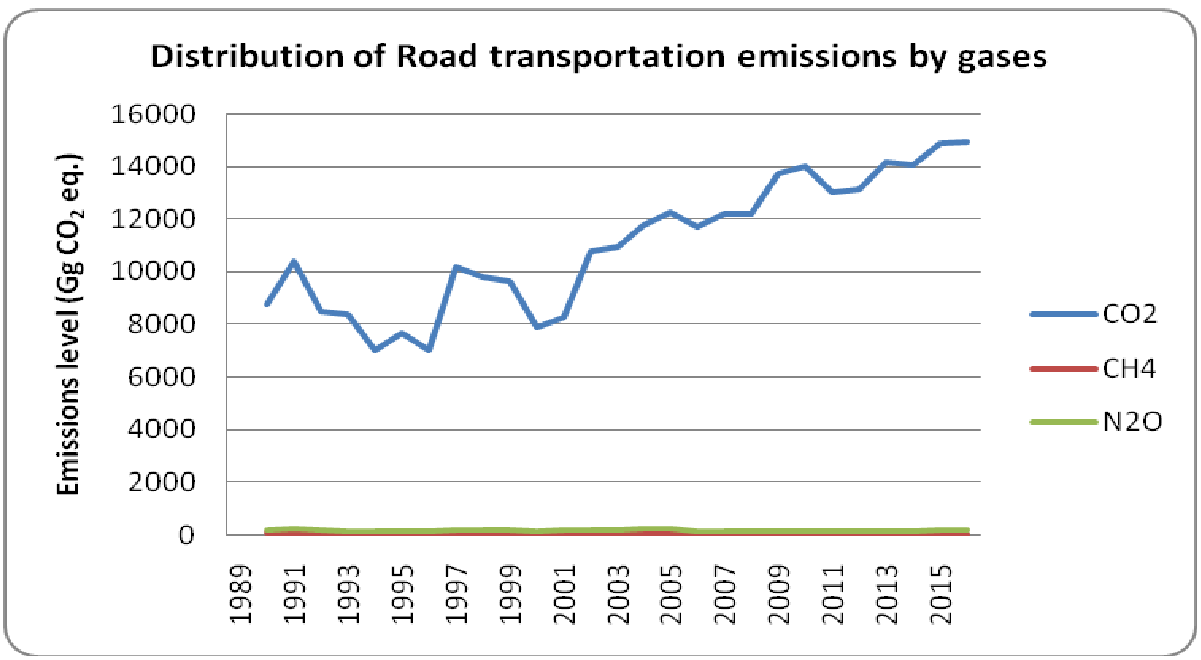


Figure 3.41 Distribution of Road transportation emissions by gases (Gg CO_2 equivalent)



Whereas CO_2 emissions are closely linked to fuel consumption, CH_4 and N_2O emissions are impacted and 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 98.77% of the total greenhouse gas emissions of the sector, in 2015.

CH_4 emissions contributed with 0.23% 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 2015, N_2O emissions contributed with 1% 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 (consumtion 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 1990-2015 period. NIS did not prepared balances in the Eurostat format for the years before 1990; therefore, the IEA Energy Balance (IEA Questionnaire) was used for the year 1989.

The other data, necessary for implementation of model COPERT- Tier 1, have been provided by national institutions: fleet data provided by Romanian National Institute for Statistics (NIS), were processed and completed by the Romanian Automobile Registry (RAR).

Biomass

In order to estimate the emissions from biomass combustion activities in road transport, data on energetic quantities provided through the Energy Balance were used.

Liquid biomass used comprise biogasoline, biodiesel and other bioliquids.

All these types are combusted to produce heat and/or power. However, CO_2 emissions released from these processes are reported as an information item, as the CO_2 is naturally captured from the air. That is not applicable for the CH_4 and N_2O emissions, being reported and accounted for, in the total inventory emissions.

The national energy balance is provided by NIS. From biomass, the net calorific values (NCVs) used for converting mass or volume units of the fuel quantities into energy units [TJ] are provided by NIS.

Choice of NCV

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

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

For the 2005-2015 period

Methodology

Model Copert 4, Tier 3 was used for the period 2005-2015, detailed statistics necessary to use higher level methods have allowed.

For period 2005-2015 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 GPG 2000 and 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 2005-2015 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.

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 2005-2015 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 3.16 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/m³)**	**T95% C⁰**	**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 Annex3.2).

3.2.7.3.3 Uncertainties and time- series consistency

The uncertainty associated to the GHG emissions estimates are:

Table 3.17 Uncertainties for road transport

Road Transport 1.A.3.b.	Uncertainty				Combined uncertainty		
	Activity Data	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 Domestic Aviation, Railways, Domestic Navigation and Other Transportation, the results of these being mentioned on the Checklists level.

Following these activities there were no unconformities recorded.

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.

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 activity data series were compared with Eurostat, the data being reported at the same level of aggregation and the figures comparable. Further elements are presented within Annex 6.3.

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

In order to improve the inventory quality:

- implementation requirements and future recommendations consistent with IPCC 2006.

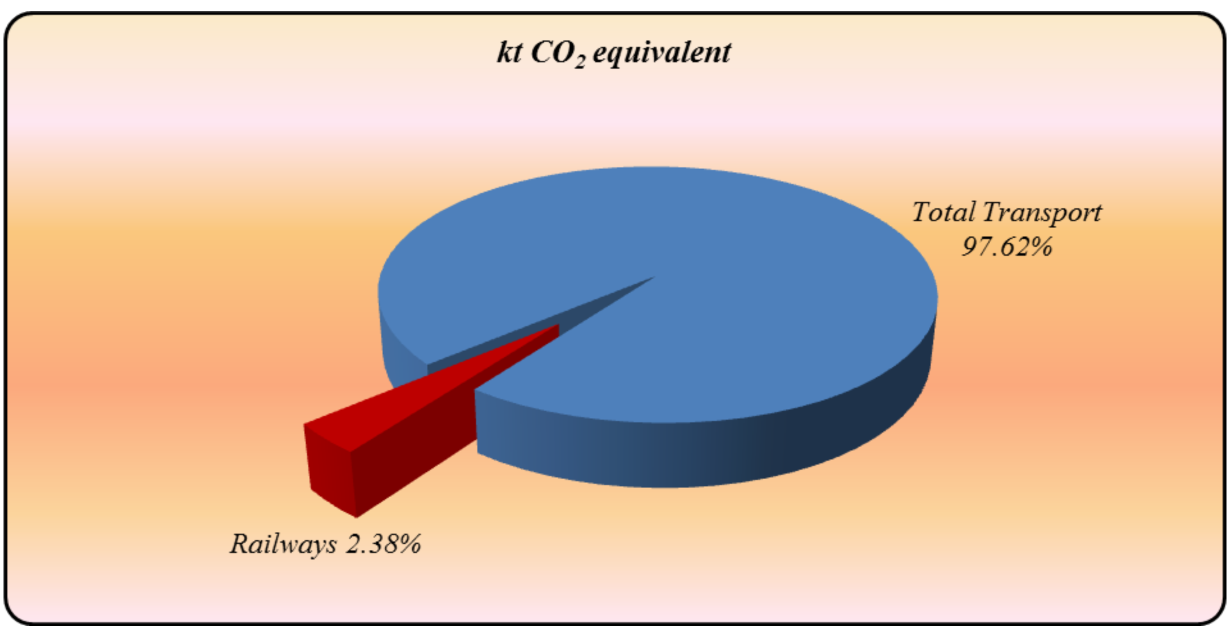
3.2.7.4 Railways (CRF 1.A.3.c)

3.2.7.4.1 Category description

The Railways Subsector 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 2015 year the emissions from Railways category represents 2.38% of total emissions from the transport sector (15,730.41 kt CO_2 equivalent).

Figure 3.42 The contribution of Railwais emissions in total GHG emissions from Transport subsector



In Railways Subsector, the emissions trend reflects the changes in this period characterized by a process of transition to a market economy.

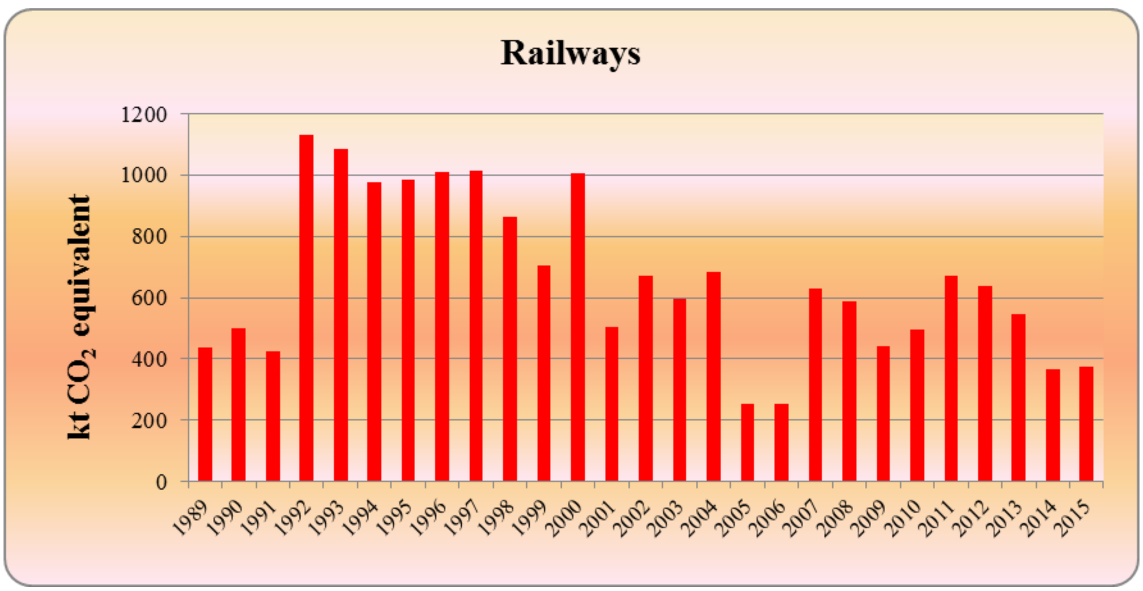
In the 1989-2004 and 2006-2008 periods increases and decreases of emissions are due to fluctuations in the number of domestic trips.

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 for 2011year the emissions were increasing that could be explained by the the fuel consumption growth.

For 2015 an decrease compared to the 2011 has been observed, due to the domestic trips number decrease.

Figure 3.43 GHG emissions Trend from 1A3c – Railways



3.2.7.4.2 Methodological issues

Methodology

The GHG emissions from Railways category are calculated according to 2006 IPCC and IPCC Good Practice Guidance.

The activity data are provided by IEA/Eurostat Questionnaire and values for emissions factors used are provided by 2006 IPCC Guidelines.

Tier 1 method

The direct GHG emissions are calculated according to IPCC2006 and calculation formula is presented in vol.2, Section 3.3.1.1.

The indirect GHG emissions are calculated according to IPCC1996 and EMEP/EEA Air Pollutant Emission Inventory Guidebook — 2009.

Tier 2 method

The CO_2emissions, are estimated using country-specific and fuel-specific emission factors.

According to the provisions in the relevant decision trees in the IPCC GPG 2000, giving their status of key categories, both by level and trend criteria, the IPCC Tier 2 approach is used to calculate the CO_2 emissions from fuel combustion in the sectors.

The CO_2 emissions, are calculated according to 2006 IPCC Guidelines vol.2 (pag.3.33, section 3.3.1.1)

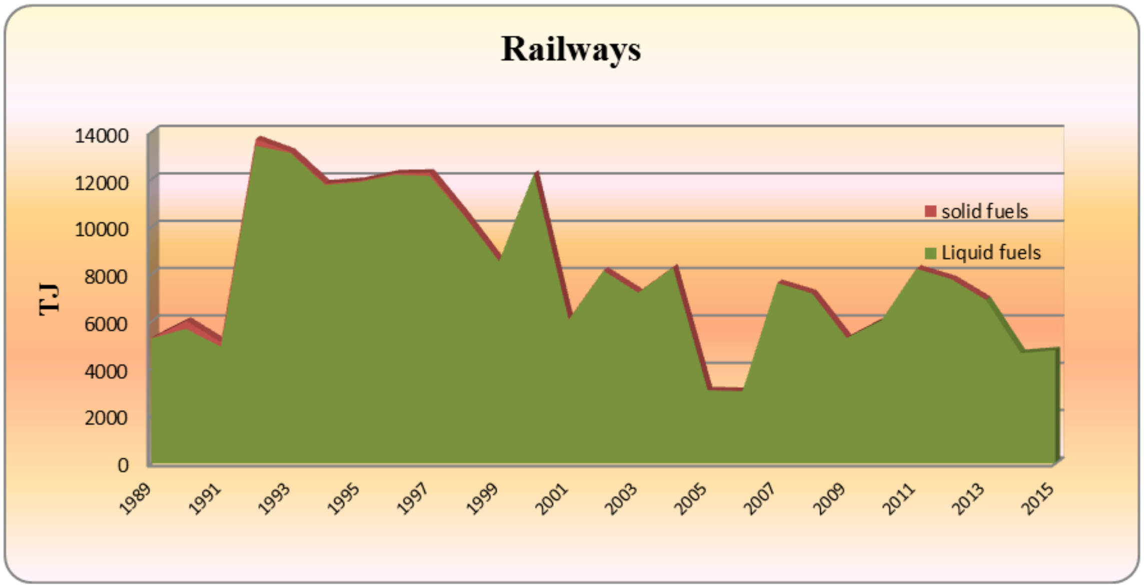
Emission factors

The values of CO_2 Emissions Factor is country specific. The values of CH_4 and N_2O emission factors are default and in according to IPCC 2006 Guidelines.

Activity data

The activity data for Railways(1.A.3.c) are provided by IEA/Eurostat Questionnaire.

Figure 3.44 Fuel consumptionfor Railwais -1.A.3.c



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 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

CH_4

❖ ***activity data:***
- Liquid: 5%
- Solid: 3%

❖ ***emision factors:***
- Liquid: 50%
- Solid: 50%
- 50% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

N_2O

❖ ***activity data:***
- Liquid: 5%
- Solid: 3%

❖ ***emision factors:***
- Liquid: 50%
- Solid: 50%
- 50% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

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

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 witht national emission factors values specific to Bulgaria, considering that similar energy activities are implemented. Further elements are presented within Annex 6.3.

3.2.7.4.5 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:

- ***emissions***:

✓ Railways (1.A.3.c.) category: the CO_2 emission values for 2013 and 2014 have been updated because the Country Specific Emission Factor values for 2013 and 2014 have been updated.

Table 3.18 Effects of data changes on CO_2 emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CO_2 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	5,290.37	5,290.37	390.03	390.03	0.00
1990	6,032.78	6,032.78	451.90	451.90	0.00
1991	5,127.04	5,127.04	381.83	381.83	0.00
1992	13,845.56	13,845.56	1,016.35	1,016.35	0.00
1993	13,345.52	13,345.52	971.27	971.27	0.00
1994	11,914.26	11,914.26	873.59	873.59	0.00
1995	12,137.68	12,137.68	881.33	881.33	0.00
1996	12,470.37	12,470.37	905.25	905.25	0.00
1997	12,473.50	12,473.50	908.53	908.53	0.00
1998	10,718.48	10,718.48	774.39	774.39	0.00
1999	8,612.53	8,612.53	629.85	629.85	0.00
2000	12,264.65	12,264.65	903.83	903.83	0.00
2001	6,153.73	6,153.73	449.97	449.97	0.00
2002	8,300.19	8,300.19	600.77	600.77	0.00
2003	7,353.37	7,353.37	532.84	532.84	0.00
2004	8,302.49	8,302.49	612.43	612.43	0.00
2005	3,122.74	3,122.74	228.47	228.47	0.00
2006	3,083.59	3,083.59	225.54	225.54	0.00
2007	7,686.18	7,686.18	564.03	564.03	0.00
2008	7,188.80	7,188.80	527.54	527.54	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CO_2 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2009	5,309.92	5,309.92	393.84	393.84	0.00
2010	6,059.00	6,059.00	444.02	444.02	0.00
2011	8,230.95	8,230.95	600.13	600.13	0.00
2012	7,789.68	7,789.68	572.88	572.88	0.00
2013	6,933.97	6,926.33	509.00	488.55	-4.02
2014	4,619.08	4,681.73	338.74	325.12	-4.02

Table 3.19 Effects of data changes on CH_4 emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [kt]		Differences [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	5,290.37	5,290.37	0.0219	0.0219	0.00
1990	6,032.78	6,032.78	0.0239	0.0239	0.00
1991	5,127.04	5,127.04	0.0207	0.0207	0.00
1992	13,845.56	13,845.56	0.0601	0.0601	0.00
1993	13,345.52	13,345.52	0.0600	0.0600	0.00
1994	11,914.26	11,914.26	0.0513	0.0513	0.00
1995	12,137.68	12,137.68	0.0553	0.0553	0.00
1996	12,470.37	12,470.37	0.0569	0.0569	0.00
1997	12,473.50	12,473.50	0.0562	0.0562	0.00
1998	10,718.48	10,718.48	0.0502	0.0502	0.00
1999	8,612.53	8,612.53	0.0375	0.0375	0.00
2000	12,264.65	12,264.65	0.0509	0.0509	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [kt]		Differences [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2001	6,153.73	6,153.73	0.0270	0.0270	0.00
2002	8,300.19	8,300.19	0.0383	0.0383	0.00
2003	7,353.37	7,353.37	0.0338	0.0338	0.00
2004	8,302.49	8,302.49	0.0345	0.0345	0.00
2005	3,122.74	3,122.74	0.0134	0.0134	0.00
2006	3,083.59	3,083.59	0.0134	0.0134	0.00
2007	7,686.18	7,686.18	0.0334	0.0334	0.00
2008	7,188.80	7,188.80	0.0299	0.0299	0.00
2009	5,309.92	5,309.92	0.0221	0.0221	0.00
2010	6,059.00	6,059.00	0.0251	0.0251	0.00
2011	8,230.95	8,230.95	0.0342	0.0342	0.00
2012	7,789.68	7,789.68	0.0323	0.0323	0.00
2013	6,933.97	6,926.33	0.0290	0.0290	0.00
2014	4,619.08	4,681.73	0.0195	0.0195	0.00

Table 3.20 Effects of data changes on N_2O emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Differences [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	5,290.37	5,290.37	0.151	0.151	0.00
1990	6,032.78	6,032.78	0.162	0.162	0.00
1991	5,127.04	5,127.04	0.141	0.141	0.00
1992	13,845.56	13,845.56	0.383	0.383	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Differences [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1993	13,345.52	13,345.52	0.376	0.376	0.00
1994	11,914.26	11,914.26	0.335	0.335	0.00
1995	12,137.68	12,137.68	0.339	0.339	0.00
1996	12,470.37	12,470.37	0.348	0.348	0.00
1997	12,473.50	12,473.50	0.347	0.347	0.00
1998	10,718.48	10,718.48	0.299	0.299	0.00
1999	8,612.53	8,612.53	0.244	0.244	0.00
2000	12,264.65	12,264.65	0.342	0.342	0.00
2001	6,153.73	6,153.73	0.174	0.174	0.00
2002	8,300.19	8,300.19	0.231	0.231	0.00
2003	7,353.37	7,353.37	0.207	0.207	0.00
2004	8,302.49	8,302.49	0.237	0.237	0.00
2005	3,122.74	3,122.74	0.082	0.082	0.00
2006	3,083.59	3,083.59	0.086	0.086	0.00
2007	7,686.18	7,686.18	0.217	0.217	0.00
2008	7,188.80	7,188.80	0.204	0.204	0.00
2009	5,309.92	5,309.92	0.151	0.151	0.00
2010	6,059.00	6,059.00	0.173	0.173	0.00
2011	8,230.95	8,230.95	0.235	0.235	0.00
2012	7,789.68	7,789.68	0.222	0.222	0.00
2013	6,933.97	6,926.33	0.196	0.196	0.00
2014	4,619.08	4,681.73	0.131	0.131	0.00

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

Analysis will be continued with the collaborating institutions in order to have a fully correspondence concerning the quantities of the fuels.

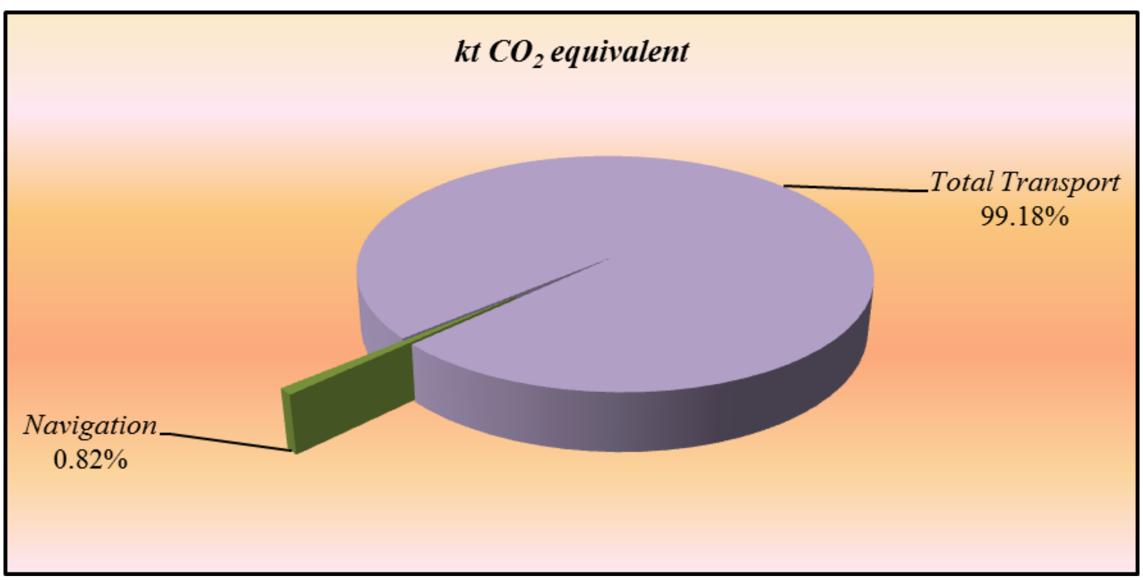
3.2.7.5 Navigation(CRF 1.A.3.d)

3.2.7.5.1 Category description

The Navigation sub-sector includes emissions from following fuels: Diesel Oil,Gasoline, Residual Fuel Oil, LPG.

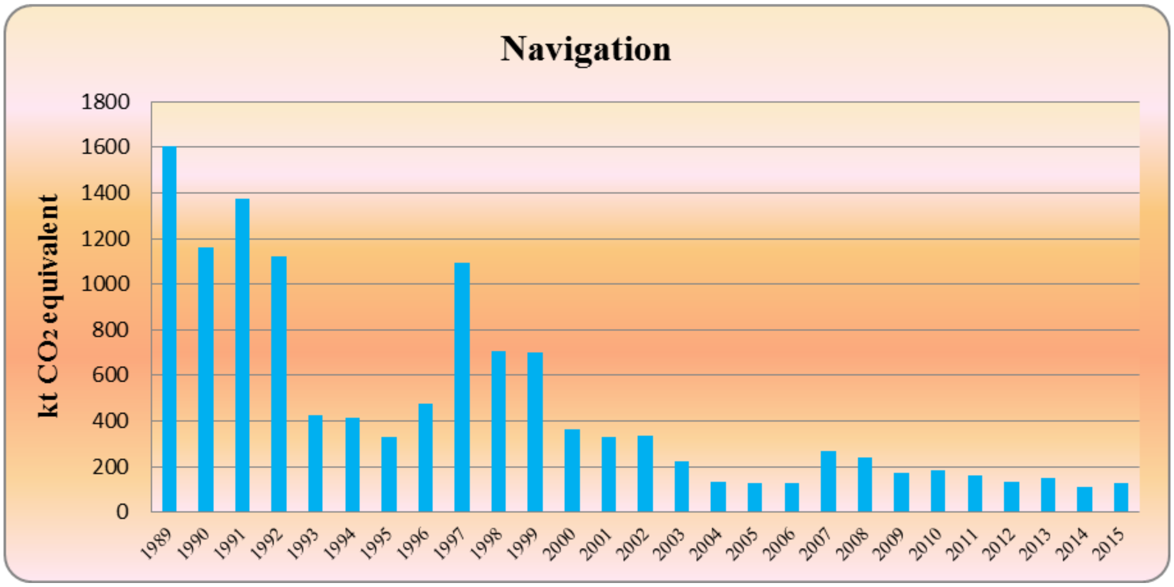
In the 2015 year the emissions from Navigation category represents 0.82% of total emissions from the transport sector (15,730.41 kt CO_2 equivalent).

Figure 3.45 The contribution of Navigation emissions in total GHG emissions from Transport subsector



In the Navigation Subsector, the decline of the economic and industrial activities and of the number of the maritime races caused the fuel consumption and GHG emissions reduction.

Figure 3.46 GHG emissions from 1A3a – Navigation



3.2.7.5.2 Methodological issues

The GHG emissions from Navigation category are calculated according to 2006 IPCC and IPCC Good Practice Guidance.

The activity data are provided by IEA/Eurostat Questionnaire and values for emissions factors used are provided by 2006 IPCC Guidelines

The Tier1 and Tier 2 method was used and are presented in section 3.2.7.4.2.

Emission Factors

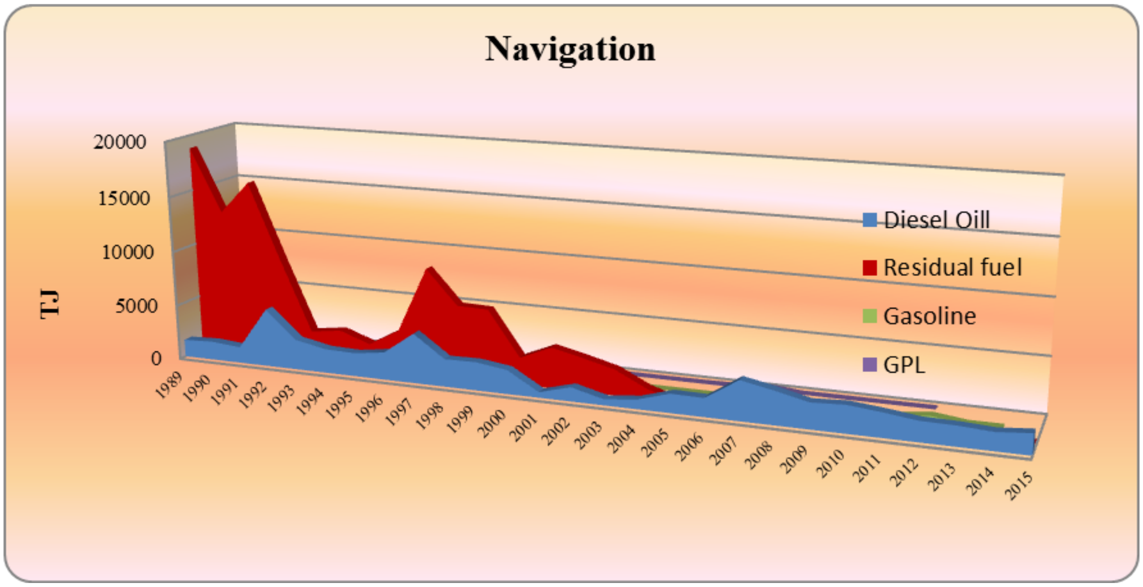
The values of CO_2 Emissions Factor is country specific.

The values of CH_4 and N_2O emission factors are default and in according to IPCC 2006 Guidelines.

Activity Data

The activity data for Navigation (1.A.3.d) are provided by IEA/Eurostat Questionnaire.

Figure 3.47 Fuel consumption 1.A.3.d Navigation 1989-2015



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:5.0 %
- Diesel oil: 5.0%
- Gasoline:3.0%

❖ ***emision factors:***
- Residual Fuel Oil:3 %
- Diesel oil: 3.0%
- Gasoline:0.8%
- 5.83% 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.

CH_4

- ***activity data:***
  - Residual Fuel Oil:5.0 %
  - Diesel oil: 5.0%
  - Gasoline:3.0%
- ***emision factors:***
  - Residual Fuel Oil:50 %
  - Diesel oil: 50%
  - Gasoline:50%
  - 50% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

N_2O

- ***activity data:***
  - Residual Fuel Oil:5.0 %
  - Diesel oil: 5.0%
  - Gasoline:3%
- ***emision factors:***
  - Residual Fuel Oil:50 %
  - Diesel oil: 50%
  - Gasoline:50%
  - 50% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

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

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:

- ***emissions:***

- ✓ Domestic Navigation (1.A.3.d.) category: the CO_2 emission values for 2013 and 2014 have been updated because the Country Specific Emission Factor values for 2013 and 2014 have been updated.

Table 3.21 Effects of data changes on CO_2 emissions level

Year	**Changes at AD level (TJ)**		**Effects of changes on emission estimates for CO_2 [kt]**		**Difference [%]**
	NGHGI 2016 v. 4	**NGHGI 2017 v. 1**	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	
1989	20,435.55	20,435.55	1,587.61	1,587.61	0.00
1990	14,850.70	14,850.70	1,151.34	1,151.34	0.00
1991	17,517.60	17,517.60	1,360.39	1,360.39	0.00
1992	14,508.15	14,508.15	1,109.38	1,109.38	0.00
1993	5,535.97	5,535.97	420.07	420.07	0.00
1994	5,341.22	5,341.22	407.27	407.27	0.00
1995	4,291.56	4,291.56	325.74	325.74	0.00
1996	6,199.40	6,199.40	472.97	472.97	0.00
1997	14,132.26	14,132.26	1,083.16	1,083.16	0.00
1998	9,068.67	9,068.67	696.73	696.73	0.00
1999	9,028.16	9,028.16	693.41	693.41	0.00
2000	4,715.60	4,715.60	358.00	358.00	0.00
2001	4,231.14	4,231.14	327.53	327.53	0.00
2002	4,308.85	4,308.85	330.59	330.59	0.00
2003	2,866.49	2,866.49	221.13	221.13	0.00
2004	1,745.97	1,745.97	132.50	132.50	0.00
2005	1,738.87	1,738.87	128.38	128.38	0.00
2006	1,697.26	1,697.26	125.31	125.31	0.00
2007	3,585.35	3,585.35	264.59	264.59	0.00
2008	3,263.50	3,263.50	236.62	236.62	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CO_2 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2009	2,306.08	2,306.08	171.12	171.12	0.00
2010	2,493.39	2,493.39	182.64	182.64	0.00
2011	2,167.16	2,167.16	158.01	158.01	0.00
2012	1,817.86	1,817.86	133.67	133.67	0.00
2013	2,106.71	2,106.71	154.27	149.20	-3.29
2014	1,583.64	1,583.64	116.48	110.26	-5.34

Table 3.22 Effects of data changes on CH_4 emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	20,435.55	20,435.55	0.143	0.143	0.00
1990	14,850.70	14,850.70	0.104	0.104	0.00
1991	17,517.60	17,517.60	0.123	0.123	0.00
1992	14,508.15	14,508.15	0.102	0.102	0.00
1993	5,535.97	5,535.97	0.039	0.039	0.00
1994	5,341.22	5,341.22	0.037	0.037	0.00
1995	4,291.56	4,291.56	0.030	0.030	0.00
1996	6,199.40	6,199.40	0.043	0.043	0.00
1997	14,132.26	14,132.26	0.099	0.099	0.00
1998	9,068.67	9,068.67	0.063	0.063	0.00
1999	9,028.16	9,028.16	0.063	0.063	0.00
2000	4,715.60	4,715.60	0.033	0.033	0.00
2001	4,231.14	4,231.14	0.029	0.029	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2002	4,308.85	4,308.85	0.030	0.030	0.00
2003	2,866.49	2,866.49	0.020	0.020	0.00
2004	1,745.97	1,745.97	0.012	0.012	0.00
2005	1,738.87	1,738.87	0.012	0.012	0.00
2006	1,697.26	1,697.26	0.012	0.012	0.00
2007	3,585.35	3,585.35	0.025	0.025	0.00
2008	3,263.50	3,263.50	0.021	0.021	0.00
2009	2,306.08	2,306.08	0.016	0.016	0.00
2010	2,493.39	2,493.39	0.017	0.017	0.00
2011	2,167.16	2,167.16	0.015	0.015	0.00
2012	1,817.86	1,817.86	0.013	0.013	0.00
2013	2,106.71	2,106.71	0.015	0.015	0.00
2014	1,583.64	1,583.64	0.011	0.011	0.01

Table 3.23 Effects of data changes on N_2O emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	20,435.55	20,435.55	0.041	0.041	0.000
1990	14,850.70	14,850.70	0.030	0.030	0.000
1991	17,517.60	17,517.60	0.035	0.035	0.000
1992	14,508.15	14,508.15	0.029	0.029	0.000
1993	5,535.97	5,535.97	0.011	0.011	0.000
1994	5,341.22	5,341.22	0.011	0.011	0.000

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1995	4,291.56	4,291.56	0.009	0.009	0.000
1996	6,199.40	6,199.40	0.012	0.012	0.000
1997	14,132.26	14,132.26	0.028	0.028	0.000
1998	9,068.67	9,068.67	0.018	0.018	0.000
1999	9,028.16	9,028.16	0.018	0.018	0.000
2000	4,715.60	4,715.60	0.009	0.009	0.000
2001	4,231.14	4,231.14	0.008	0.008	0.000
2002	4,308.85	4,308.85	0.009	0.009	0.000
2003	2,866.49	2,866.49	0.006	0.006	0.000
2004	1,745.97	1,745.97	0.003	0.003	0.000
2005	1,738.87	1,738.87	0.003	0.003	0.000
2006	1,697.26	1,697.26	0.003	0.003	0.000
2007	3,585.35	3,585.35	0.007	0.007	0.000
2008	3,263.50	3,263.50	0.006	0.006	0.000
2009	2,306.08	2,306.08	0.005	0.005	0.000
2010	2,493.39	2,493.39	0.005	0.005	0.000
2011	2,167.16	2,167.16	0.004	0.004	0.000
2012	1,817.86	1,817.86	0.004	0.004	0.000
2013	2,106.71	2,106.71	0.004	0.004	0.000
2014	1,583.64	1,583.64	0.003	0.003	0.055

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

Analysis will be continued with the collaborating institutions in order to have a fully correspondence concerning the quantities of the fuels.

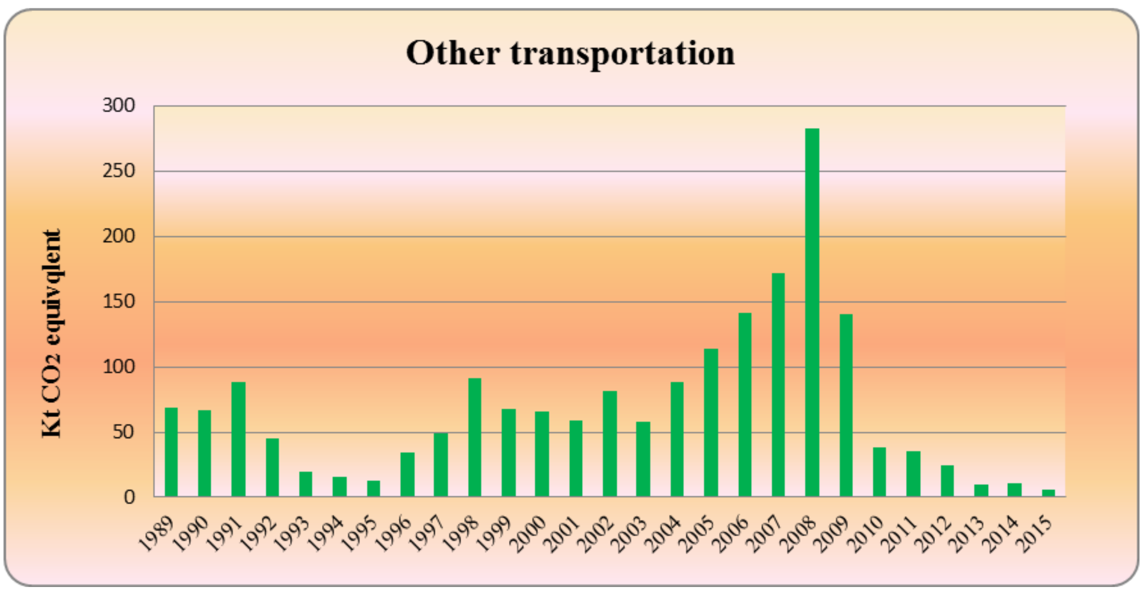
3.2.7.6 Other transportation- (CRF 1.A.3.e)

3.2.7.6.1 Category description

This sub-sector includes Pipeline Transport (1A.3.e.i) and Off-road Transport (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 2015 year the emissions from sub-sector Other Transortation represents 0.067% of total emissions from the transport sector (15,612.38 kt CO_2 equivalent).

Figure 3.48 The GHG emissions from 1A3e – Other transportation category



3.2.7.6.2 Methodological issues

The GHG emissions from Other Transportation are calculated according to 2006 IPCC Guidelines and IPCC good practice guidance.

The Tier1 and Tier 2 method was used and are presented in the section 3.2.7.4.2.

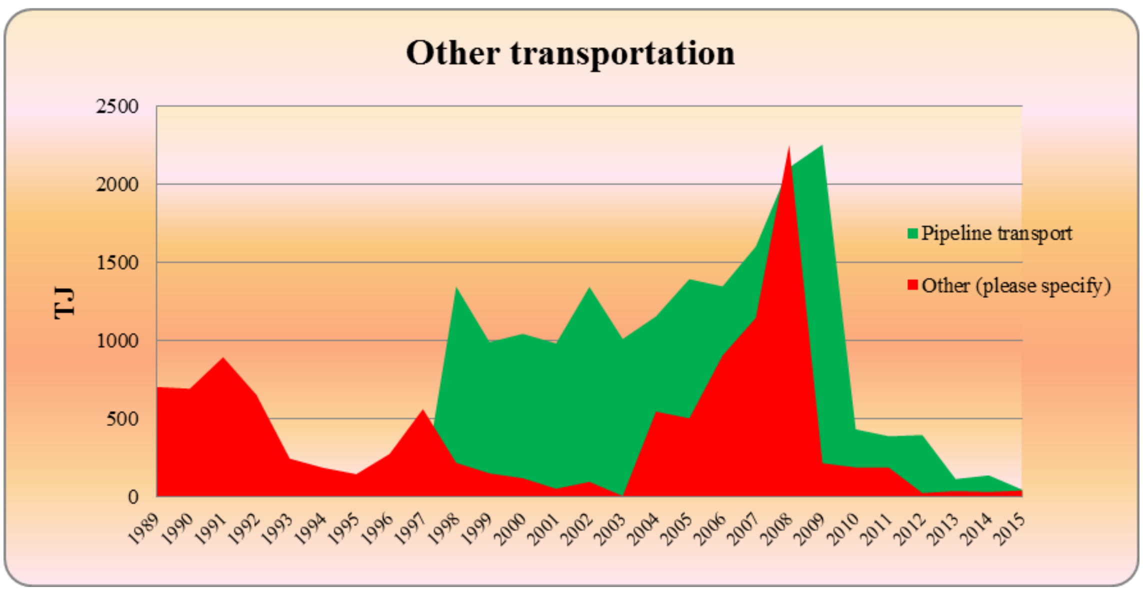
Emission Factors

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 NOx, emission factors are default and in according to2006 IPCC Guidelines. The values of CO, NMVOC, SO_2 emission factors are default and in according to2006 IPCC Guidelines, IPCC 1996 Guidelines and EMEP/EEA guidebook 2009.

Activity Data

The activity data for Other transportation(1.A.3.e) are provided by IEA/Eurostat Questionnaire.

Figure 3.49 Fuel consumption 1.A.3.c Other transportation 1989 -2015



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: 3.0%
  - Solid: 3.0%
  - Gaseous: 3.0%
  - Biomass: 3.0%
- ***emision factors:***
  - Liquid: 3%
  - Solid: 4.0%
  - Gaseous:2 %
  - Biomass: 20%
  - 3% liquid ,2% 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 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

CH_4

- ***activity data:***
  - Liquid: 3.0%
  - Solid: 3.0%
  - Gaseous:3.0%
  - Biomass: 3.0%
- ***emision factors:***
  - Liquid: 50%
  - Solid: 50%
  - Gaseous:50 %
  - Biomass: 50%
  - 50% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

N_2O

- ***activity data*:**
  - Liquid: 3.0%
  - Solid: 3.0%
  - Gaseous: 3.0%
  - Biomass: 3.0%
- ***emision factors:***
  - Liquid: 50%
  - Solid: 50%
  - Gaseous:50 %
  - Biomass: 50%
  - 50% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency-University of Graz consortium; additional information are included in Annex6.3.

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 Fugitive emissions 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. 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 witht national emission factors values specific to Bulgaria, considering that similar energy activities are implemented. Further elements are presented within Annex 6.3.

3.2.7.6.5 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:

❖ ***emissions:***

- ✓ Other Transportation (1.A.3.e.) category: the CO_2 emission value for 2004 have been updated due to a tehnical erorr of the CRF Reporter;
- ✓ Other Transportation (1.A.3.e.) category: the CO_2 emission values for 2012, 2013 and 2014 have been updated because the Country Specific Emission Factor values for 2012, 2013 and 2014 have been updated

Table 3.24 Effects of data changes on CO_2 emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CO_2 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	710.37	710.37	67.51	67.51	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CO_2 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1990	700.39	700.39	65.69	65.69	0.00
1991	900.42	900.42	86.40	86.40	0.00
1992	658.57	658.57	44.51	44.51	0.00
1993	293.47	293.47	19.19	19.19	0.00
1994	234.32	234.32	15.90	15.90	0.00
1995	195.13	195.13	13.09	13.09	0.00
1996	495.53	495.53	34.22	34.22	0.00
1997	609.72	609.72	48.58	48.58	0.00
1998	1,566.23	1,566.23	90.37	90.37	0.00
1999	1,145.13	1,145.13	67.43	67.43	0.00
2000	1,167.09	1,167.09	65.26	65.26	0.00
2001	1,038.88	1,038.88	58.39	58.39	0.00
2002	1,443.56	1,443.56	81.46	81.46	0.00
2003	1,020.55	1,020.55	58.20	58.20	0.00
2004	1,704.36	1,704.36	106.32	78.18	-26.47
2005	1,898.19	1,898.19	113.25	113.25	0.00
2006	2,252.56	2,252.56	140.06	140.06	0.00
2007	2,746.99	2,746.99	169.79	169.79	0.00
2008	4,353.77	4,353.77	278.28	278.28	0.00
2009	2,470.93	2,470.93	140.32	140.35	0.02
2010	626.44	626.44	37.83	37.83	0.00
2011	580.62	580.62	35.30	35.30	0.00
2012	426.79	426.79	24.17	24.17	0.00
2013	158.14	158.14	9.45	9.45	0.00
2014	176.85	176.85	10.40	10.40	0.00

Table 3.25 Effects of data changes on CH_4 emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	710.37	710.37	0.022	0.022	0.00
1990	700.39	700.39	0.021	0.021	0.00
1991	900.42	900.42	0.027	0.027	0.00
1992	658.57	658.57	0.008	0.008	0.00
1993	293.47	293.47	0.004	0.004	0.00
1994	234.32	234.32	0.003	0.003	0.00
1995	195.13	195.13	0.001	0.001	0.00
1996	495.53	495.53	0.006	0.006	0.00
1997	609.72	609.72	0.015	0.015	0.00
1998	1,566.23	1,566.23	0.008	0.008	0.00
1999	1,145.13	1,145.13	0.007	0.007	0.00
2000	1,167.09	1,167.09	0.003	0.003	0.00
2001	1,038.88	1,038.88	0.003	0.003	0.00
2002	1,443.56	1,443.56	0.005	0.005	0.00
2003	1,020.55	1,020.55	0.002	0.002	0.00
2004	1,704.36	1,704.36	0.009	0.009	0.00
2005	1,898.19	1,898.19	0.017	0.017	0.00
2006	2,252.56	2,252.56	0.032	0.032	0.00
2007	2,746.99	2,746.99	0.038	0.038	0.00
2008	4,353.77	4,353.77	0.075	0.075	0.00
2009	2,470.93	2,470.93	0.008	0.008	0.02
2010	626.44	626.44	0.007	0.007	0.00
2011	580.62	580.62	0.007	0.007	0.00
2012	426.79	426.79	0.001	0.001	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for CH_4 [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2013	158.14	158.14	0.001	0.001	0.00
2014	176.85	176.85	0.001	0.001	0.00

Table 3.26 Effects of data changes on N_2O emissions level

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	710.37	710.37	0.0027	0.0027	0.00
1990	700.39	700.39	0.0027	0.0027	0.00
1991	900.42	900.42	0.0035	0.0035	0.00
1992	658.57	658.57	0.0009	0.0009	0.00
1993	293.47	293.47	0.0004	0.0004	0.00
1994	234.32	234.32	0.0003	0.0003	0.00
1995	195.13	195.13	0.0002	0.0002	0.00
1996	495.53	495.53	0.0009	0.0009	0.00
1997	609.72	609.72	0.0018	0.0018	0.00
1998	1,566.23	1,566.23	0.0008	0.0008	0.00
1999	1,145.13	1,145.13	0.0008	0.0008	0.00
2000	1,167.09	1,167.09	0.0003	0.0003	0.00
2001	1,038.88	1,038.88	0.0003	0.0003	0.00
2002	1,443.56	1,443.56	0.0005	0.0005	0.00
2003	1,020.55	1,020.55	0.0003	0.0003	0.00
2004	1,704.36	1,704.36	0.0024	0.0024	0.00
2005	1,898.19	1,898.19	0.0018	0.0018	0.00

Year	Changes at AD level (TJ)		Effects of changes on emission estimates for N_2O [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2006	2,252.56	2,252.56	0.0031	0.0031	0.00
2007	2,746.99	2,746.99	0.0039	0.0039	0.00
2008	4,353.77	4,353.77	0.0074	0.0074	0.00
2009	2,470.93	2,470.93	0.0010	0.0010	0.17
2010	626.44	626.44	0.0007	0.0007	0.00
2011	580.62	580.62	0.0006	0.0006	0.00
2012	426.79	426.79	0.0001	0.0001	0.00
2013	158.14	158.14	0.0001	0.0001	0.00
2014	176.85	176.85	0.0001	0.0001	0.00

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

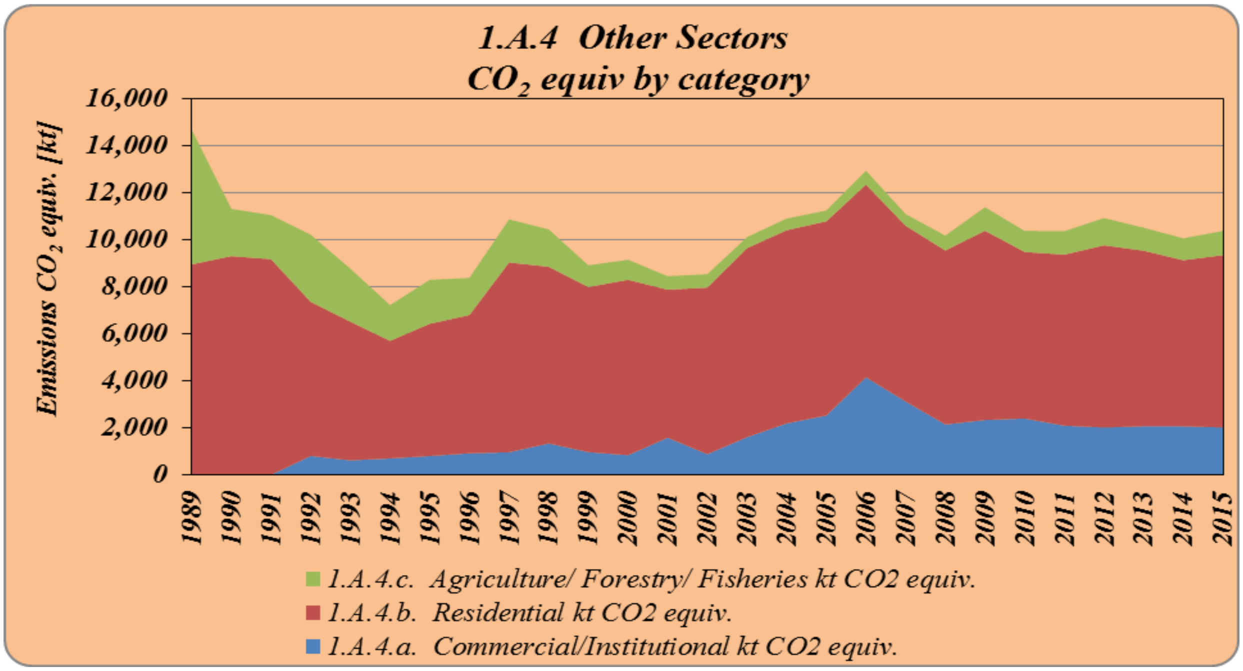
Analysis will be continued with the collaborating institutions in order to have a fully correspondence concerning the quantities of the fuels.

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 gaseous fuel – level and trend, excluding and including LULUCF, CO_2 key category by solid fuel - trend, excluding and including LULUCF, CO_2 key category by liquid fuels – level, excluding and including LULUCF and is a CH_4 key category by biomass – level and trend, excluding and including LULUCF.

Figure 3.50 GHG emissions from 1.A.4. – Other, by category

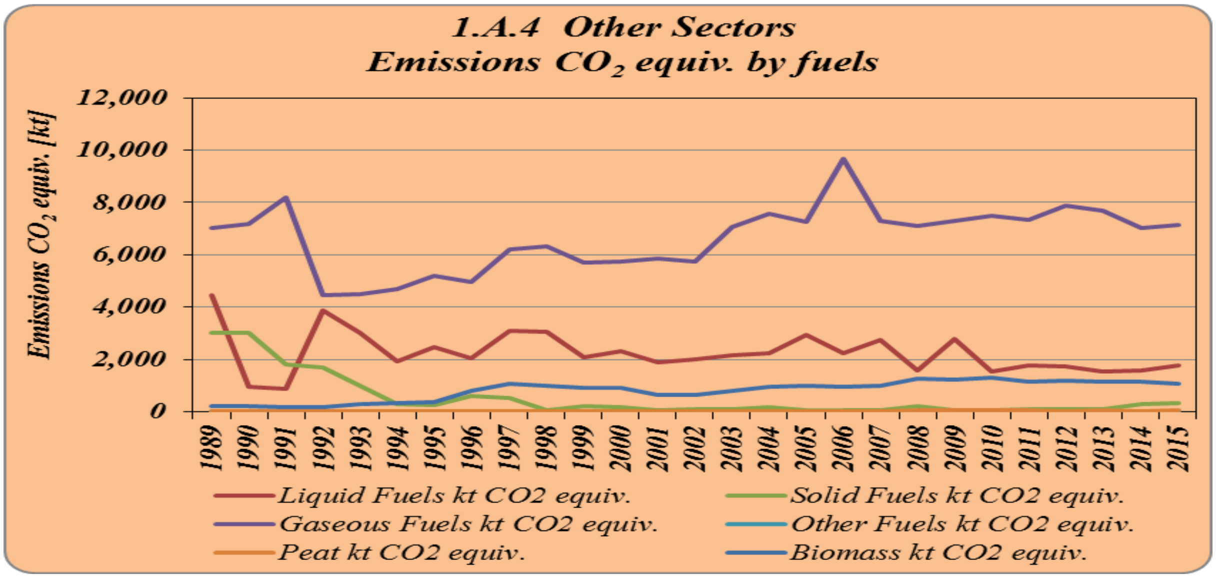


The fuel consumption in the following subcategories is included in this category:

- ❖ 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.

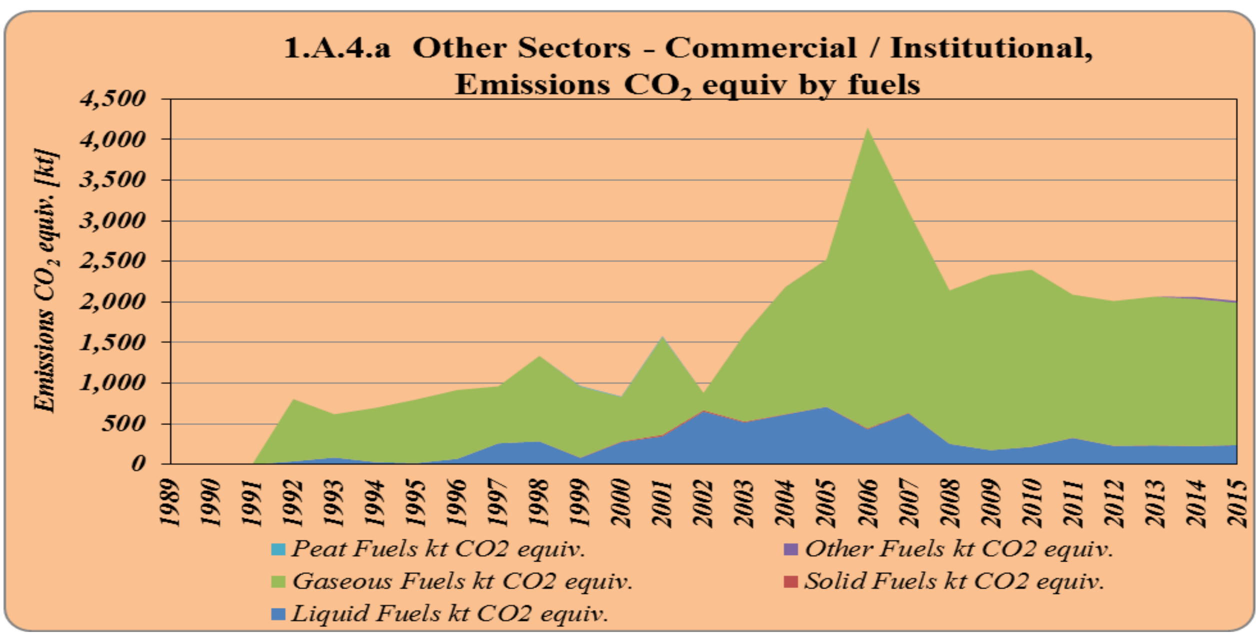
Figure 3.51 GHG emissions from 1.A.4. – Other, by fuels



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

3.2.8.2.1 Category description

Figure 3.52 GHG emissions from 1.A.4.a – Commercial / Institutional, by fuels



The share of the total GHG emissions from the 1.A.4.a category to the 1.A.4 sub-sector is about 19.41 %, current year, 2015. The reporting of combustion on this category started with the 1992 year. The contribution of this category is about 2,014.25 kt CO_2 equiv., in 2015. It is observed a main contribution of the natural gas usage as fuel in this activity category, mostly on the period 2003 - 2012.

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 sectoral expert administrating the 1.B - Fugitive Emission sector. 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

No recalculations were performed due to the activity data changes. For more details and effect of the activity data changes on the emissions estimation, see the chapter 3.2.4.5.

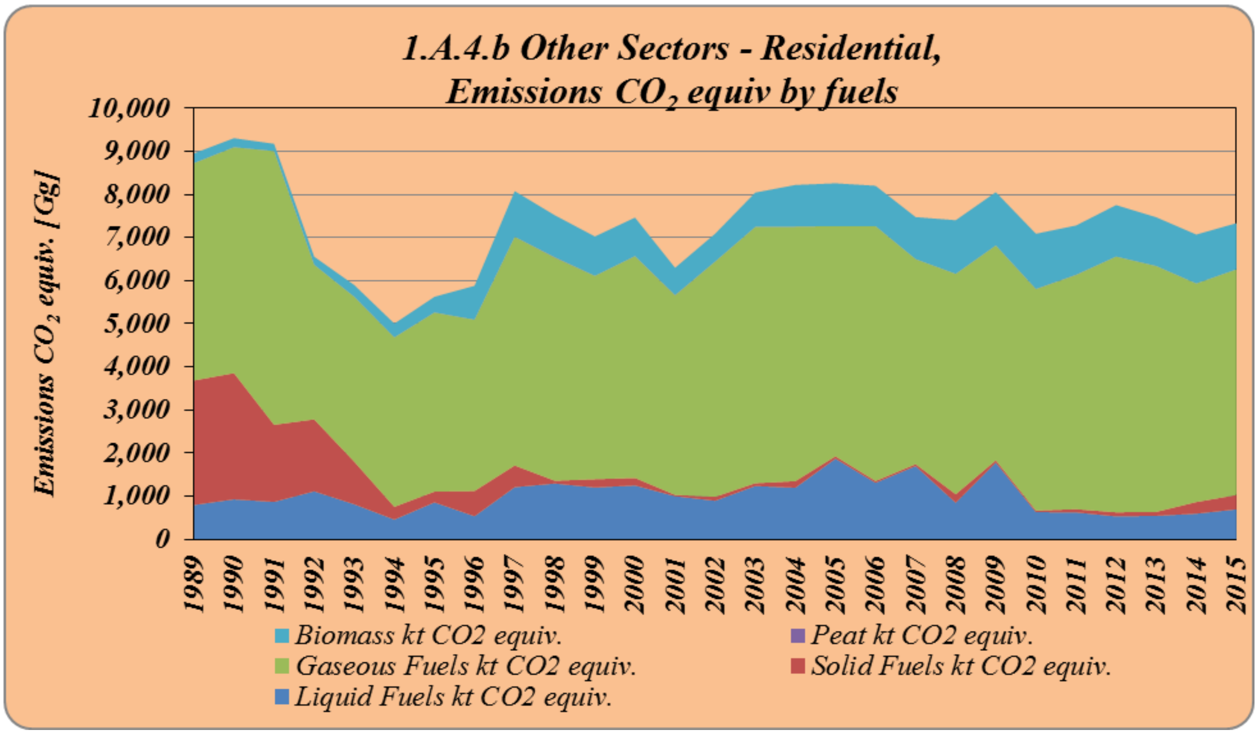
3.2.8.2.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

See the Chapter 3.2.4.6 for more details.

3.2.8.3 Fuel combustion, Other Sectors – Residential (CRF 1.A.4.b)

3.2.8.3.1 Category description

Figure 3.53 GHG emissions from 1.A.4.b – Residential, by fuels



The share of the total GHG emissions of the 1.A.4.b category to the 1.A.4 sub-sector is about 60.99% - base year to the 70.67%, current year, 2015. The contribution of this category is about 7,334.14 kt CO_2 equiv., in 2015. 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 (CH_4 and N_2O accounted).

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. 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.

3.2.8.3.3 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 1.B - Fugitive Emission sector. 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

No recalculations were performed due to the activity data changes. 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

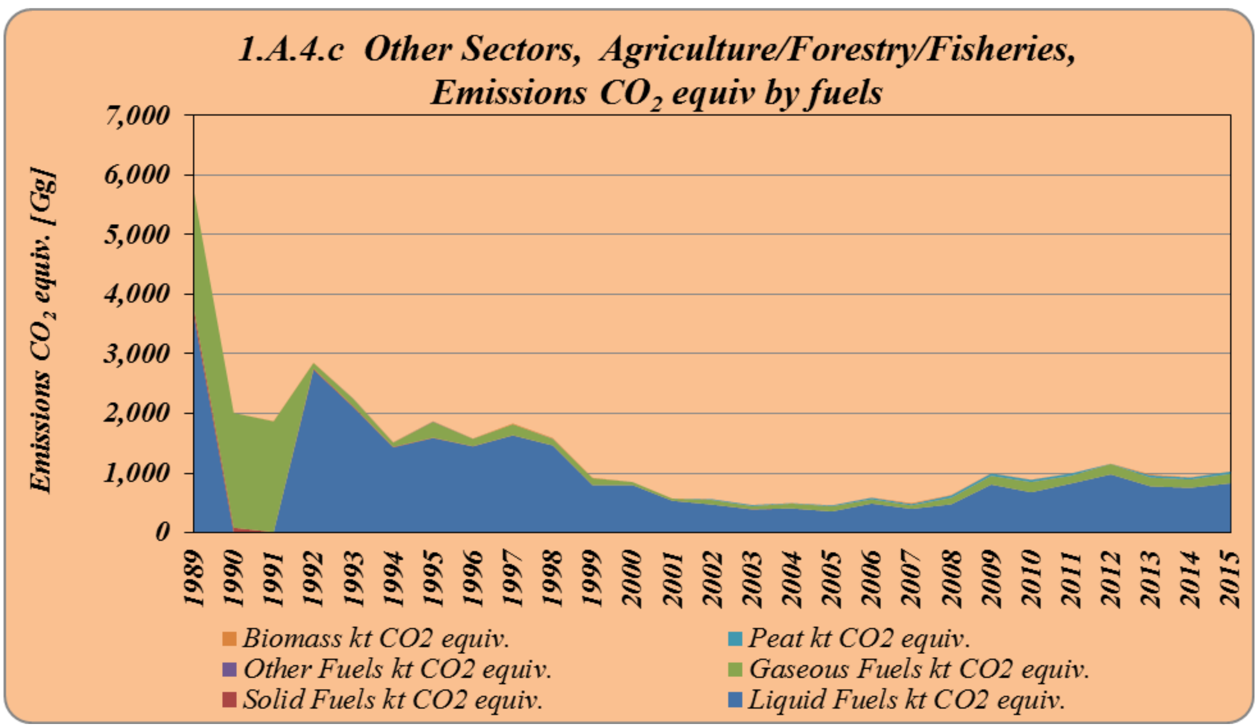
See the Chapter 3.2.4.6 for more details.

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.).

Figure 3.54 GHG emissions from 1.A.4.c – Agriculture/Forestry/Fisheries, by fuels



The share of the total GHG emissions of the 1.A.4.c category to the 1.A.4 sub-sector is about 39.01% - base year to the 9.92 %, current year, 2015. The contribution of this category is about

1,029.99 kt CO_2 equiv., in 2015. It is observed a main contribution of the liquid fuel combustion in this activity category, on the entire time-series.

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 1.B - Fugitive Emission sector. 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

No recalculations were performed due to the activity data changes. 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

See the chapter 3.2.4.6 for more details.

3.2.9 Fuel combustion, Other Sectors (Not specified elsewhere) - Stationary (CRF 1.A.5.a)

3.2.9.1 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.).

3.2.9.2 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 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.

3.2.9.3 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.

3.2.9.4 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 1.B - Fugitive Emission sector. See the chapter 3.2.4.4 for more details.

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

No recalculations were performed for the current submission.

3.3 Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production (CRF 1.B)

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.

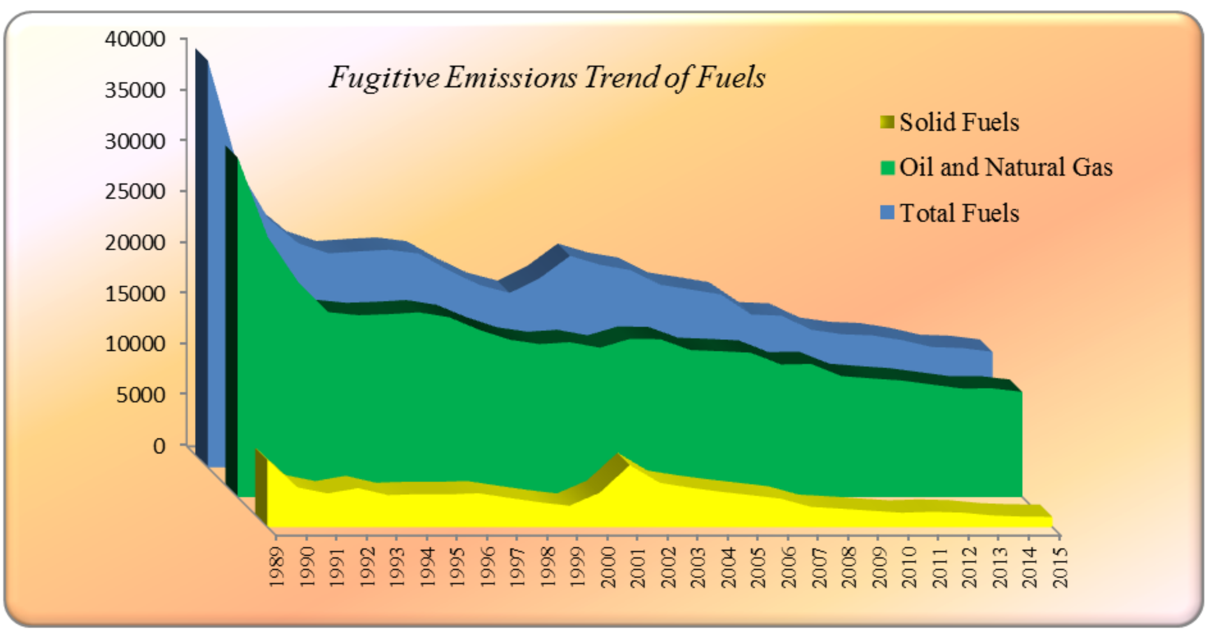
In 2015 GHG emissions from the Fugitive Emissions from Fuels. Subsector accounted for 11,350.48 kt CO_2 equivalent, which represent 9.75% of the total national GHG emissions in this year. In the base year, the total GHG emissions from the Fugitive Emissions from Fuels Subsector amounted to 39,967.51 kt CO_2 equivalent, which represent 13.26% of the total national GHG emissions in this year (see in the table below).

Table 3.27 The contribution of Fugitive Emissions from Fuels Subsector emissions to the total GHG in Romania, for 1989–2015 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	301,359.00	39,967.51	13.26
1990	246,271.86	29,442.90	11.96
1991	203,183.45	24,481.97	12.05
1992	187,102.76	22,013.90	11.77
1993	177,799.21	21,025.41	11.83
1994	174,505.21	21,228.50	12.16
1995	181,112.91	21,385.52	11.81
1996	183,883.61	21,004.56	11.42
1997	171,745.73	19,327.60	11.25
1998	152,203.29	17,926.19	11.78
1999	134,361.24	17,141.81	12.76
2000	140,163.06	18,603.45	13.27
2001	147,244.17	20,781.37	14.11
2002	145,935.95	19,901.17	13.64
2003	150,525.60	19,396.21	12.89
2004	149,161.45	17,937.13	12.03

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 [%]
2005	146,454.48	17,486.17	11.94
2006	147,841.16	16,991.76	11.49
2007	150,878.01	15,021.93	9.96
2008	145,828.88	14,905.46	10.22
2009	126,571.89	13,519.98	10.68
2010	120,899.59	13,087.35	10.82
2011	126,992.67	12,975.63	10.22
2012	124,418.24	12,504.69	10.05
2013	115,389.18	11,825.55	10.25
2014	115,413.20	11,724.80	10.16
2015	116,426.73	11,350.48	9.75

Figure 3.55 Total GHG emissions from Fugitive Emissions from Fuels Subsector for 1989–2015 period



Mostly GHG emissions are resulting from Oil and Natural Gas category, responsible for 91.15 % of total GHG emissions from Fugitive Emissions subsector, Solid Fuels category contributes with 8.85 %.

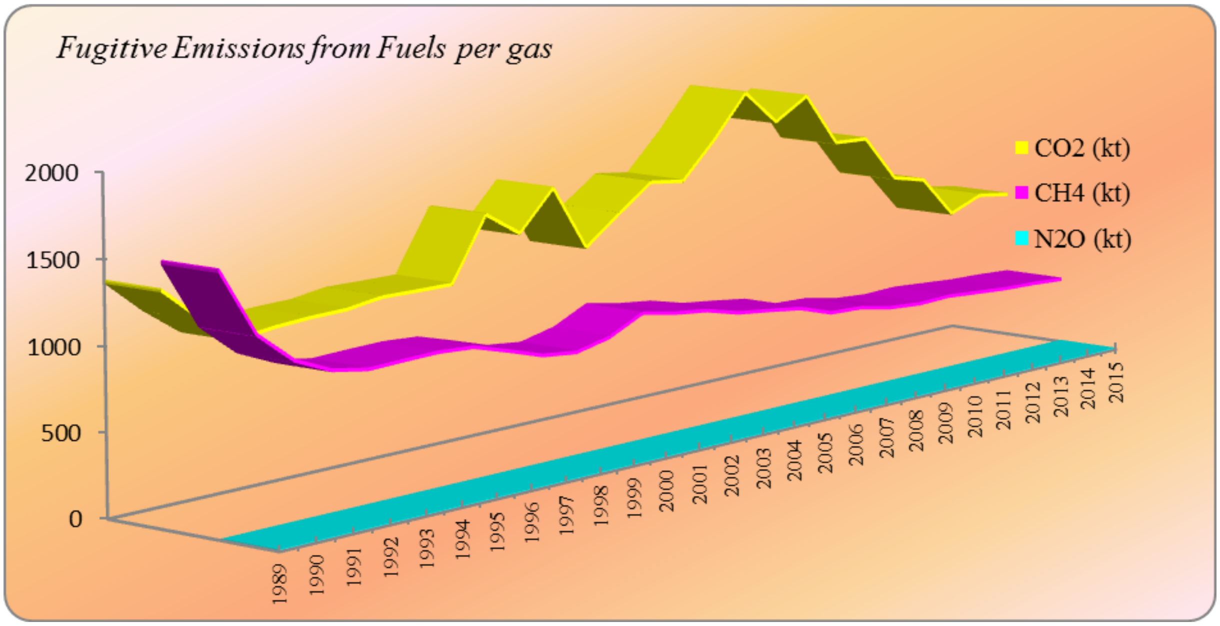
GHG emissions from *Oil and Natural G*as and *Solid Fuels* are key category sources: by level and trend for CH_4 emissions from Solid Fuels source category, level and trend for CH_4 and CO_2 emissions from *Oil and Natural Gas* source category, from *Oil* sub-source category, level and trend for CH_4 emissions from *Oil and Natural Gas* source category, from *Natural Gas* sub-source category, level and trend for CH_4 from *Venting and Flaring* sub-source category and from *Other* sub-source category (see Table 3.3).

Table 3.28 GHG emissions from Fugitive Emissions from Fuels Subsector, per gas, and contribution of these in total GHG emissions from Fugitive Emissions from Fuels Subsector, for the 1989 – 2015 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	39,967.51	38,585.87	96.54	1,377.53	3.45	4.12	0.010
1990	29,442.90	28,262.78	95.99	1,176.62	4.00	3.49	0.012
1991	24,481.97	23,470.52	95.87	1,008.45	4.12	3.00	0.012
1992	22,013.90	20,975.36	95.28	1,035.47	4.70	3.07	0.014
1993	21,025.41	19,972.94	94.99	1,049.36	4.99	3.11	0.015
1994	21,228.50	20,171.08	95.02	1,054.30	4.97	3.11	0.015
1995	21,385.52	20,297.07	94.91	1,085.35	5.08	3.10	0.014
1996	21,004.56	19,920.69	94.84	1,080.82	5.15	3.05	0.015
1997	19,327.60	18,246.34	94.41	1,078.26	5.58	2.99	0.015

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.	%
1998	17,926.19	16,464.34	91.85	1,458.95	8.14	2.91	0.016
1999	17,141.81	15,832.16	92.36	1,306.81	7.62	2.84	0.017
2000	18,603.45	17,056.11	91.68	1,544.54	8.30	2.80	0.015
2001	20,781.37	19,638.43	94.50	1,140.17	5.49	2.77	0.013
2002	19,901.17	18,588.41	93.40	1,309.58	6.58	3.18	0.016
2003	19,396.21	17,925.59	92.42	1,467.53	7.57	3.09	0.016
2004	17,937.13	16,498.16	91.98	1,436.42	8.01	2.55	0.014
2005	17,486.17	15,822.93	90.49	1,660.71	9.50	2.53	0.014
2006	16,991.76	15,069.47	88.69	1,919.81	11.30	2.48	0.015
2007	15,021.93	13,316.55	88.65	1,703.19	11.34	2.18	0.015
2008	14,905.46	13,071.52	87.70	1,831.83	12.29	2.10	0.014
2009	13,519.98	12,019.70	88.90	1,498.29	11.08	1.99	0.015
2010	13,087.35	11,598.72	88.63	1,486.73	11.36	1.90	0.015
2011	12,975.63	11,777.13	90.76	1,196.61	9.22	1.88	0.015
2012	12,504.69	11,357.03	90.82	1,145.89	9.16	1.78	0.014
2013	11,825.55	10,936.54	92.48	887.18	7.50	1.82	0.015
2014	11,724.80	10,754.01	91.72	969.00	8.26	1.79	0.015
2015	11,350.48	10,412.19	91.73	936.52	8.25	1.78	0.016

Figure 3.56 GHG emissions from Fugitive Emissions from Fuels Subsector, per gas



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.

3.3.1 Solid Fuels (CRF 1.B.1)

3.3.1.1 Category description

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

❖ "Coal Mining and Handling", "Solid Fuel Transformation" and "Other".

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

❖ Emission: CH_4;
❖ Key source: Yes.

The sub-source category "Coal Mining and Handling" is a key source of CH_4 emissions in terms of both emissions level and trend.

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 lignite brown 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 1990-2015 periods.

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 2011–2015 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 economy revitalization.

In 2006, a reduction of primary energy production was registered, except for lignite and 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 2011 there was an increase in coal resources (excluding coke) compared to 2010, along with the decrease of oil, hydro energy and natural gas resources.

In 2012, there were an decrease in coal resources (excluding coke) (-5,4% compared to 2011) and lignite and brown coal (-4% compared to 2011), along with the increase of imports of coal (including coke) (+12,2% compared to 2011).

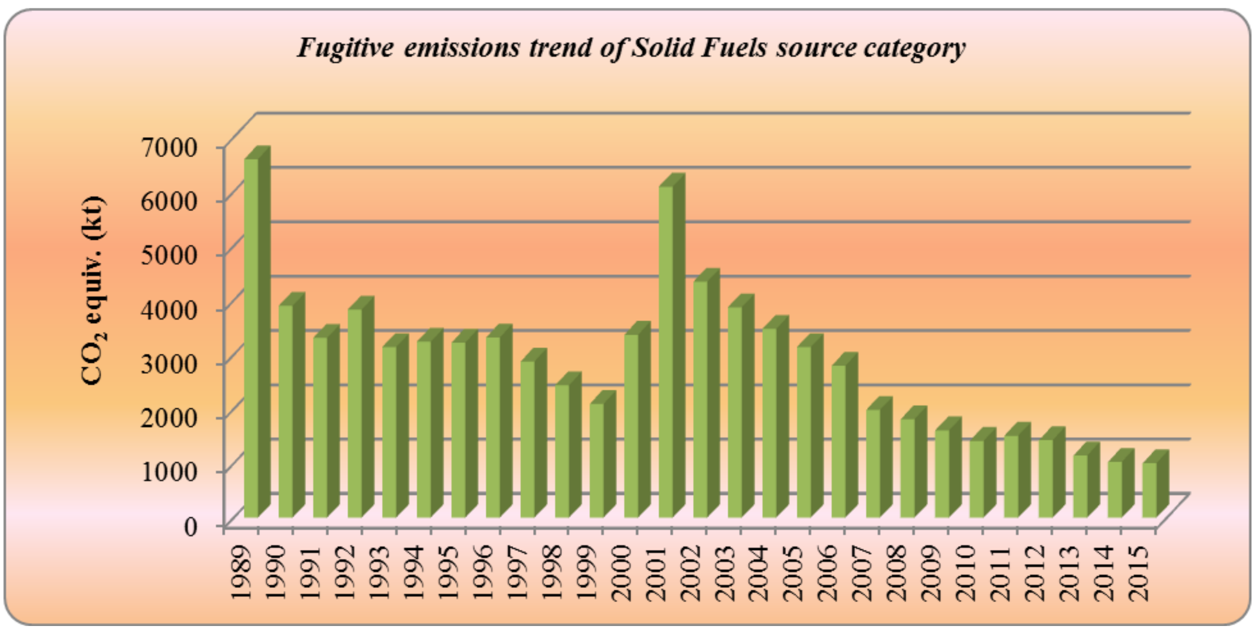
In 2013 continued the decrease of coal resources (-1.786 million toe).

In 2014 the coal resources decreased by 5.3% (-324 000 toe), while imports of coking coal fell by almost a trivial amount of 14 000 toe (-47 000 toe, representing -77.0%).

In 2015 there were increases of 5.9% (4,711,000 toe) of the coal production (excluding coke) and at the imports of coal and coke (86,000 toe, representing + 8.9%) compared to 2014. (Source – Romanian National Institute for Statistics).

The trend of the CH_4 emissions from solid fuels category is shown in the figure below.

Figure 3.57 Fugitive Emissions of CH_4 from Solid Fuels (1.B.1)



3.3.1.2 Methodological issues

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

- Emission: CH_4;
- Key source: Yes.

Underground mines (1.B.1.a.i.)

- *Mining activities ((1.B.1.a.i.1);*
- *Post mining activities (1.B.1.a.i.2.)*
- *Abandoned Underground Mines (1.B.1.a.i.3.).*

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

Statistical data available and activity data assumptions from National Institute for Statistics (NIS) and Institute for Studies and Power Engineering (ISPE) study indicates that in Romania the shares of underground-mined coal and surface mined coal are the following: hard coal and 15% of the lignite (including brown coal) is extracted from underground mines and 85% of the lignite (including brown coal) is extracted from surface mines.
The activity data include:
1989_BAL_Romania have been used for 1989, and IEA/ Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

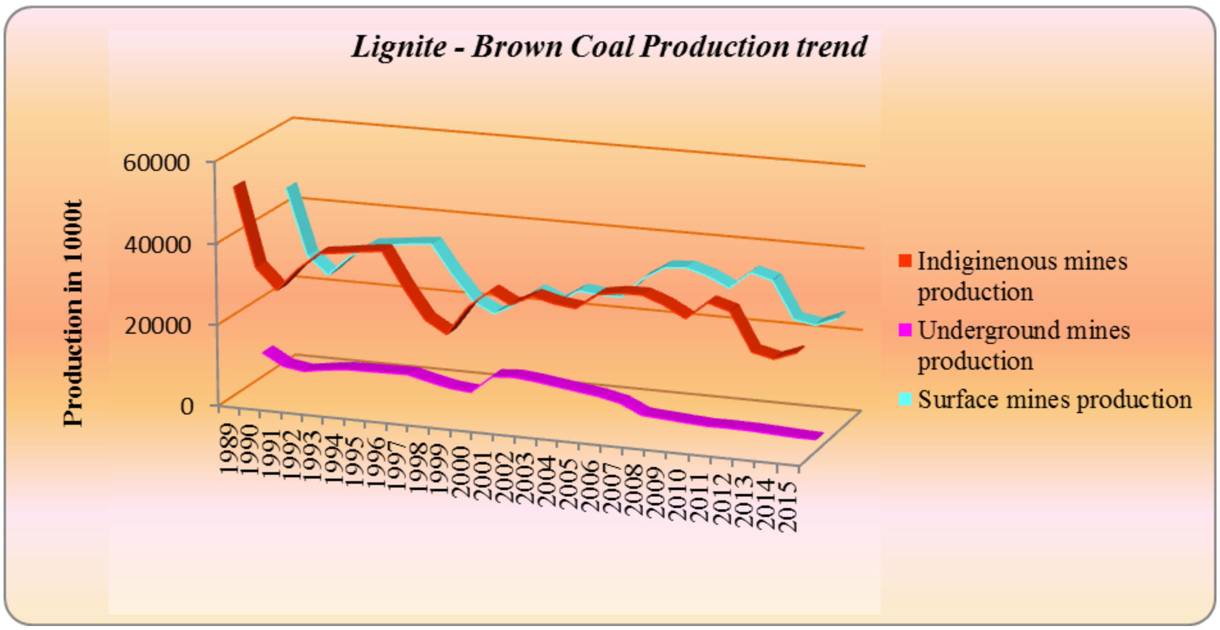
- *Underground Coal Production (Mt):* IEA/Eurostat Questionnaire 2015 - Indigenous Production (Anthracite – 100 %, Coking Coal – 100 %, Other Bituminous Coal - 100 %, Sub-bituminous Coal - 100 %, Peat - 100 %, Lignite/Brown Coal - 15 % for 1989-1999 time series and Lignite/Brown Coal - 100 % for 2000-2015 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 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 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 3.58 Lignite – Brown Coal Production trend



Abandoned Underground Mines (1.B.1.a.i.3.)

The emissions from *Abandoned underground mines* were estimated according with the Mining Industry Strategy, the data used to estimate of emissions of pit coal mines are from CNH Petrosani company utterly, for the lignite underground mines the data used to estimate of emissions are 5% of all mines closed from the S.N.L.O. Tg. Jiu and S.N.C. Ploiesti companies.

Methodology

Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors for the *Abandoned Underground Mines* reporting are used. The formula used in the calculations is *Equation 4.1.10* from 2006 IPCC GL, volume 2, chapter 4.1.5.1., page 4.21.

Activity Data

Emissions from abandoned mines were approximated based on the data of the table on page 15 of the Mining Industry Strategy:
http://www.minind.ro/resurse_minerale/Strategia_Industriei_Miniere_2012_2035.pdf.
According with this table the data used to calculate emissions of abandoned mines are those of the company CNH Petrosani; only to this company are accounted for underground mines for coal extraction; the other companies dealing with extraction of lignite from surface mines; with extraction of uranium, salt and other mineral resources.

Emission factor

- *Default values - percentage of coal mines that are gassy* from 2006 IPCC GL, volume 2, chapter 4.1.3.2, page 4.24, Table 4.1.5;
- *Default Emission Factor*: Tier 1 Abandoned Underground Mines from 2006 IPCC GL, volume 2, chapter 4.1.3.2, page 4.25, Table 4.1.6.

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 3.59 Underground Mines category and Solid Fuel Transformation category emissions trend

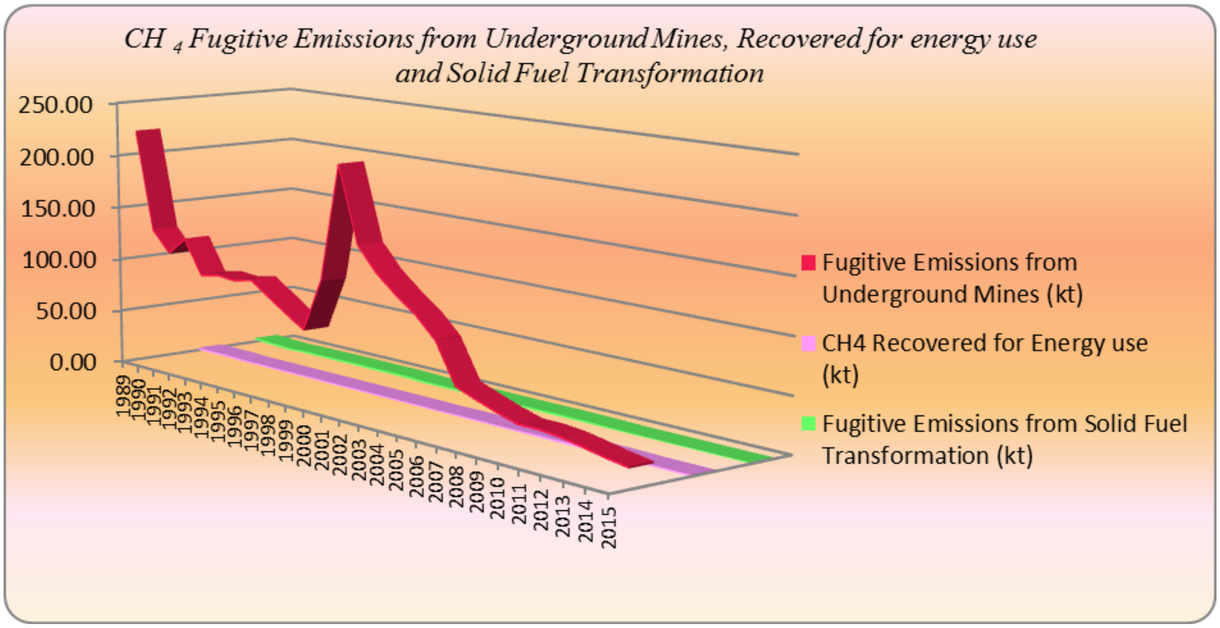


Table 3.29 Fugitive Emissions of CH_4 from Underground Mines and CH_4 Recovered for energy use

Year	Underground mines	
	CH_4 fugitive emissions (kt)	CH_4 Recovered for energy use (kt)
1989	221.92	1.36
1990	129.32	1.25
1991	110.31	1.25
1992	126.31	0.58
1993	95.61	0.58
1994	98.89	0.58
1995	97.54	0.58
1996	101.13	0.58
1997	89.52	0.58
1998	77.61	0.45

Year	Underground mines	
	CH_4 fugitive emissions (kt)	CH_4 Recovered for energy use (kt)
1999	66.76	0.45
2000	115.30	0.45
2001	220.96	0.45
2002	152.72	0.45
2003	131.29	0.19
2004	115.97	0.53
2005	102.45	0.59
2006	84.29	0.50
2007	48.91	0.58
2008	42.00	0.91
2009	35.57	0.95
2010	30.12	1.02
2011	30.14	0.93
2012	28.27	0.76
2013	24.81	0.37
2014	20.94	0.49
2015	17.99	0.55

Surface mines (1.B.1.a.ii)

- *Mining activities (1.B.1.a.ii.1);*
- *Post mining activities (1.B.1.a.ii.2.).*

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 2006 IPCC GL, volume 2, chapter 4.1.4., page 4.18.

Activity Data

Consequence of the fact that values of the production of lignite (including the brown coal) for the period 1990-1999 were not available in the Eurostat/IEA data, the data were obtained by extrapolating existing data series, by applying a fraction of 0.85 to total amount of lignite extracted (according with the explanation of lignite production in Romania supplied by the study which indicates that in Romania the shares of underground-mined coal and surface mined coal are the following: hard coal and 15% of the lignite (including brown coal) is extracted from underground mines and 85% of the lignite (including brown coal) is extracted from surface mines).

For the 1989-1999 period: *Surface Coal Production (Mt):* IEA/Eurostat Questionnaire 2015 - Indigenous Production (Lignite/Brown Coal - 85 %)

For the 2000 – 2015 period: *Surface Coal Production (Mt):* IEA/Eurostat Questionnaire 2015 - Indigenous Production (Lignite/Brown Coal - 100 %).

Emissions Factor

- *Default Emission Factor*: from 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 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 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).

3.3.1.2.2 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 2015- for entire 1990-2015 time series have been used.

- *Coking Coal Production (Mt):* IEA/Eurostat Questionnaire 2015– 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.

3.3.1.3 Uncertainties and time-series consistency

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

- ***Coal Mining and Handling sub-source category***
  - AD: 5%;
  - EF:
    - CO_2: 200%;
    - CH_4: 200%;
    - 200.06 % 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 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

- ***Solid Fuel Transformation sub-source category***
  - 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 3.2.8 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 2015 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 1989-2015 is consistent.

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

All quality control activities described in the QA/QC Programme were performed. A cross-checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the *Stationary Combustion* categories, 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 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.

3.3.1.5 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:

The implications of all changes made on emission estimates are described in the following table:

Table 3.30 Change made at activity data and their effects on CH_4 emission estimates Sub-sector 1.B 1. - Solid Fuels

Year	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	263.88	263.88	0.00
1990	155.97	155.97	0.00
1991	132.39	132.39	0.00
1992	153.19	153.19	0.00
1993	125.67	125.67	0.00
1994	129.58	129.58	0.00
1995	128.93	128.93	0.00
1996	132.74	132.74	0.00
1997	114.95	114.95	0.00
1998	97.59	97.59	0.00
1999	83.74	83.74	0.00

Year	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2000	134.69	134.69	0.00
2001	243.65	243.65	0.00
2002	173.63	173.63	0.00
2003	154.90	154.90	0.00
2004	139.10	139.10	0.00
2005	125.66	125.66	0.00
2006	111.88	111.88	0.00
2007	79.30	79.30	0.00
2008	72.52	72.52	0.00
2009	64.36	64.36	0.00
2010	56.54	56.54	0.00
2011	60.33	60.33	0.00
2012	57.18	57.18	0.00
2013	45.88	45.88	0.00
2014	41.20	41.20	0.00

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

No source-specific planned improvements are envisaged.

3.3.2 Oil and natural gas and other emissions from energy production(CRF 1.B.2)

3.3.2.1 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 oil-pools deposits are limited on the terms in which were not identified new oil-pools deposits having an important potentially. Oil reserves in Romania have an estimated potential of about 74 million tones.

The National Society of Oil, PETROM S.A., has the exclusive right to extract oil from all of the Romanian oil-fields.

The most important companies of the fuel distribution in Romania are: OMV (PETROM), LUKOIL, ROMPETROL and MOL. In 2006, in Romania there were a total of 2,140 gas-stations.

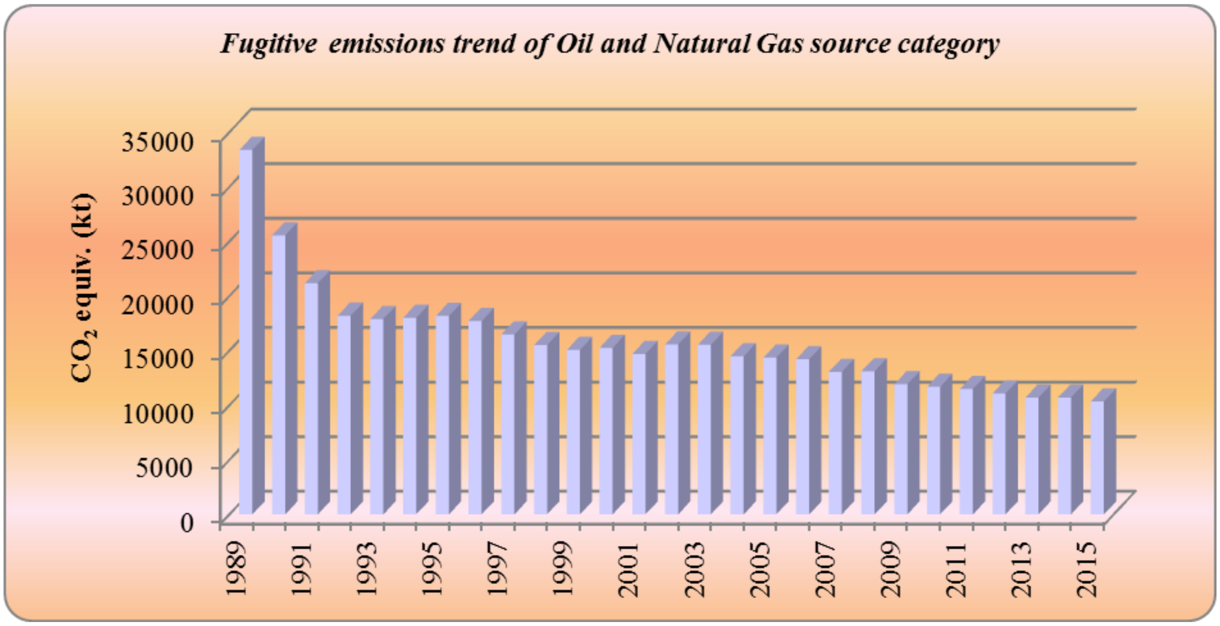
According to the estimations of the 2007, the Romania’s natural gas pools reseves are limited and they were estimated at about 185 billions cubic metters taking into account of the domestic production decline.

According to the Romanian National Energy Regulatory Agency (ANRE) for repports of 2010, the domestic production of the natural gas was dominated by ROMGAZ S.A. with about 53.4 %, followed by OMV PETROM with 44.44 %; this production of the oil, ”coveres” of about 82.84 % of the total consumption, the rest being covered by import.

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 12585 km of the transporting pipelines and of the feeding points plus over 553 km of pipelines also for the international transit.

The information regarding the methane gas distribution is monitorized by the Romanian National Energy Regulatory Agency (ANRE).

Figure 3.60 Total GHG Oil and Natural Gas source category emissions trend



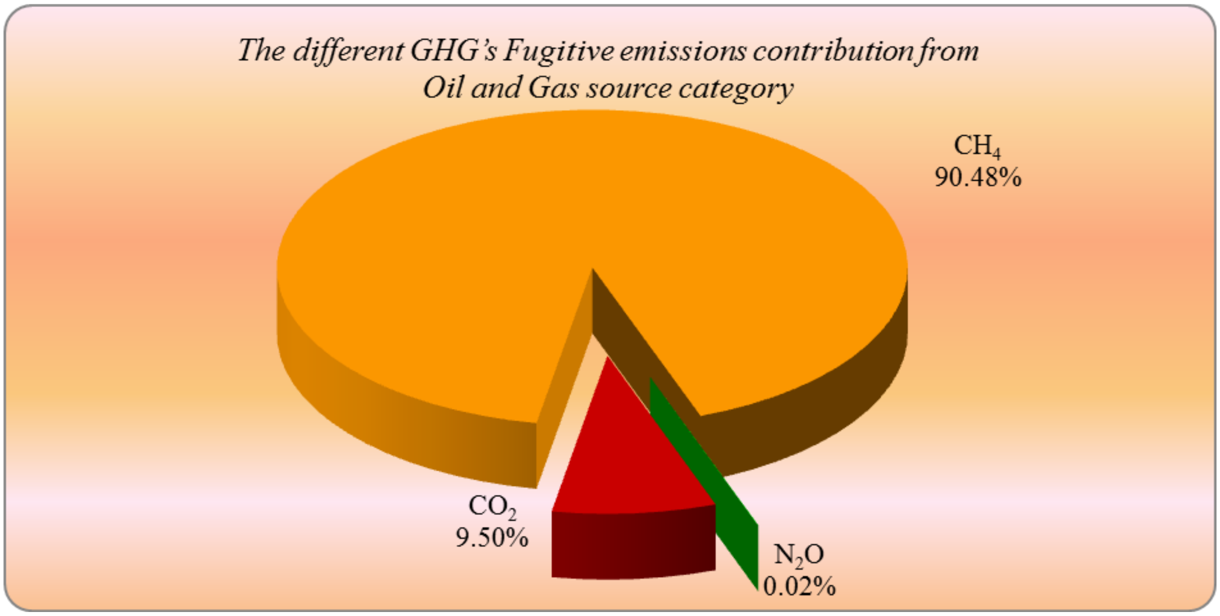
The emissions trend for the entire period is characterized by a continuos decrease, which is due to a number of factors:

- 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;
- increase of energy efficiency at the end consumer by changing the old technologies with new technologies, decreasing energy consumption in large cities due to drastic decline in thermal energy demand from industrial consumers, but also because disconnection of households from the public centralized heat supply system, combined with the increasing trend of using individual apartment heating systems;
- 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 (+3.1%), offsetting the small decrease of the primary energy production due to diminished crude oil (-8.1%);
- natural gas and hydroelectric power production,compared to 2005 (Source – Romanian National Institute for Statistics);
- the increase of natural gas resources in 2006 was driven by the significant increase in

imports (+14.3 %);

- the decrease of crude oil and hydropower resources in 2011 was compensated by the increase of natural gas available for use;
- imports of natural gas have increased in 2011 over the level in the previous year, representing 35.7% of the total imports of energy products; meanwhile a decreased level was registred in case of imports of crude oil, which represent 47.1% of the total imports of energy products;
- in 2012, the decrease of resources of crude oil (-6,8%) and natural gas (-0,7%) was been accompanied by the decrease of imports of crude oil (-5.9%) and natural gas (-6.7%);
- in 2013 continued decline the natural gas resources (-1.025 million toe), but these were partially offset by the petroleum resources increases (423,000 toe);
- in 2014, among the main sources of primary energy the most important growth has been at the resources of crude oil (1.23 million toe, representing + 12.1%); meanwhile the resources of natural gas decreased with 5.3f% (-614 000 toe);
- imports of petroleum products was slightly higher than in 2013 (55 000 toe), mainly due to significant increase in import of crude oil (1.428 000 toe respectively + 27.0%).
- It notes the sharp decline the imports of natural gas (-60.1%) over the previous year. (Source – Romanian National Institute for Statistics);
- In 2015 there were deascreased of 1.2% of the crude oil production and the natural gas production increased with 0.2% compared with 2014. (Source – Romanian National Institute for Statistics).

Figure 3.61 The contribution of GHG s Fugitive emission per gas from Oil and Natural Gas source category



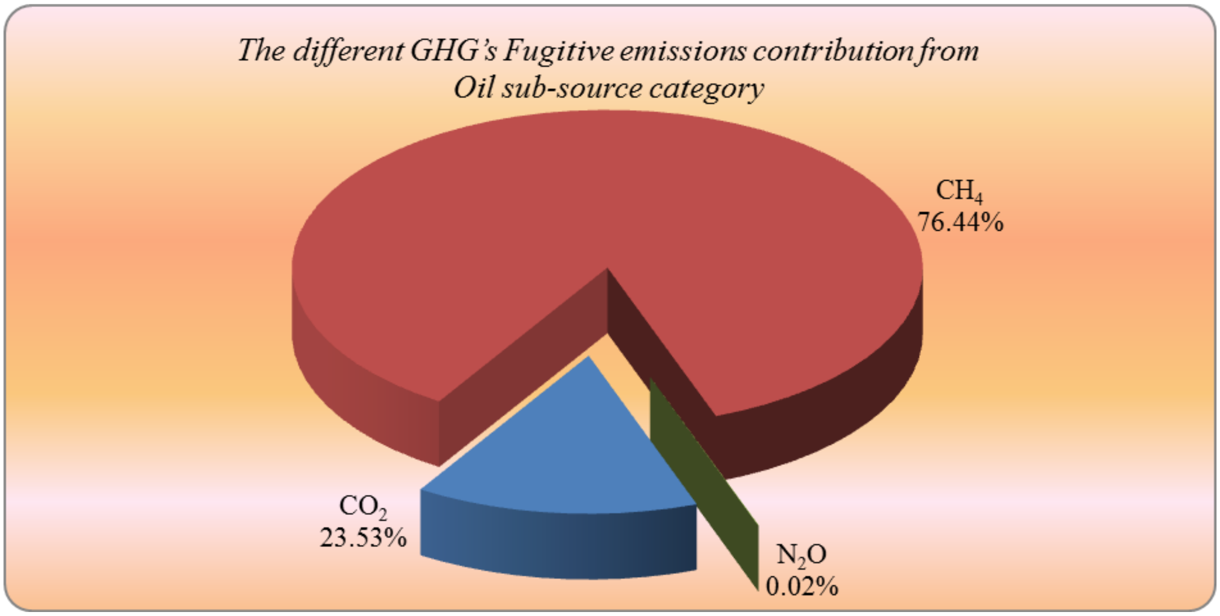
3.3.2.2 Methodological issues

3.3.2.2.1 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. The formula used in the calculations is *Equation 4.2.1* from 2006 IPCC GL, Volume. 2, Chapter 4.2.2.2, page 4.41.

Figure 3.62 The different GHG's Fugitive emissions contribution from Oil sub-source category



The most important GHG in the Energy sector is CH_4 emissions and small amounts of CO_2 and N_2O are emitted in Fugitive emissions from Oil sub-source category also.

Exploration oil

Exploration oil (1.B.2.a.iii.1): Fugitive emissions (excluding venting and flaring) from oil drilling, drill stem, and well completions.

Methodology

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

Emission Factor

- *The default value of 0.001702 $Gg/10^3m^3$* (Exploration) for CH_4 (average CH_4 Emission Factor) according to 2006 IPCC GL for “Oil extraction-well drilling, testing, servicing” has been used.
- *The default value of 0.080417$Gg/10^3m^3$* (Exploration) for CO_2 (average CO_2 Emission Factor) according to 2006 IPCC GL for “Oil extraction-well drilling, testing, servicing” has been used.
- *The default value of 0.000000584 $Gg/10^3m^3$* (Exploration) for N_2O (average N_2O Emission Factor) according to 2006 IPCC GL for “Oil extraction –well testing” has been used.

Activity Data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 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://asgmt.com/wp-content/uploads/2016/02/014.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 2015 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg].

As long as, the density values for each fuel type are different and the activity data values are not unitary as content on the time series analysed period, the implied emission factors of CO_2, CH_4 and N_2O are different.

Production and upgrading

Production and upgrading (1.B.2.a.iii.2): Fugitive emissions from oil production (excluding venting and flaring) 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 (i.e., well effluent, emulsion, oil shale and oil sands) to treating or extraction facilities, activities at extraction and upgrading facilities, associated gas re-injection systems and produced water disposal systems.

Methodology

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

Emission Factor

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	*0,0196000*	Gg per 10^3 m^3 total oil production
CO_2	0.00028	0.0047	*0,0024900*	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 2015 - for entire 1990-2015 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://asgmt.com/wp-content/uploads/2016/02/014.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 2015 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons in [kJ/kg].

Transport *- N.O.*

Transport (1 B 2 a iii 3) - N.O: Fugitive emissions (excluding venting and flaring) related to the transport of marketable crude oil (including conventional, heavy and synthetic crude oil and bitumen) to upgraders and refineries. The transportation systems may comprise pipelines, marine tankers, tank trucks and rail cars. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.

Methodology

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

Emission Factor

The default Emission Factor value of 0,0000054 *Gg/10^{3}m^3* (Oil Transport Pipelines) for CH_4 according to 2006 IPCC, volume 2, chapter 4.2.2.3, page 4.46, Tabel 4.2.5., page 4.61 has been used.

The default Emission Factor value of 0,00000049 *Gg/10^{3}m^3* (Oil Transport Pipelines) for CO_2 according to 2006 IPCC, volume 2, chapter 4.2.2.3, page 4.46, Tabel 4.2.5., page 4.61 has been used.

N_2O – N.A.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

From *IEA/Eurostat Questionnaire 2015 Petrol - Indigenous Production + Import + Export:*

- Crude Oil, Natural Gas Liquids and Other Hydrocarbons;

NCV- from IEA/Eurostat Questionnaire 2015 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg].

Refining / Storage

Refining / Storage (1 B 2 a iii 4): Fugitive emissions (excluding venting and flaring) at petroleum refineries. Refineries process crude oils, natural gas liquids and synthetic crude oils to produce final refined products (e.g., primarily fuels and lubricants). Where refineries are integrated with other facilities (for example, upgraders or co-generation plants) their relative emission contributions can be difficult to establish.

Methodology

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

Emission factor

Default Emission factor for Refining and Storage Tank: Revised 1996 IPCC, ch 1 Energy 21-40 RB Table 1-58, page 121.

The default value of 745 kg/PJ (Refinery) for CH_4 (average CH_4 Emission Factor) has been used.

The default value of 135 kg/PJ (Storage Tank) for CH_4 (average CH_4 Emission Factor) has been used.

The default value of ***Combined EF*** **of 880** kg/PJ for CH_4 has been used.

The country specific values of EF for CO_2 has been used:

Refining Storage	1989-2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2 (kt/PJ)	93.73	94.52	91.85	94.02	98.50	96.83	92.80	92.34	92.34

EF N_2O– N.A.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

From *IEA/Eurostat Questionnaire 2015* Refinery Intake (Observed):

- ❖ Crude oil, Natural Gas Liquids and Other Hydrocarbons.

NCV- from IEA/Eurostat Questionnaire 2015 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg]

- ❖ Petroleum Coke used in refineries as catalytic regenerator

NCV- Country Specific NCV in [TJ/t] has been used.

Distribution of oil products

Distribution of oil products (1 B 2 a iii 5)- N.A.- Distribution of Oil Products (Revised 1996 IPCC: 1B2a v Oil - Distribution of Oil Production)

This comprises fugitive emissions (excluding venting and flaring) from the transport and distribution of refined products, including those at bulk terminals and retail facilities.

Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.

Refined Product Distribution: Gasoline, Diesel, Aviation Fuel, Jet Kerosene

CO_2 – N.A.

CH_4 – N.A.

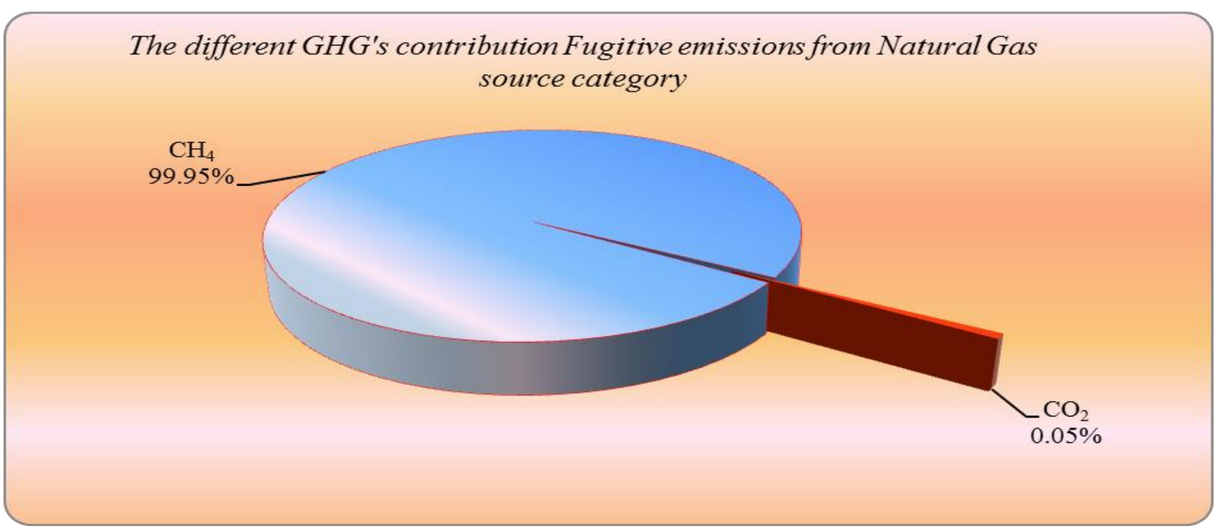
N_2O – N.A.

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

- Emissions: CH_4, CO_2
- Key source: Yes

This *sub-source category* ccomprises 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. The formula used in the calculations is presented in *Equation 4.2.1 Tier 1: Estimating Fugitive Emissions from an industry segment*.

Figure 3.63 The different GHG's Natural Gas sub-source category emissions contribution



Production

Production (1 B 2 b iii 2): Fugitive emissions (excluding venting and flaring) from gas processing facilities (Revised 1996 IPCC: 1B2b ii Natural Gas - Production/ Processing).

Methodology

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

Emission factor

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.

Flaring	**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.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

From *IEA/Eurostat Questionnaire 2015* 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

Processing (1 B 2 b iii 3): Fugitive emissions (excluding venting and flaring) from gas processing facilities (Revised 1996 IPCC: 1B2b ii Natural Gas - Production/ Processing).

Methodology

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

Emission factor

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	0.000012	0.000028	*0.00002*	Gg per 10^6 m^3 gas production
CO_2	0.00015	0. 00035	*0.00025*	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 2015 - for entire 1990-2015 time series have been used.

From *IEA/Eurostat Questionnaire 2015* 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

Transmission and Storage (1B2b iii 4):

- Fugitive emissions from systems used to transport processed natural gas to market (i.e., to industrial consumers and natural gas distribution systems).
- Fugitive emissions from natural gas storage systems should also be included in this category.
- Emissions from natural gas liquids extraction plants on gas transmission systems should be reported as part of natural gas processing (category 1.B.2.b.iii.3).
- Fugitive emissions related to the transmission of natural gas liquids should be reported under category 1.B.2.a.iii.3.

Methodology

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

Emission factor

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	0.0000166	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.

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

From *IEA/Eurostat Questionnaire 2015* 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)

Distribution gas

Distribution (1B2b iii5): Fugitive emissions (excluding venting and flaring) from the distribution of natural gas to end users.

Methodology

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

Emission factor

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.

Activity data

- 1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

From *IEA/Eurostat Questionnaire 2015* 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

Other (1B2b iii 6): Fugitive emissions from natural gas systems (excluding venting and flaring) not otherwise accounted for in the above categories.
This may include emissions from well blowouts and pipeline ruptures or dig-ins.

❖ ***Other Leakage***

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

Default Emission factors - from Revised 1996 IPCC, RM, Table 1-6, page 1.121

	lower	**upper**	**average**	**units**
CH_4	175,000	384,000	*279,500*	kg/PJ

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used:

❖ ***Natural Gas*** - sheet "2ii_TFC_EnergyUse" row 5 (Transport Sector) + 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

Default Emission factors – from Revised 1996 IPCC, RM, Table 1-6, page 1.121

	lower	upper	average	units
CH_4	87,000	192,000	*139,500*	kg/PJ

Activity data

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 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).

In order to improve the emissions estimates quality some important recalculations were made:

❖ ***emissions***:

- Exploration oil (1.B.2.a.1) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value for 1989-2015 period have been updated.
- Production oil (1.B.2.a.1) category: the emission values for 1989-2015 period have been updated because the Activity Data values for 1989-2015 period have been updated;
- Refining / Storage (1.B.2.a.6) category: the emission values for 1989-2015 period have been updated because the Country Specific Emission Factor values for 1989-2015 period have been updated;
- Venting Gas (1.B.2.c.1.ii) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value and CO_2 Emission Factor values for 1989-2015 period have been updated;
- Flaring Gas (1.B.2.c.2.ii) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value and the CO_2, CH_4 and N_2O Emission Factor values for 1989-2015 period have been updated.

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

Table 3.31 Change made at activity data and their effects on CO_2 emission estimates Oil and Natural Gas category

Year	Effects of changes on CO_2 emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	1,399.89	1,377.53	-1.60
1990	1,213.08	1,176.62	-3.01
1991	1,034.90	1,008.45	-2.56
1992	1,057.82	1,035.47	-2.11
1993	1,070.73	1,049.36	-2.00
1994	1,073.89	1,054.30	-1.82

Year	Effects of changes on CO_2 emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1995	1,104.34	1,085.35	-1.72
1996	1,098.10	1,080.82	-1.57
1997	1,093.80	1,078.26	-1.42
1998	1,481.00	1,458.95	-1.49
1999	1,326.13	1,306.81	-1.46
2000	1,567.44	1,544.54	-1.46
2001	1,156.46	1,140.17	-1.41
2002	1,506.50	1,309.58	-13.07
2003	1,665.52	1,467.53	-11.89
2004	1,458.69	1,436.42	-1.53
2005	1,728.30	1,660.71	-3.91
2006	2,042.83	1,919.81	-6.02
2007	1,752.99	1,703.19	-2.84
2008	1,839.58	1,831.83	-0.42
2009	1,506.90	1,498.29	-0.57
2010	1,494.60	1,486.73	-0.53
2011	1,182.79	1,196.61	1.17
2012	1,133.23	1,145.89	1.12
2013	894.63	887.18	-0.83
2014	977.30	969.00	-0.85

Table 3.32 Change made at activity data and their effects on CH_4 emission estimate

Oil and Natural Gas category

Year	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2016 v.4	NGHGI 2017 v.1	
1989	1,286.90	1279.56	-0.57

Year	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2016 v.4	NGHGI 2017 v.1	
1990	1,149.84	974.54	-15.25
1991	916.80	806.43	-12.04
1992	759.61	685.82	-9.71
1993	743.01	673.25	-9.39
1994	740.32	677.26	-8.52
1995	738.32	682.95	-7.50
1996	708.03	664.08	-6.21
1997	651.41	614.91	-5.60
1998	593.03	560.98	-5.40
1999	578.58	549.55	-5.02
2000	569.46	547.55	-3.85
2001	570.50	541.89	-5.02
2002	596.40	569.91	-4.44
2003	587.58	562.13	-4.33
2004	544.44	520.82	-4.34
2005	534.33	507.25	-5.07
2006	512.16	490.89	-4.15
2007	470.51	453.36	-3.64
2008	469.80	450.34	-4.14
2009	430.97	416.43	-3.37
2010	417.42	407.40	-2.40
2011	418.22	410.76	-1.78
2012	402.08	397.11	-1.24
2013	393.90	391.58	-0.59
2014	390.64	388.96	-0.43

Table 3.33 Change made at activity data and their effects on N_2O emission estimates Oil and Natural Gas category

Year	Effects of changes on N_2O emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	0.0136	0.0138	1.25
1990	0.0116	0.0117	0.98
1991	0.0100	0.0101	0.99
1992	0,0102	0.0103	0.71
1993	0.0104	0.0104	0.65
1994	0,0104	0.0105	0.55
1995	0,0103	0.0104	0.54
1996	0.0102	0.0102	0.52
1997	0.0100	0.0100	0.43
1998	0,0097	0.0098	0.40
1999	0,0095	0.0095	0.41
2000	0,0094	0.0094	0.40
2001	0,0093	0.0093	0.41
2002	0,0119	0.0107	-10.63
2003	0,0116	0.0104	-10.81
2004	0,0085	0.0086	0.41
2005	0,0088	0.0085	-3.04
2006	0,0090	0.0083	-7.12
2007	0,0075	0.0073	-1.74
2008	0,0070	0.0071	0.47
2009	0,0066	0.0067	0.56
2010	0,0063	0.0064	0.55
2011	0,0063	0.0063	0.53
2012	0,0059	0.0060	0.59
2013	0.0061	0.0061	0.61

Year	Effects of changes on N_2O emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2014	0.0060	0.0060	0.68

3.3.2.2.3 Venting and Flaring (CRF – 1.B.2.c.)

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

Venting Oil* and *Flaring Oil

Venting (1.B.2.a.i.)- Emissions from venting of associated gas and waste gas/vapour streams at oil facilities.
Flaring (1.B.2.a.ii.)- Emissions from flaring of natural gas and waste gas/vapour streams at oil facilities.

Methodology

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

Emission Factor

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 10^6 m^3 total oil production
CO_2	0.0018	0.0025	*0.00215*	Gg per 10^6 m^3 total oil production

N_2O – N.A.

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	0.0000029	*0.000025*	Gg per 10^6 m^3 total oil production
CO_2	0.034	0.047	*0.0405*	Gg per 10^6 m^3 total oil production
N_2O	0.00000054	0.00000074	*0.00000064*	Gg per 10^6 m^3 total oil production

Activity Data

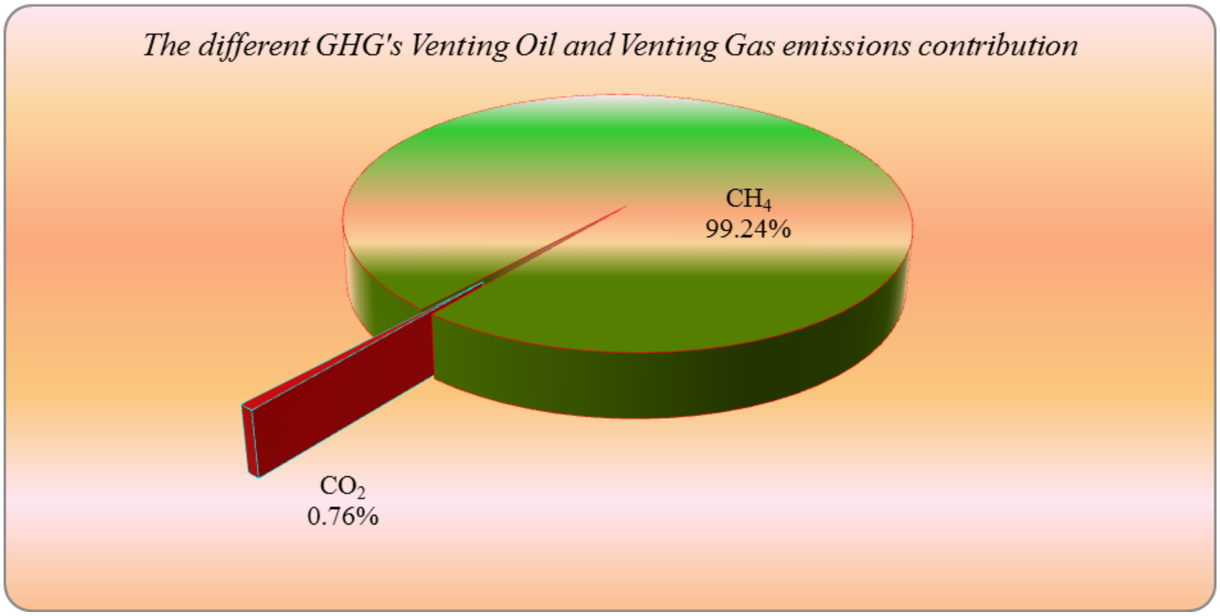
1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

According with the methodological provisions, activity data level used in *Venting Oil (1.B.2.a.i.)* and *Flaring Oil (1.B.2.a.ii.)* categories 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://asgmt.com/wp-content/uploads/2016/02/014.pdf);
- ***Other Hydrocarbons*** - indigenous production (density = 550 kg/m^3 according to http://pubs.acs.org/doi/abs/10.1021/je60058a030).

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 Venting oil and Venting Gas emissions contribution



Venting Gas* and *Flaring Gas

Venting (1.B. 2. b. i.): Emissions from venting of natural gas and waste gas/vapour streams at gas facilities

Flaring (1 B 2 b ii): Emissions from flaring of natural gas and waste gas/vapour streams at gas facilities.

Methodology

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

Emission factor

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.

Emission factor

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.

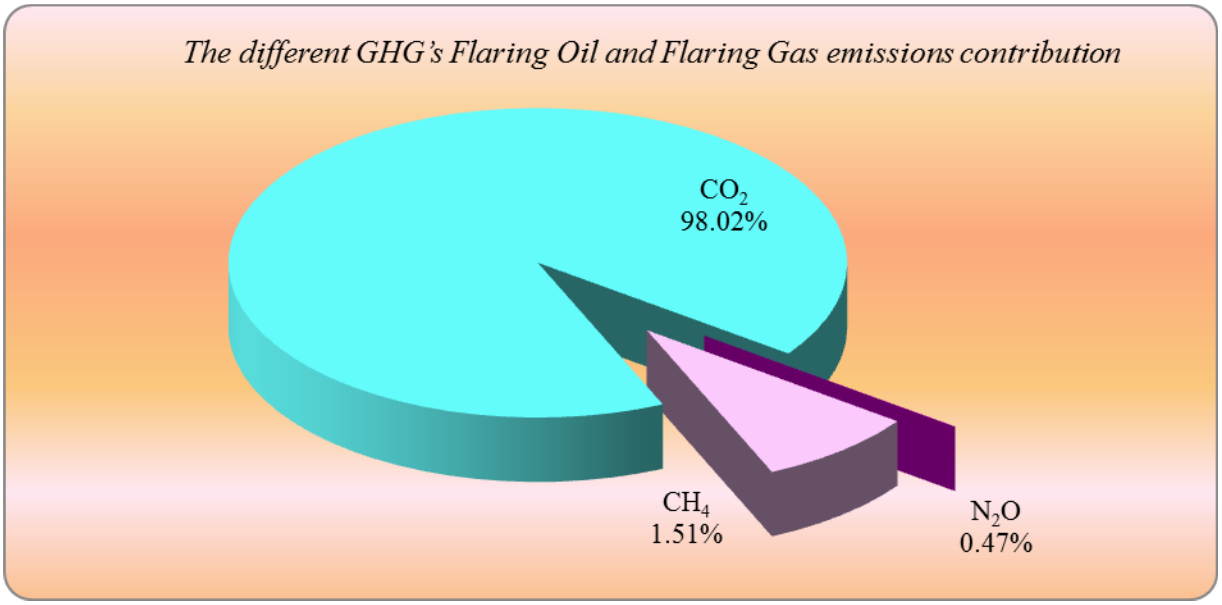
Flaring gas	lower	upper	average	units
CH_4	0.00000076	0.000001	*0.00000088*	Gg per 10^6 m^3 gas production
CO_2	0.0012	0.0016	*0.0014*	Gg per 10^6 m^3 gas production
N_2O	0.000000021	0.000000029	*0.000000025*	Gg per 10^6 m^3 gas production

1989_BAL_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2015 - for entire 1990-2015 time series have been used.

According with the methodological provisions, activity data level used in *Venting Gas (1.B.2.b.i.)* and *Flaring Gas (1.B.2.b.ii.)* categories is:

❖ Natural Gas– Indigenous Production – in 10^6 m^3 units

Figure 3.65 The different GHG's Flaring Oil and Flaring Gas emissions contribution



3.3.2.3 Uncertainties and time-series consistency

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

❖ ***Oil sub-source category***

- 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 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

❖ ***Natural Gas sub-source category***

- 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 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

- ***Venting sub-source category*:**
  - 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 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

- ***Flaring sub-source category*:**
  - 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 3.2.8 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 2012 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 1989-2015 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 *Stationary Combustion* categories, 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 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.

3.3.2.5 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***:

- Exploration oil (1.B.2.a.1) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value for 1989-2015 period have been updated.
- Production oil (1.B.2.a.1) category: the emission values for 1989-2015 period have been updated because the Activity Data values for 1989-2015 period have been updated;
- Refining / Storage (1.B.2.a.6) category: the emission values for 1989-2015 period have been updated because the Country Specific Emission Factor values for 1989-2015 period have been updated;
- Venting Gas (1.B.2.c.1.ii) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value and CO_2 Emission Factor values for 1989-2015 period have been updated;
- Flaring Gas (1.B.2.c.2.ii) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value and the CO_2, CH_4 and N_2O Emission Factor values for 1989-2015 period have been updated.

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

Table 3.34 Change made at activity data and their effects on CO_2 emission estimates Oil and Natural Gas category

Year	Effects of changes on CO_2 emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	1,399.89	1,377.53	-1.60
1990	1,213.08	1,176.62	-3.01
1991	1,034.90	1,008.45	-2.56
1992	1,057.82	1,035.47	-2.11
1993	1,070.73	1,049.36	-2.00
1994	1,073.89	1,054.30	-1.82
1995	1,104.34	1,085.35	-1.72

Year	Effects of changes on CO_2 emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1996	1,098.10	1,080.82	-1.57
1997	1,093.80	1,078.26	-1.42
1998	1,481.00	1,458.95	-1.49
1999	1,326.13	1,306.81	-1.46
2000	1,567.44	1,544.54	-1.46
2001	1,156.46	1,140.17	-1.41
2002	1,506.50	1,309.58	-13.07
2003	1,665.52	1,467.53	-11.89
2004	1,458.69	1,436.42	-1.53
2005	1,728.30	1,660.71	-3.91
2006	2,042.83	1,919.81	-6.02
2007	1,752.99	1,703.19	-2.84
2008	1,839.58	1,831.83	-0.42
2009	1,506.90	1,498.29	-0.57
2010	1,494.60	1,486.73	-0.53
2011	1,182.79	1,196.61	1.17
2012	1,133.23	1,145.89	1.12
2013	894.63	887.18	-0.83
2014	977.30	969.00	-0.85

Table 3.35 Change made at activity data and their effects on CH_4 emission estimate Oil and Natural Gas category

Year	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2016 v.4	NGHGI 2017 v.1	
1989	1,286.90	1279.56	-0.57
1990	1,149.84	974.54	-15.25

Year	Effects of changes on CH_4 emission estimates [kt]		Difference [%]
	NGHGI 2016 v.4	NGHGI 2017 v.1	
1991	916.80	806.43	-12.04
1992	759.61	685.82	-9.71
1993	743.01	673.25	-9.39
1994	740.32	677.26	-8.52
1995	738.32	682.95	-7.50
1996	708.03	664.08	-6.21
1997	651.41	614.91	-5.60
1998	593.03	560.98	-5.40
1999	578.58	549.55	-5.02
2000	569.46	547.55	-3.85
2001	570.50	541.89	-5.02
2002	596.40	569.91	-4.44
2003	587.58	562.13	-4.33
2004	544.44	520.82	-4.34
2005	534.33	507.25	-5.07
2006	512.16	490.89	-4.15
2007	470.51	453.36	-3.64
2008	469.80	450.34	-4.14
2009	430.97	416.43	-3.37
2010	417.42	407.40	-2.40
2011	418.22	410.76	-1.78
2012	402.08	397.11	-1.24
2013	393.90	391.58	-0.59
2014	390.64	388.96	-0.43

Table 3.36 Change made at activity data and their effects on N_2O emission estimates Oil and Natural Gas category

Year	Effects of changes on N_2O emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
1989	0.0136	0.0138	1.25
1990	0.0116	0.0117	0.98
1991	0.0100	0.0101	0.99
1992	0,0102	0.0103	0.71
1993	0.0104	0.0104	0.65
1994	0,0104	0.0105	0.55
1995	0,0103	0.0104	0.54
1996	0.0102	0.0102	0.52
1997	0.0100	0.0100	0.43
1998	0,0097	0.0098	0.40
1999	0,0095	0.0095	0.41
2000	0,0094	0.0094	0.40
2001	0,0093	0.0093	0.41
2002	0,0119	0.0107	-10.63
2003	0,0116	0.0104	-10.81
2004	0,0085	0.0086	0.41
2005	0,0088	0.0085	-3.04
2006	0,0090	0.0083	-7.12
2007	0,0075	0.0073	-1.74
2008	0,0070	0.0071	0.47
2009	0,0066	0.0067	0.56
2010	0,0063	0.0064	0.55
2011	0,0063	0.0063	0.53
2012	0,0059	0.0060	0.59
2013	0.0061	0.0061	0.61

Year	Effects of changes on N_2O emission estimates [kt]		Difference [%]
	NGHGI 2016 v. 4	NGHGI 2017 v. 1	
2014	0.0060	0.0060	0.68

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.

3.4 CO_2 transport and storage (CRF 1.C)

CO_2 transport and CO_2 storage is 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				

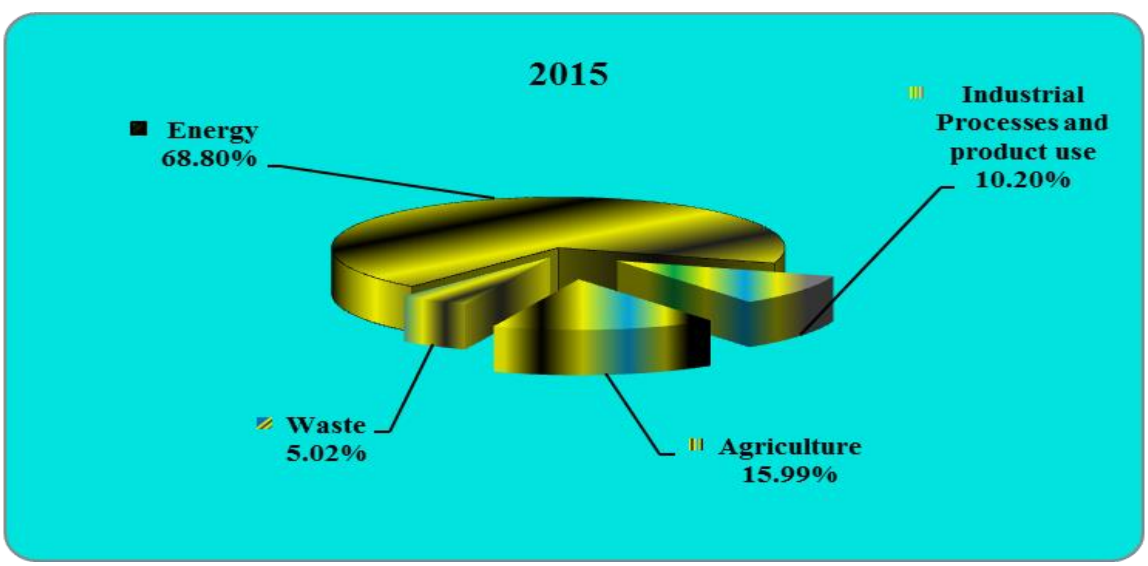
2 INDUSTRIAL PROCESSES AND PRODUCT USE	**Emissions estimation status**			
IPCC category	**CO_2**	**CH_4**	**N_2O**	**PFC**
2.B.1. AMMONIA PRODUCTION	✓	NE	NE	NA
2.B.2. NITRIC ACID PRODUCTION	NA	NA	✓	NA
2.B.3. ADIPIC ACID PRODUCTION	NO	NO	NO	NO
2.B.4. CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID PRODUCTION 2.B.4.a. CAPROLACTAM 2.B.4.b. GLYOXAL 2.B.4.c. GLYOXYLIC ACID	NE	NE	✓	NO
2.B.5.a. SILICON CARBIDE PRODUCTION	IE	✓	NA	NA
2.B.5.b. CALCIUM CARBIDE PRODUCTION	✓	NE	NO	NO
2.B.6. TITANIUM DIOXIDE PRODUCTION	IE	NA	NA	NA
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	✓	NE	NA	NA

2 INDUSTRIAL PROCESSES AND PRODUCT USE	**Emissions estimation status**			
IPCC category	**CO_2**	**CH_4**	**N_2O**	**PFC**
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				
2.C.2. FERROALLOYS PRODUCTION	✓	✓	NA	NA
2.C.3. ALUMINIUM PRODUCTION	✓	NE	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.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 INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions estimation status			
IPCC category	**CO_2**	**CH_4**	**N_2O**	**PFC**
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	NE	NE	NE	NO
2.H.2. FOOD AND BEVERAGES INDUSTRY	NE	NE	NE	NO
2.H.3. OTHER	NO	NO	NO	NO

In 2015 the GHG emissions from Industrial Processes and Product Use Sector contributed with 10.20% 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 2015 year



Emissions from this sector estimated in 2015 decreased by 71.61% compared with 1989 and increased with 3.04% compared with 2014.

The decrease from 1989 to 2013 is the result of the restructuration and privatization in various activity sectors.

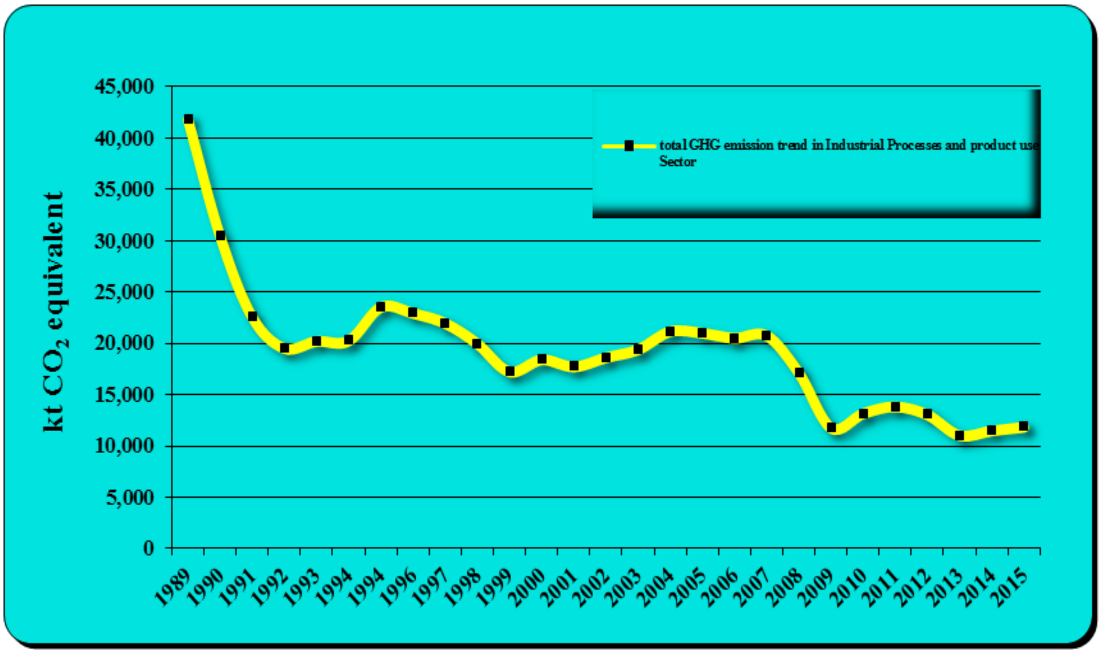
Starting with 2008 the emissions mainly decreased due to the reduction of various productions.

In 2010–2011 the emissions have recorded a increase due to increase of various industry productions.

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):

- 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 2007 the emissions mainly decreased due to the reduction of various productions;
- in 2010-2011 the emissions have recorded a increase due to increase of various industry 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 2014 the emissions rised due to increase of cement production, other process uses of carbonates, soda ash use;
- in 2013-2014 the emissions increased due to increase of various production activities (cement production, lime production, limestone and dolomite consumption, ammonia production and iron and steel production sub-sectors).
- in 2015 the emissions increased due to increase of various production activities (cement production, glass production, limestone and dolomite consumption, soda ash production and iron and steel production, product uses as substitutes for ODS sub-sectors).
- the reduction of PFC emissions from production of aluminum due to changes in technology starting with 1997 and 2003.

Figure 4.2 Total GHG emissions trend in Industrial Processes and Product Use Sector, for 1989–2015 period



Metal Industry contributes with 34.58% to the total GHG emissions from Industrial Processes and Product Use Sector in 2015.

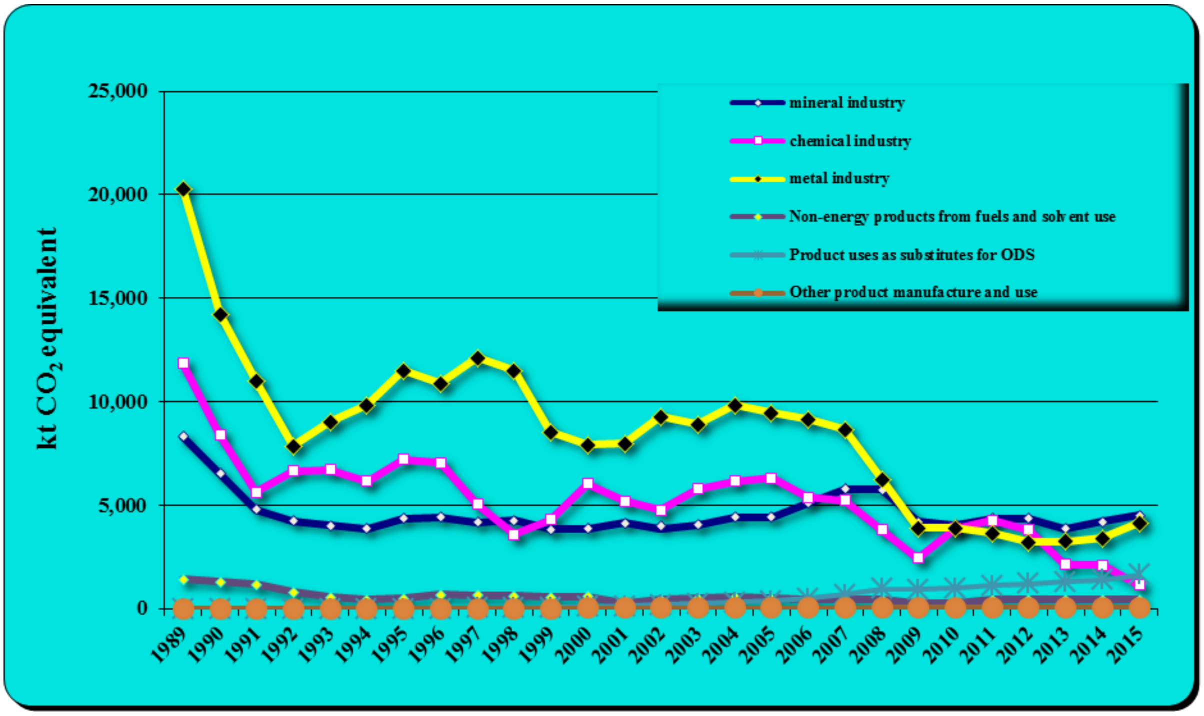
Mineral Industry and Chemical Industry are the two other main contributing Sub-sectors with 38.03% and 9.45%, respectively, of the total GHG emissions in this sector.

The contribution of Product uses as ODS substitutes Sub-sector to the overall sector is 13.79%.

The contribution of Non-energy product from fuels and solvent use Sub-sector to the overall sector is very low: 3.68%.

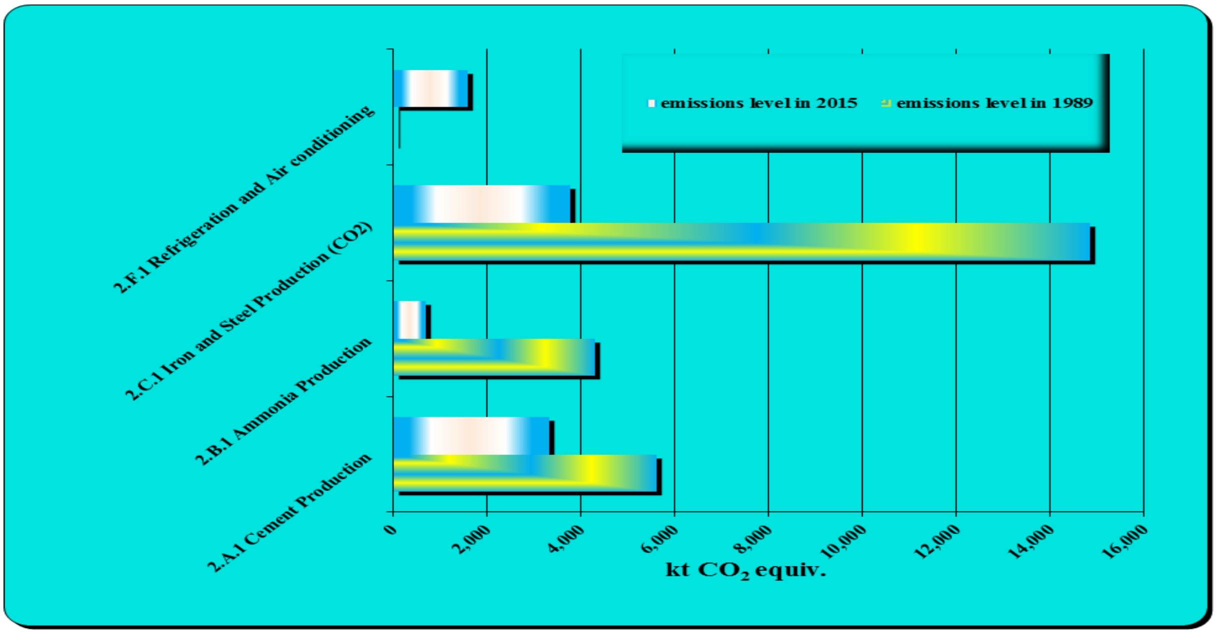
Other product manufacture and use contributes with 0.47% to the total GHG emissions from Industrial Processes and Product Use Sector.

Figure 4.3 GHG emissions trends in Industrial Processes and Product Use Sector, by sub-sectors, for 1989–2015 period



In the base year, various Industrial Processes and Product Use Sub-sectors contributions were: Mineral Industry 19.88%, Chemical Industry 28.29%, Metal Industry 48.47%, Non-energy product from fuels and solvent use 3.36%, Product uses as ODS substitutes 0.00% and Other product manufacture and use 0.00%.

Figure 4.4 Key categories in Industrial Processes and Product Use Sector in 2015 year, both by level and trend criteria



The Tier 1 key category analysis performed for 2015 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 2015 year

Key category	GHG	Criteria	Contribution in total GHG emissions [%]
2.A.1 Cement Production	CO_2	L,T (Tier 1, excluding and including LULUCF)	2.87%
2.B.1 Ammonia Production	CO_2	L,T (Tier 1, excluding and including LULUCF)	0.60%
2.C.1 Iron and Steel Production	CO_2	L,T (Tier 1, excluding and including LULUCF)	3.23%
2.F.1 Refrigeration and Air conditioning	HFC	L,T (Tier 1, excluding and including LULUCF)	1.37%

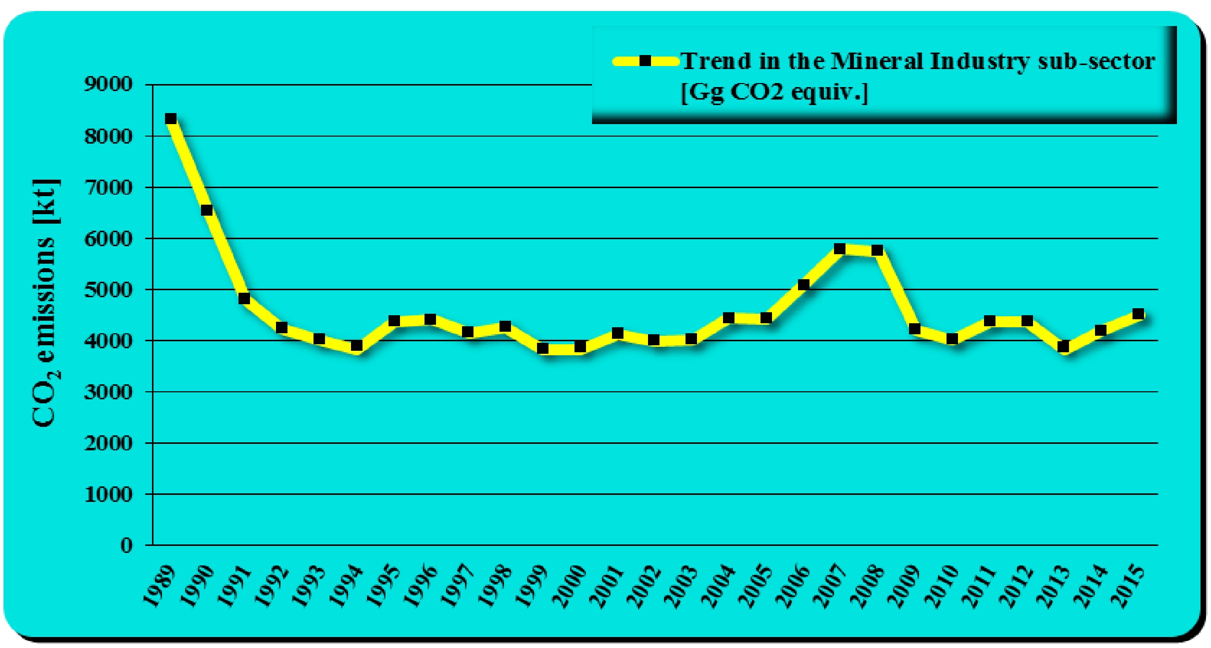
4.2 Mineral Industry (CRF 2.A)

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 2015 CO_2 emissions from production of cement contributed with 2.87% to total greenhouse gas emissions). In the base year, these emissions accounted for 1.86% from the total GHG emissions.

Figure 4.5 GHG emissions trend in the Mineral Industry Sub-sector for 1989–2015 period



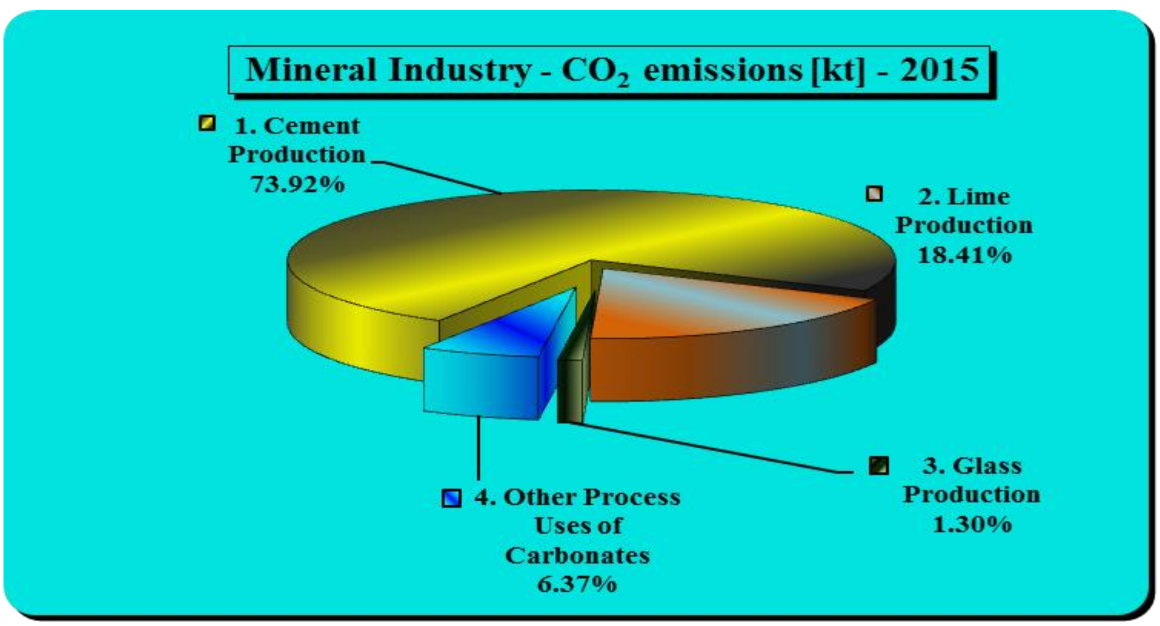
GHG emissions in the Mineral Industry Sub-sector were decreased during 1989–2011 period due to the decrease recorded after 1989 in Cement Production, Lime Production, Glass Production and Other Process Uses of Carbonates; the emissions were relatively stable during 1993–2007 period. Starting with 2004 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 2015 the emissions rised due to increase of cement production, other process uses of carbonates, soda ash use.
Mineral Industry Sub-sector was responsible for 38.03% of the Industrial Processes and Product Use Sector related GHG emissions in 2015.

Table 4.3 CO_2 emissions in the Mineral Industry Sub-sector, in the 2015 year

Sector	CO_2 emissions [kt]
2.A Mineral Industry	**4,515.27**
2.A.1 Cement Production	3,337.47
2.A.2 Lime Production	831.36
2.A.3 Glass Production	58.73
2.A.4 Other Process Uses of Carbonates	287.72

Figure 4.6 Structure of the Mineral Industry Sub-sector, in 2015 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 1989-2015 period; plant specific content of CaO (%) in clinker was provided by each company (according with laboratory analyses) starting with 2008 year; plant specific content of MgO (%) in clinker was provided by each company (according with laboratory analyses) starting with 2008 year.

The cement kiln dust (CKD) are completely recycled in the kiln and for the period 1989-2006 the correction factor for discarded amounts of dust varies between 1.00 and 1.13 because two plants reported a correction factor for discarded amounts of dust: one of them for the period 1989–2003 and other plant for 2006 year and starting with 2007 year there was no reported correction factor for discarded amounts of dust. Of the three operators in the cement industry, only two of them reported values of correction factor for CKD, one for the period 1989-2006 (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 1989-2006 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 2007-2015 two operators reported values for CKD (electrostatic powder that are not reintroduced in the system), an operator said that it not makes correction for CKD and it was considered = 1.00 as 2006 IPCC GL p. 2.12, and other operator said a correction factor for CKD = 1.00.

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 CO2/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 CO2/t clinker, the resulted specific emission factor is 0.5285 t CO2/t clinker. 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 CO2 emissions or plant specific clinker EF (plant specific content of CaO and MgO – % in clinker was provided by each company – according with laboratory analyses).

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). We can provide the average values related with the plant specific content of CaO and MgO – % in clinker (0.651 for CaO and 0.017 for MgO for 2008 year, 0.656 for CaO and 0.015 for MgO for 2009 year, 0.655 for CaO and 0.015 for MgO for 2010 year, 0.656 for CaO and 0.015 for MgO for 2011 year, 0.657 for CaO and 0.015 for MgO for 2012 year, 0.658 for CaO and 0.014 for MgO for 2014 year, 0.660 for CaO and 0.014 for MgO for 2015 year).

Starting with 2008 EF for clinker is calculated based on the below presented IPCC formula.

Equation 4.1 Calculation of EF for clinker

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

Emissions resulted from discarded cement kiln dust were calculated separately, taking into account its degree of calcinations and added to the CO_2 emissions resulted from calcinations (the production of clinker), using the Equation 2.2 from page 2.9 in according with 2006 IPCC GL methodology.

The correction factor for discarded amounts of dust varies between 1.00 and 1.13 for the period 1989-2007. Starting with 2008 the value of correction factor for discarded amounts of dust is 1 – page 2.12 from 2006 IPCC GL.

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 CKD. 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 1989–2015 period

Year	Activity data and CO_2 emissions from Cement Production Sub-sector		
	Clinker production [kt]	Emission factor [tCO_2/t clinker]	CO_2 Emissions [kt]
1989	10,571.00	0.5285	5,609.10
1990	8,379.00	0.5285	4,445.30
1991	6,037.00	0.5285	3,200.75
1992	5,488.00	0.5285	2,905.96

Year	Activity data and CO_2 emissions from Cement Production Sub-sector		
	Clinker production [kt]	Emission factor [tCO_2/t clinker]	CO_2 Emissions [kt]
1993	5,349.00	0.5285	2,833.43
1994	5,232.00	0.5285	2,770.91
1995	5,937.82	0.5285	3,145.84
1996	6,037.50	0.5285	3,200.04
1997	5,669.27	0.5285	3,004.94
1998	5,497.25	0.5285	2,915.95
1999	4,971.03	0.5285	2,644.77
2000	5,005.78	0.5285	2,655.96
2001	5,218.31	0.5285	2,768.36
2002	4,984.02	0.5285	2,642.09
2003	4,995.76	0.5285	2,650.04
2004	5,661.24	0.5285	2,992.09
2005	6,006.96	0.5285	3,174.81
2006	6,916.22	0.5285	3,655.57
2007	7,670.40	0.5285	4,053.98
2008	7,780.03	0.52997	4,142.66
2009	5,801.76	0.53092	3,093.07
2010	5,198.98	0.53097	2,777.89
2011	5,751.21	0.53165	3,088.84
2012	5,873.60	0.53196	3,150.25
2013	5,039.75	0.52914	2,694.53
2014	5,466.54	0.53157	2,943.95
2015	6,203.42	0.53225	3,337.47

4.2.2.2 Lime Production (CRF 2.A.2)

Methodology

The Lime Production is a key category from level point of view (Tier 1, excluding and including LULUCF). 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 1989–2015. For each type of lime, the following data was requested:

- Identification data (holder of the activity, type of activity performed, address, contact person, telephone/fax, email address);
- Type of lime kiln;
- Production capacity, tonnes/year;
- Production reported to INS (Yes/No);
- Annual quantity of lime produced for each type of lime, tonnes/year;
- Water content in the slaked lime, %;
- Stoichiometric ratio (t CO_2 / t CaO for lime or t CO_2 / t CaO·MgO for dolomite lime);
- Specific average CaO or CaO·MgO content (t CaO/t lime or t CaO·MgO/t lime dolomite);
- The lime dust quantity produced, tonnes;
- Average CaO or CaO·MgO contents in the lime dust, %.

These questionnaires were sent to a total of 30 potential operators lime producers, identified based on their membership in a sector where it is necessary to use / manufacture lime, based on the analysis of the integrated environmental authorizations and their inclusion in the EU–ETS.

Thus eight economic operators producing lime as main product and for marketing purposes have been identified, as well as three economic operators from metallurgy, 7 from the sugar industry, two from chemical industry and 10 from the pulp and paper industry.
The following table shows a summary of the number of units that have sent data to each year and for each parameter considered. 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 1989–2015

Due to differences given by production data reported by the NIS and to the data collected during the project, the estimation of the activity data upon the quantity of calcium quicklime produced during the period 1989–2013 was divided into two periods:

- 2009–2013 for which the annual activity data will be used (calcium quicklime quantity) collected from economic operators based on questionnaires;
- 1989–2008, for which the activity data reported by the NIS will be used, after being adjusted with a correction factor.

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 2009–2012. The value of these percentages varies between 68.06% in 2012 and 78.94% in 2011;
- Calculating the average weighted value of this correction factor for the years 2009–2012;
- Applying the correction factor value (75.16%) for the production data related to the calcium quicklime produced and reported by the NIS for the years 1989–2008.

Estimating the quantity of dolomite lime during the period 1989–2015

In order to estimate the quantity of dolomitic lime produced, the NIS data will be used because the data collected from the economic operators are not sufficient (one single operator reported for the period 2001–2007).

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

The default value of the stoichiometric ratio for calcium lime presented in the 2006 IPCC is 0,785 t CO_2/t CaO. This value depends on the chemical composition of the limestone used in the process of obtaining calcium lime. The data reported by the lime producers show values of the parameter stoichiometric ratio which vary between 0.7200 t CO_2/t CaO and 0.9650 t CO_2/t CaO. For each year in the period 2005–2015 the average value was calculated as a weighted average taking into account the quantity of calcium quicklime and the afferent stoichiometric ratio of this parameter; this value of the stoichiometric report for this period is presented in Table 4.5.

Table 4.5 Value of the stoichiometric report for high calcium lime

Year	**Stoichiometric raport**
	t CO_2/t CaO
2005	0.8665
2006	0.9267
2007	0.9171
2008	0.9163
2009	0.9053
2010	0.9126
2011	0.9144
2012	0.9086

Year	Stoichiometric raport
	t CO_2/t CaO
2013	0.9055
2014	0.8815
2015	0.8781

The value of the stoichiometric ratio report which will be used for the rest of the data series was calculated as a weighted average value. The period selected was the period 2009–2013 because the number of values collected was improved and it was constant. In order to determine the possibility of using the value of 0.9094 of the stoichiometric ratio for the calcium lime, an analysis was performed upon the representativeness of the activity data for which values were reported. Therefore, during the period 2009–2013, the activity data for which value were reported within the stoichiometric ratio represent between 47% (for 2009) and 52% (for 2013) of the activity data collected. Therefore, we can conclude that the calculated value of the stoichiometric ratio for calcium lime at this moment we cannot extrapolate to all amount of calcium lime due to the low representativity. All aspects considered, taking into account that the values collected of the stoichiometric report were provided by producers of commercial calcium lime falling under the EU–ETS; we analyzed the possibility of using these values only for this category of producers. Thus, it is observed that during the period 2009–2014 the representativity level of the stoichiometric report is very high (between 85% and 95%). In these conditions, it is recommended to use the following values (Table 4.6).

Table 4.6 Value of the stoichiometric report for high calcium lime

Years	Type of economic units	
	EU–ETS lime producers	EU–ETS captive lime productions and non-ETS lime production units
1989-2008	0.9094	0.785
2009	0.9053	0.785
2010	0.9126	0.785

Years	Type of economic units	
	EU–ETS lime producers	EU–ETS captive lime productions and non-ETS lime production units
2011	0.9144	0.785
2012	0.9086	0.785
2013	0.9055	0.785
2014	0.8815	0.785
2015	0.8781	0.785

No data were completed related to values determined by economic operators for the dolomite lime in the stoichiometric report. It is proposed to use the default value of the dolomite lime stoichiometric report.

The CaO or CaO•MgO content in the lime

The default value of CaO 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. The data reported by manufacturers lime parameter values CaO content vary between 0.8200 t CaO / t calcium lime and 0.9638 t / t calcium lime. For each of the 2005–2015 years the mean (weighted average) of this parameter was calculated and is presented in Table 4.8.

Table 4.7 Average content of CaO in the high calcium lime

Year	CaO content in the high calcium lime
	t CaO/t high calcium lime
2005	0.9366
2006	0.9141
2007	0.9045
2008	0.9124

Year	CaO content in the high calcium lime
	t CaO/t high calcium lime
2009	0.9193
2010	0.9195
2011	0.9126
2012	0.9151
2013	0.9198
2014	0.9229
2015	0.9290

The amount of CaO in the calcium lime that will be used for the rest of the data series was calculated as the weighted average. 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 0.9155 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 stoichiometric report have been provided are between 89% for the 2009 year and 94% 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. Under these conditions, for estimating CO_2 emissions it is recommended to use the following values.

Table 4.8 Average content of CaO in the high calcium lime

Type of economic units	1989-2008	2009	2010	2011	2012	2013	2014	2015
Lime producers	0.9155	0.9193	0.9195	0.9126	0.9151	0.9198	0.9229	0.9290

No data were completed in regard to determinant values by the economic operators for the CaO•MgO content in the dolomite lime. It is suggested that the implicit value of the CaO•MgO of the dolomite 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 IPCC 2006 – Chapter 2 – page 2.24.

Estimating the CO_2 emission levels for the calcium lime production and for the dolomite lime production

In order to estimate the CO_2 emission levels resulted at the production of calcium lime and dolomite lime, we use the Equation 2.6 from Chapter 2 – IPCC 2006 – page 2.21. Thus, for estimating lime production achieved by EU–ETS commercial lime producers for the 1989–2008 period, we applied the average weighed value from the national production. This average value was calculated as a weighted average value for the 2009–2013 years. In the next table, the values of the production weighs for commercial lime are presented in Table 4.10, as found in EU–ETS units from the total of the lime productions, for the period between 1989–2015. The amount of calcium lime produced in captive or non–ETS units is calculated as the difference from the total calcium lime production.

Table 4.9 The weights value for the comercial lime (under EU–ETS) from the total lime production

Year	1989-2008	2009	2010	2011	2012	2013
Weight, %	53.55	55.84	51.41	52.03	54.42	54.56

Table 4.10 CO_2 emissions from Lime Production in the period 1989–2015

Year	Emissions from Lime Production Sub-sector
	CO_2 emissions [kt]
1989	2,474.837
1990	1,897.608
1991	1,454.064
1992	1,215.342
1993	1,089.196
1994	1,017.628
1995	1,104.894
1996	1,091.952
1997	1,054.848
1998	1,252.884
1999	1,122.001
2000	1,136.683
2001	1,275.921
2002	1,249.906
2003	1,252.871
2004	1,332.056
2005	1,173.827
2006	1,300.598
2007	1,523.871
2008	1,394.829
2009	948.042
2010	1,057.252
2011	1,052.643
2012	925.164
2013	900.626
2014	952.158

Year	Emissions from Lime Production Sub-sector
	CO_2 emissions [kt]
2015	831.361

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 (1989–2015) 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 1989–2015.

Each economic operator was requested the following data:

- Identification data (holder of the activity, type of activity performed, address, contact person, telephone/fax, email address);
- Type of melting furnace;
- Production capacity, tons/year;
- Production reported to NIS (Yes/No);
- Type of glass produced;
- Yearly melted glass quantity produced, tonnes/year;

- Quantity of the glass pieces reintroduced into the process (cullet), t;
- Percentage of glass pieces reintroduced into the process (cullet ratio), %.

Based on the analysis of the operators included into the EU–ETS, 6 large glass producers were identified and contacted. For the three glass categories produced in Romania, we compared between the activities data received from the economic operators with the activity data from the 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 2003–2013 it is recommended to use NIS data 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. 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 2006–2013 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, it is recommended that we use the NIS data adjusted with 86.3%.

For the period 2008–2014 it is recommended to use the activity data collected 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 2009–2014 it is recommended to use the activity data collected because they represent the quantity of melted glass wool.

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% will be used, and for the period 2007–2015 the average values reported by the economic operators will be used.

Correction factor for the glass wool

For the plain 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 1989–2006 the value of 16.91%, will be used and for the period 2007–2015 the average values reported by the economic operators will be used.

Table 4.11 CO_2 emissions from Glass Production in the 1989–2015 period

Year	**Emissions from Glass Production Sub-sector**
	CO_2 emissions [kt]
1989	183.286
1990	149.944
1991	122.666
1992	100.615
1993	80.96
1994	87.591
1995	97.323
1996	104.527
1997	87.511
1998	78.507
1999	45.332
2000	61.846
2001	64.243
2002	63.942
2003	81.571
2004	59.959
2005	46.902
2006	45.281
2007	74.846
2008	77.286
2009	61.475

Year	Emissions from Glass Production Sub-sector
	CO_2 emissions [kt]
2010	68.34
2011	65.308
2012	62.383
2013	62.288
2014	56.126
2015	58.726

4.2.2.4 Other Process Uses of Carbonates (CRF 2.A.4)

Methodology

he 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 - 2014 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 4.12 Amount of Other Process Uses of Carbonates and CO_2 emissions in the 1989–2015 period

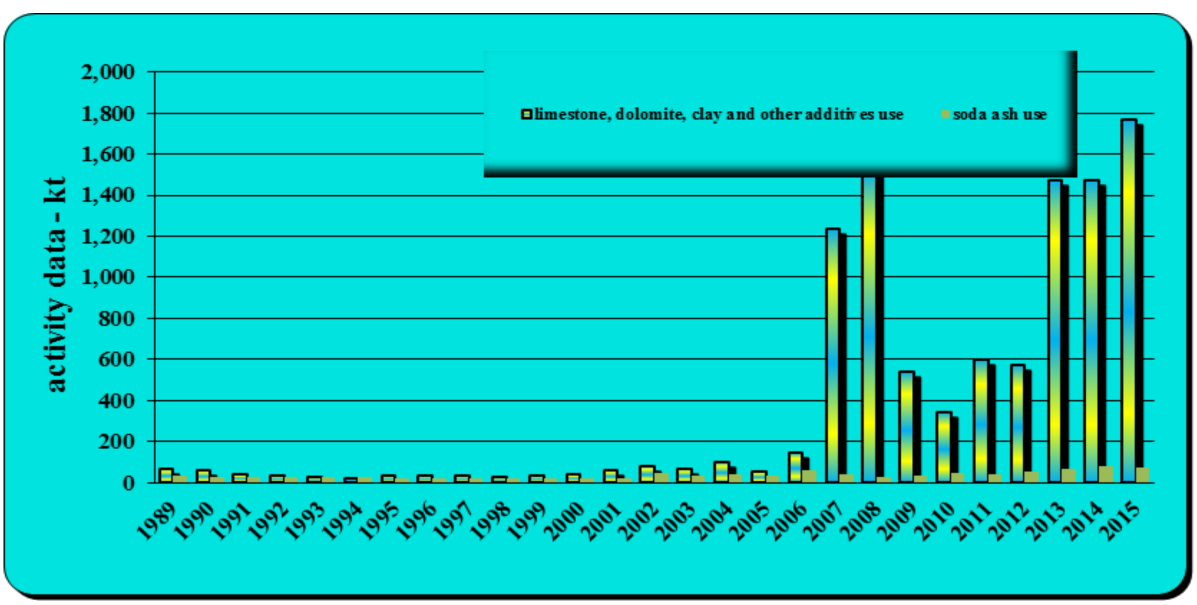
Year	Activity data from Other Process Uses of Carbonates Sub-sector			
	Limestone, dolomite, clay, fly ash and other additives use (2.A.4.a Ceramics)	Limestone and Dolomite Use (2.A.4.d Other)	Soda ash use (2.A.4.b Other uses of Soda Ash)	CO_2 emission from Other Process Uses of Carbonates
	[kt]			[kt]
1989	10.85	59.22	33.21	44.70
1990	10.86	48.79	28.85	38.31
1991	10.84	29.84	26.42	28.96
1992	10.86	21.95	26.64	25.58
1993	10.81	14.57	25.96	22.03
1994	11.06	12.75	25.75	21.25
1995	11.02	24.94	23.94	25.85
1996	11.05	22.33	20.82	23.42
1997	9.02	21.97	18.47	21.36
1998	8.89	21.46	18.07	20.91
1999	8.97	22.80	18.47	21.70
2000	11.98	26.57	22.38	26.42
2001	12.48	45.25	24.02	35.52
2002	15.10	64.48	45.95	54.25
2003	18.84	45.78	37.24	44.08
2004	17.71	79.58	40.16	60.25
2005	21.33	33.65	36.16	39.47
2006	101.12	42.36	59.98	89.38
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	108.57

Year	Activity data 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]
2010	345.56	0.39	44.40	127.30
2011	501.24	96.24	39.30	175.50
2012	256.48	316.47	53.83	239.32
2013	1,187.58	287.13	65.31	220.94
2014	1,158.02	312.44	80.40	248.67
2015	1,401.56	363.90	75.06	287.72

Emission factors

The default emission factors 440 kg CO_2/tonne limestone, 477 kg CO_2/tonne dolomite and 415 kg CO_2/tonne soda ash are used.

Figure 4.7 CO_2 emissions from Other Process Uses of Carbonates in the 1989–2015 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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 Transport and Fugitive Emissions from Fuels subsectors, the results of these being mentioned on the Checklists level.

Following these activities there were 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 2015 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 are described in the Chapter 4.2.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend and at the Chapter 10 – Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 4.2.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.

All noted unconformities following the UNFCCC review of the 2015 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

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 6.11.

4.2.5 Category-specific recalculation, 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:***
    - Other Process Uses of Carbonates (CRF 2.A.4).

Table 4.13 The effects of recalculations in Mineral Industry Sub–sector

The effects of recalculations in Mineral Industry Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
1989	8,311.93	8,311.93	0.00
1990	6,531.16	6,531.16	0.00
1991	4,806.44	4,806.44	0.00
1992	4,247.51	4,247.51	0.00
1993	4,025.62	4,025.62	0.00
1994	3,897.38	3,897.38	0.00
1995	4,373.91	4,373.91	0.00
1996	4,419.94	4,419.94	0.00
1997	4,168.66	4,168.66	0.00
1998	4,268.25	4,268.25	0.00
1999	3,833.81	3,833.81	0.00
2000	3,880.91	3,880.91	0.00
2001	4,144.05	4,144.05	0.00
2002	4,010.20	4,010.20	0.00
2003	4,028.57	4,028.57	0.00
2004	4,444.35	4,444.35	0.00
2005	4,435.01	4,435.01	0.00
2006	5,090.82	5,090.83	0.00
2007	5,792.31	5,792.32	0.00
2008	5,758.56	5,758.57	0.00
2009	4,211.16	4,211.16	0.00
2010	4,030.78	4,030.78	0.00

The effects of recalculations in Mineral Industry Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
2011	4,382.28	4,382.29	0.00
2012	4,377.11	4,377.12	0.00
2013	3,878.38	3,878.39	0.00
2014	4,200.89	4,200.90	0.00
2015		4,515.27	

Recalculation have been made for the 2005-2014 period. Recalculations were made as a result of due to the changes in activity data for those years for the 2.A.4.b Other uses of Soda Ash category.

Table 4.14 Recalculations of CO_2 emissions in the Other Process Uses of Carbonates Sub–sector

The effects of recalculations in Other Process Uses of Carbonates Subsector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
1989	44.70	44.70	0.00
1990	38.31	38.31	0.00
1991	28.96	28.96	0.00
1992	25.58	25.58	0.00
1993	22.03	22.03	0.00
1994	21.25	21.25	0.00
1995	25.85	25.85	0.00
1996	23.42	23.42	0.00
1997	21.36	21.36	0.00
1998	20.91	20.91	0.00
1999	21.70	21.70	0.00

The effects of recalculations in Other Process Uses of Carbonates Subsector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	CO_2 emissions [kt]		
2000	26.42	26.42	0.00
2001	35.52	35.52	0.00
2002	54.25	54.25	0.00
2003	44.08	44.08	0.00
2004	60.25	60.25	0.00
2005	39.47	39.47	0.01
2006	89.37	89.38	0.01
2007	139.62	139.63	0.01
2008	143.78	143.79	0.01
2009	108.57	108.57	0.01
2010	127.29	127.30	0.01
2011	175.49	175.50	0.00
2012	239.31	239.32	0.00
2013	220.93	220.94	0.01
2014	248.66	248.67	0.00
2015		287.72	

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.

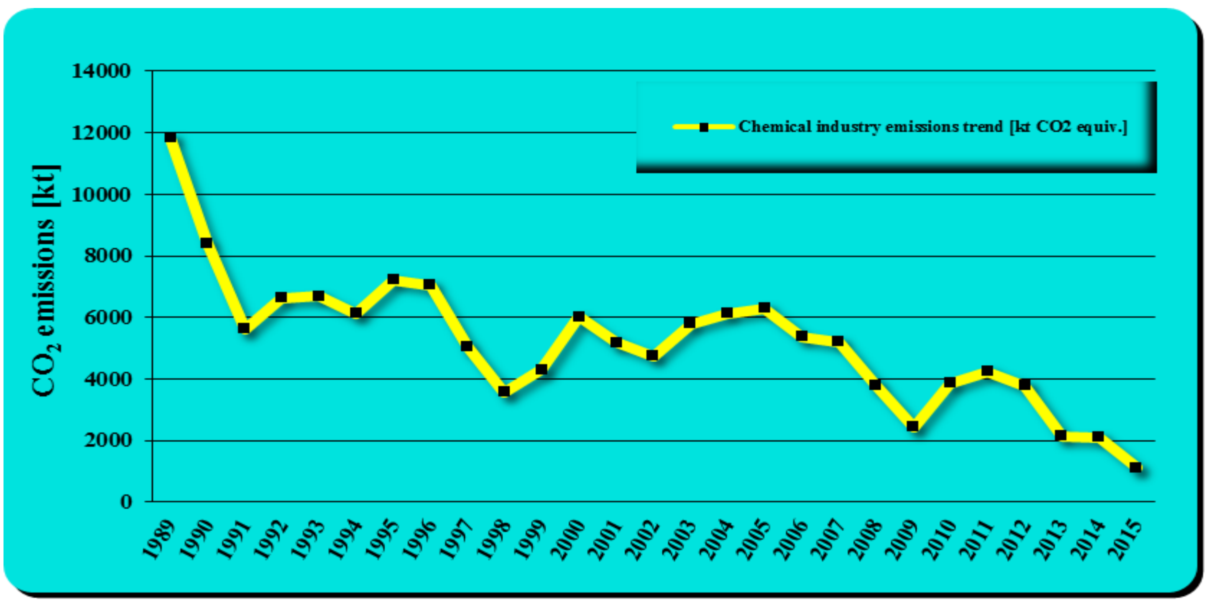
4.3 Chemical Industry (CRF 2.B)

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 9.45% of the total Industrial Processes Sector GHG emissions in 2015.

Figure 4.8 GHG emissions trend in the Chemical Industry Sub-sector for 1989–2015 period



GHG emissions trend in the Chemical Industry Sub-sector for 1989–2015 period due:

- lowest level of emissions from the ammonia production was recorded in 1998 (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 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 2012–2014 the emissions decreased due to decrease of various production activities (ammonia production, nitric acid production, carbide production).

Table 4.15 GHG emissions from the Chemical Industry Sector, in 2015 year

Sector	CO_2	CH_4	N_2O
	[kt] - 2015		
2.B Chemical Industry	**774.75**	**774.75**	**774.75**
2.B.1 Ammonia Production	699.00	699.00	699.00
2.B.2 Nitric Acid Production	NO	NO	NO
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	IE	IE
2.B.5.b Calcium Carbide Production	6.12	6.12	6.12
2.B.6 Titanium dioxide production	IE	IE	IE
2.B.7 Soda ash production	69.63	69.63	69.63
2.B.8 Petrochemical and carbon black production	NO	NO	NO
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 3.2) 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.

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, 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 2012–2015 the emissions decreased due to decrease of ammonia production.

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 produces for all-time series 1989–2014. In 2015 two ammonia production plants have ceased its activities, remaining three plants that provided data on the production of 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.

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 IPCC.
- The CO_2 emissions going to produce urea are not substracted from CO_2 emissions from ammonia production and will be considered as are released into the atmosphere. From CO_2 emissions from ammonia production are substracted only the CO_2 emissions resulting from the use of urea as a fertilizer, wich are included in the Agriculture sector in H. Urea application subsector.

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 raw material is obtained from the operators;
- The amount of *natural gas use as fuel* is excluded from the CO_2 emissions calculation inside the Industrial Process and Product Use Sector because this type of energetic gas is considering in Energy Sector. The amount of *natural gas used as feedstock* is considering only within Industrial Process and Product Use Sector, not to Energy Sector.

Carbon content of natural gas used as feedstock

- Unit measurement: kg C / Nm^3 natural gas;
- In order to convert Nm^3 of natural gas in kg of natural gas, the density of the natural gas was used (ρ= 0.8779 kg/m^3);
- For accurate calculations, the Carbon content of natural gas used as feedstock is obtained from the operators.

Conversion factor of carbon in carbon dioxide

- Unit measurement: dimensionless;

Conversion factor of carbon in carbon dioxide is stoichiometric ratio between molecular weight of carbon dioxide – CO_2 (44) and molecular weight of carbon – C (12). Value is 44/12.

Ammonia annual production

- Unit measurement: t/year (tone Ammonia Production 100%/year);

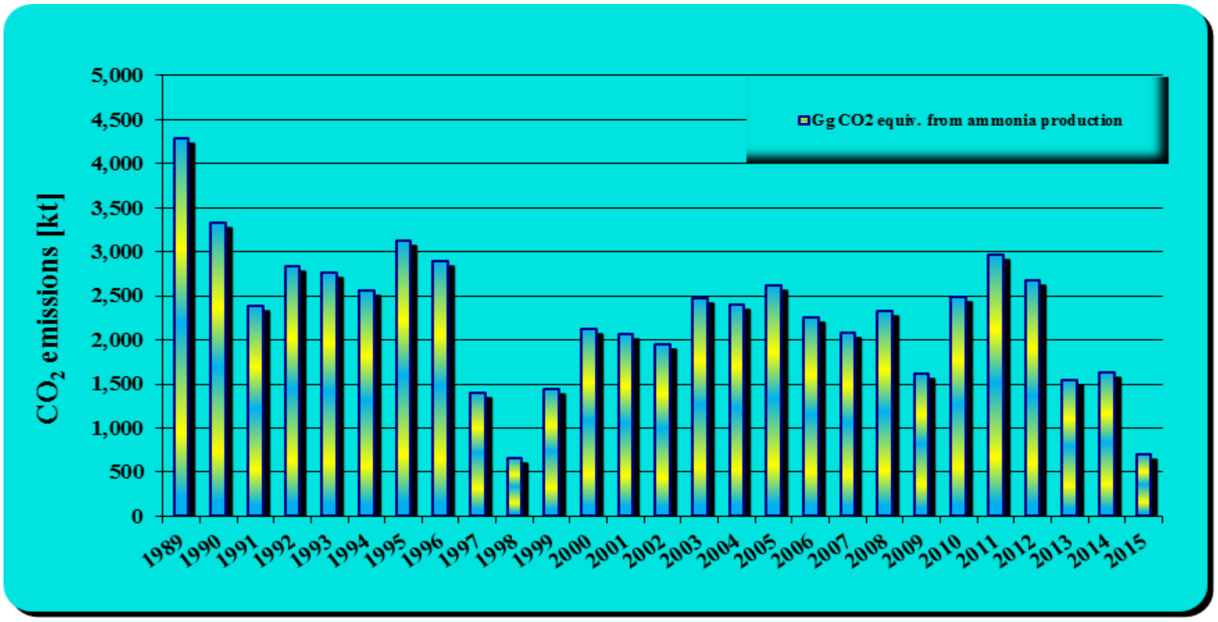
Annual production is annually obtained from operators.

Table 4.16 Ammonia Production related to the CO_2 emissions in the 1989–2015 period

Year	**Activity data and emissions from Ammonia Production Subsector**	
	Natural gas consumption [kt]	**CO_2 emissions [kt]**
1989	1,947.02	4,286.66
1990	1,510.90	3,322.66
1991	1,064.03	2,379.87

Year	Activity data and emissions from Ammonia Production Subsector	
	Natural gas consumption [kt]	CO_2 emissions [kt]
1992	1,261.58	2,838.02
1993	1,237.55	2,764.67
1994	1,147.35	2,564.81
1995	1,397.03	3,133.36
1996	1,287.90	2,900.92
1997	635.41	1,400.41
1998	305.00	651.62
1999	644.60	1,440.76
2000	945.06	2,121.14
2001	924.56	2,066.08
2002	872.56	1,956.23
2003	1,101.06	2,474.49
2004	1,070.13	2,394.56
2005	1,161.78	2,614.00
2006	1,003.98	2,260.93
2007	919.82	2,074.12
2008	1,038.18	2,331.27
2009	747.10	1,618.90
2010	1,081.52	2,488.78
2011	1,245.43	2,965.13
2012	1,042.46	2,676.61
2013	700.33	1,545.74
2014	728.50	1,628.72
2015	337.70	699.00

Figure 4.9 The trend of CO_2 emissions from Ammonia Production in the 1989–2015 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

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 there are currently three chemical plants, where five 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” (6 facilities):

- The N_2O default emission factor is 8 – 10 kg N_2O/t HNO_3, according to the 2000 IPCC GPG, table 3.8 (for dual pressure, double absorption plants) and 9 kg N_2O/t HNO_3, according to the 2006 IPCC Guideline, table 3.3 (for high pressure plants). A **9 kg N_2O/t HNO_3** average value was used to estimate the emissions, in the absence of continuous emission measurements.

b) For old facilities, commissioned before 1975, without a NSCR, operating under low pressure (one facility):

- 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.

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.

The analysis of the N_2O 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;
- There are currently three chemical plants, where five HNO_3 production facilities are in operation;
- Five operating HNO_3 production facilities are fitted with nitrogen oxide reduction and emission monitoring systems;

- Upgrading efforts are made in all seven operating HNO_3 production facilities, to reduce nitrogen oxide emissions.

In the Table 4.17 are presented the estimations of the N_2O emissions 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 4.17 Nitric Acid Production related to the N_2O emissions in the 1989–2015 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
1991	741.95	0.33	6.47
1992	1,051.09	0.46	9.17
1993	1,024.76	0.45	8.94
1994	884.85	0.14	7.88
1995	1,025.81	0.10	9.17
1996	1,057.15	0.05	9.48
1997	768.56	0.07	6.88
1998	547.69	0.05	4.90
1999	609.55	0.16	5.38
2000	874.12	0.26	7.70
2001	750.72	0.31	6.56
2002	795.35	0.10	7.09
2003	960.24	0.07	8.60

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]**
2004	1,059.14	0.45	9.25
2005	1,102.14	0.21	9.79
2006	869.25	0.36	7.60
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

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.

N_2O emission level trend

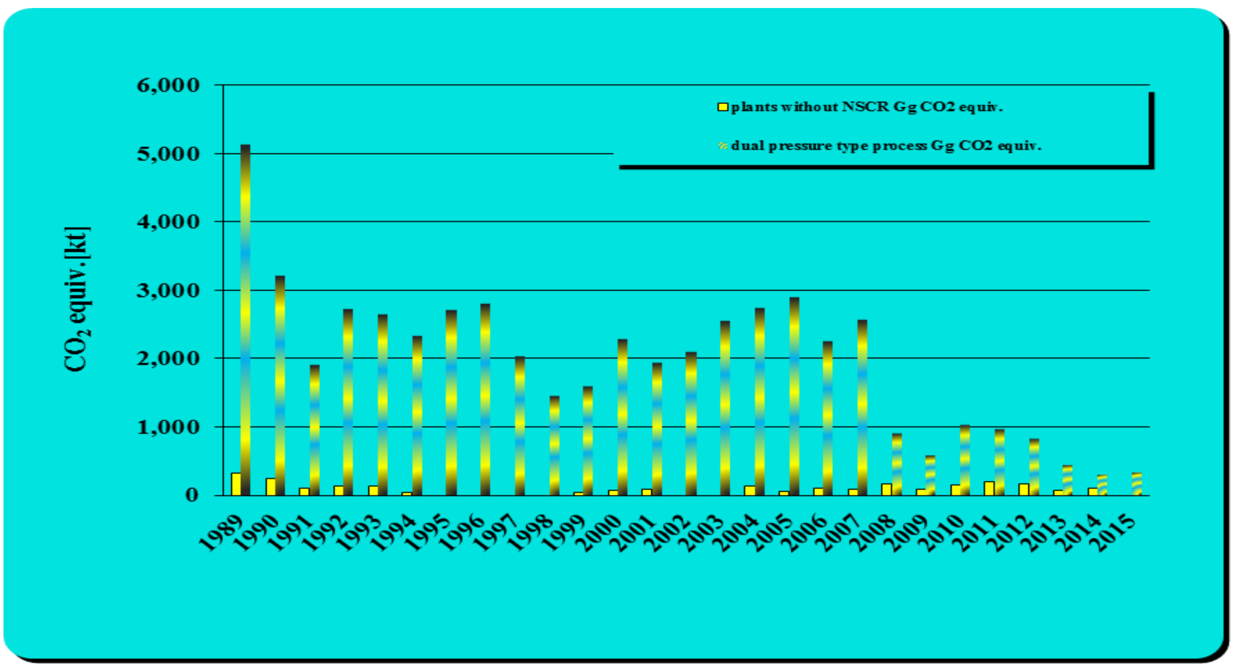
- The emissions decreased between 1989 and 2001, following the decrease of production.
- The emission level was maintained between 2002 and 2007, simultaneous with the production increase. Explanation: technological improvements, catalyst replacement.
- A drop of emissions was registered between 2008 and 2014, while the production level was

maintained. Explanation: the mounting of the N_2O reduction systems.

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.

Figure 4.10 The trend of CO_2 emissions from Nitric Acid Production, 1989–2015 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 4.18 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.

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

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 Production 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 4.19 CO_2 emissions from Calcium Carbide Production in the 1989–2015 period

Year	Emissions from Calcium Carbide Production Sub-sector
	CO_2 emissions [kt]
1989	288.77
1990	224.30

Year	Emissions from Calcium Carbide Production Sub-sector
	CO_2 emissions [kt]
1991	176.57
1992	164.04
1993	162.35
1994	127.13
1995	163.49
1996	177.92
1997	151.61
1998	125.04
1999	91.15
2000	91.85
2001	90.84
2002	86.71
2003	66.48
2004	94.89
2005	60.88
2006	42.78
2007	21.68
2008	13.19
2009	15.82
2010	18.35
2011	13.61
2012	9.39
2013	6.59
2014	0.69
2015	6.12

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

Methodology

Titanium dioxide production is not a ket category. The method for calculating emissions of CO_2 from Titanium Dioxide Production is 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 titanium dioxide production” from 2006 IPCC GL - page 3.49 (Figure 3.9).

Activity data

The amount of titanium slag production data was provided by the National Institute for Statistics. In Romania this category is not a key category and therefore apply level 1 for the estimation of the CO_2 emissions. Because no national emission factor is available for titanium slag production, in the 2006 IPCC guide an emission factor default can not be find and considering that the emission factor is based on the amount of reducing agent used, in order to avoid double counting the emissions from this category are included in the Energy sector. The CO_2 emissions from titanium slag production are noted as IE because are accounted in Energy Sector.

Emission factors

For confidentiality reasons the presentation of CO_2 emission factor used to estimate emission from Titanium Slag Production is omitted.

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.

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 in the 1989–2015 period

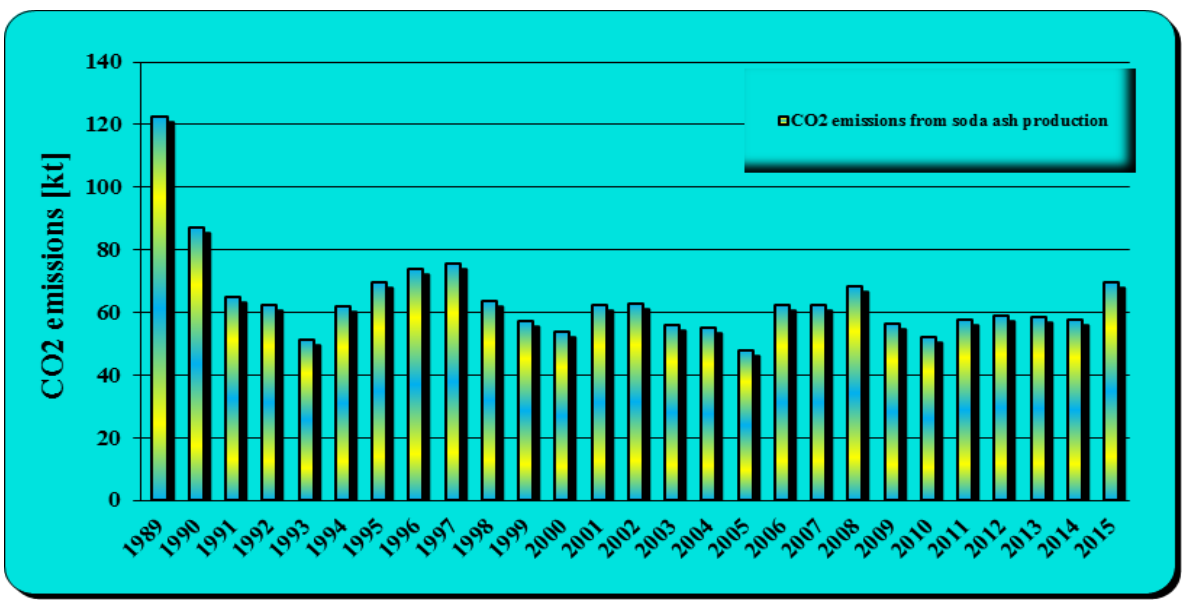


Table 4.20 CO_2 emissions from Soda Ash Production in the 1989–2015 period

Year	**Emissions from Soda Ash Production Sub-sector**
	CO_2 emissions [kt]
1989	122.57
1990	87.14
1991	64.94
1992	62.32
1993	51.15
1994	61.91
1995	69.49
1996	73.90
1997	75.41
1998	63.70
1999	57.22
2000	53.91
2001	62.22
2002	62.59
2003	55.98
2004	54.87
2005	47.70
2006	62.46
2007	62.32
2008	68.11
2009	56.39
2010	51.98
2011	57.49
2012	59.01
2013	58.60
2014	57.77

Year	Emissions from Soda Ash Production Sub-sector
	CO_2 emissions [kt]
2015	69.63

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

Methodology

Petrochemical and carbon black Production is a key category from trend point of view (Tier 1, excluding LULUCF). Total CO_2 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 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

National 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 and sulphuric acid 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 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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 Transport and Fugitive Emissions from Fuels subsectors, 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.

In 2015 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 are described in the Chapter 4.3.5 – Category–specific recalculations, including changes made in response to the review process and impact on emission trend and at the Chapter 10 - Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 4.3.5 – Category–specific recalculations, including changes made in response to the review process and impact on emission trend.

All noted unconformities following the UNFCCC review of the 2015 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

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:***
  - Ammonia Production (CRF 2.B.1).

Table 4.21 The effects of recalculations in Chemical Industry Sub–sector

The effects of recalculations in Chemical Industry Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
1989	11,892.27	11,828.92	-0.53
1990	8,455.74	8,393.27	-0.74

The effects of recalculations in Chemical Industry Sector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	CO_2 emissions [kt]		
1991	5,651.89	5,625.72	-0.46
1992	6,663.30	6,638.76	-0.37
1993	6,731.02	6,698.11	-0.49
1994	6,174.45	6,144.65	-0.48
1995	7,235.41	7,206.29	-0.40
1996	7,071.85	7,046.35	-0.36
1997	5,069.73	5,044.77	-0.49
1998	3,599.92	3,575.76	-0.67
1999	4,329.29	4,307.85	-0.50
2000	6,047.17	6,024.39	-0.38
2001	5,213.47	5,187.91	-0.49
2002	4,776.51	4,753.75	-0.48
2003	5,810.94	5,786.93	-0.41
2004	6,161.21	6,135.49	-0.42
2005	6,340.79	6,312.30	-0.45
2006	5,407.05	5,383.04	-0.44
2007	5,234.80	5,209.53	-0.48
2008	3,815.14	3,788.49	-0.70
2009	2,479.52	2,451.34	-1.14
2010	3,892.94	3,863.83	-0.75
2011	4,283.87	4,254.04	-0.70
2012	3,819.56	3,791.95	-0.72
2013	2,165.05	2,132.30	-1.51
2014	2,135.41	2,106.56	-1.35
2015		1,121.87	

Recalculation have been made for the entire period 1989-2014. Recalculations were made as a result of due to recalculate the amount of CO_2 from urea use as fertilizer. Because there are insufficient data on the use of urea-based catalyst, these emissions will be accounted in the category 2.B.1 Ammonia Production and will be considered as are released into the atmosphere. The CO_2 emissions resulting from the use of urea as a fertilizer are included in the Agriculture sector. They will be subtracted from the CO_2 emissions for category 2.B.1 Ammonia Production. (CRF 2.B.1 Category).

Table 4.22 The effects of recalculations in Ammonia Production Sub–sector

The effects of recalculations in Ammonia Production Subsector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
1989	4,350.00	4,286.66	-1.46
1990	3,385.13	3,322.66	-1.85
1991	2,406.04	2,379.87	-1.09
1992	2,862.56	2,838.02	-0.86
1993	2,797.58	2,764.67	-1.18
1994	2,594.61	2,564.81	-1.15
1995	3,162.48	3,133.36	-0.92
1996	2,926.42	2,900.92	-0.87
1997	1,425.37	1,400.41	-1.75
1998	675.78	651.62	-3.57
1999	1,462.20	1,440.76	-1.47
2000	2,143.92	2,121.14	-1.06
2001	2,091.64	2,066.08	-1.22
2002	1,979.00	1,956.23	-1.15
2003	2,498.49	2,474.49	-0.96
2004	2,420.28	2,394.56	-1.06
2005	2,642.49	2,614.00	-1.08

The effects of recalculations in Ammonia Production Subsector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	CO_2 emissions [kt]		
2006	2,284.95	2,260.93	-1.05
2007	2,099.40	2,074.12	-1.20
2008	2,357.92	2,331.27	-1.13
2009	1,647.09	1,618.90	-1.71
2010	2,517.90	2,488.78	-1.16
2011	2,994.97	2,965.13	-1.00
2012	2,704.22	2,676.61	-1.02
2013	1,578.50	1,545.74	-2.07
2014	1,657.57	1,628.72	-1.74
2015		699.00	

Recalculation have been made for the entire period 1989-2013. Recalculations were made as a result of due to the improvements on estimating CO_2 emissions. Because there are insufficient data on the use of urea-based catalyst, these emissions will be accounted in the category 2.B.1 Ammonia Production and will be considered as are released into the atmosphere. The CO_2 emissions resulting from the use of urea as a fertilizer are included in the Agriculture sector. They will be subtracted from the CO_2 emissions for category 2.B.1 Ammonia Production.

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)

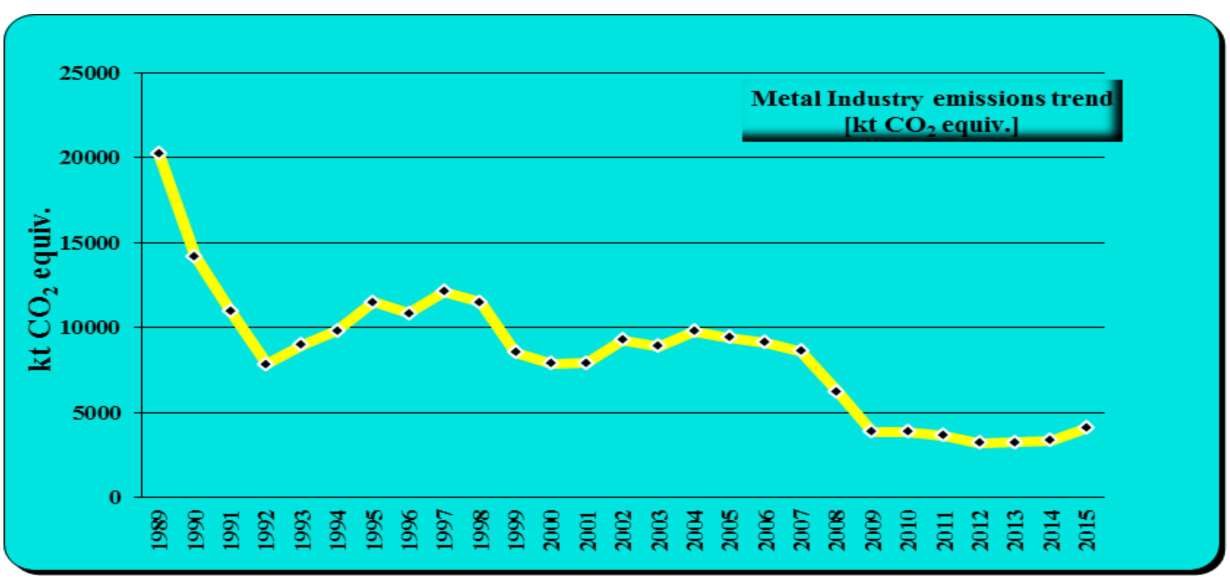
4.4.1 Category description

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 Sub–sector is responsible for 34.58% of the total Industrial Processes and Product Use Sector GHG emissions in 2015.

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 2015 CO_2 emissions from production of iron and steel contributed 3.23% to total greenhouse gas emissions). In the base year, these emissions accounted for 4.94% from the total GHG emissions. The CO_2 emissions from Ferroalloys Production have been included in the inventory. Aluminium Production results in a smaller quantity of CO_2 emissions and also PFCs emissions. PFCs emissions from Aluminium Production represent a significant source of emissions due to high GWP values.

Figure 4.12 GHG emissions trend in the Metal Industry Sub–sector for 1989–2015 period



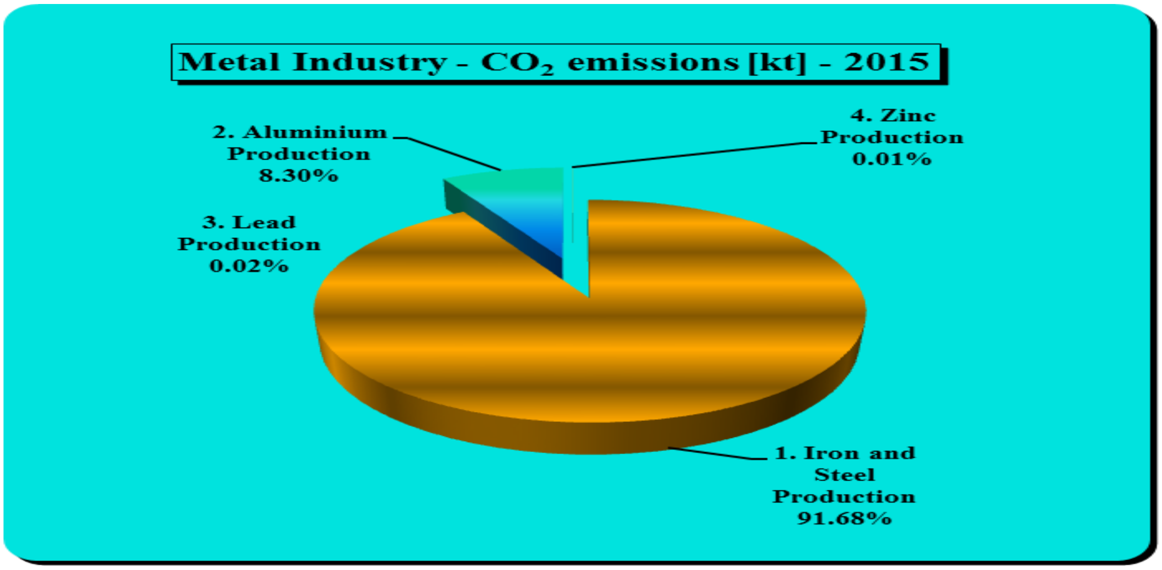
GHG emissions trend in the Metal Industry Sub-sector for 1989–2015 period due:

- 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 aluminum 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 Sub-sectors;
- 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 sub–sectors).
- in 2015 year the emissions trends have recorded an increase due to increased of various production activities (iron and steel production, aluminium production and zinc production subsectors).

Table 4.23 GHG emissions from Metal Industry Sub–sector, in the 2015 year

Sector	CO_2	CH_4	PFCs
	CO_2 equivalent [kt]		
2.C Metal Industry	**4,094.40**	**4.65**	**6.57**
2.C.1 Iron and Steel Production	3,759.34	4.65	0.00
2.C.2 Ferroalloys Production	0.00	0.00	0.00
2.C.3 Aluminium Production	334.03	0.00	6.57
2.C.4 Magnesium Production	0.00	0.00	0.00
2.C.5. Lead Production	0.69	0.00	0.00
2.C.6. Zinc Production	0.34	0.00	0.00

Figure 4.13 Structure of the Metal Industry Sub–sector, in 2015 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 2015. The data requested for the assessment of the emissions from sinter production and iron and steel production are shown in the tables below.

Table 4.24 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 4.25 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)	√	√
BF gas transferred to sinter plant	√	√

Since the data requirements for the assessment of the emissions from iron and steel production on the BF-OF 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 1989–2015 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 Guide, for the period 1989-2015. 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 2012–2014;
- The average carbon contents for coke, coal dust, limestone, dolomite, and steel for the period 1989–2006 are those in the last year for which there are specific analyses, namely 2007.

The table below shows the CO_2 emissions estimated for the period 1989-2015

Table 4.26 CO_2 emissions estimated for the 1989–2015 period

Year	CO_2 emissions [kt CO_2 equivalent]
1989	11,661.95
1990	8,846.24
1991	6,718.28
1992	4,849.35
1993	5,015.37
1994	5,534.77
1995	6,872.59
1996	6,260.62
1997	7,625.33
1998	7,551.99
1999	5,517.22
2000	5,661.09
2001	6,011.36
2002	7,744.43
2003	7,921.69
2004	8,840.00
2005	8,618.03
2006	8,443.91
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	3,020.35
2015	3,745.65

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. 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 period 1989–2014. This emission factor was applied to the difference between the EAF steel production and the quantities provided by NIS (National Institute of Statistics). The table below shows the CO_2 emissions estimated for the 1989–2015 period.

Table 4.27 CO_2 emissions estimated for the 1989–2015 period

Year	Total CO_2 emissions EAF [kt CO_2 equivalent]
1989	342.74
1990	195.01
1991	139.80
1992	93.26

Year	Total CO_2 emissions EAF [kt CO_2 equivalent]
1993	108.12
1994	109.64
1995	98.82
1996	84.89
1997	77.82
1998	62.14
1999	39.36
2000	39.29
2001	39.24
2002	34.02
2003	34.45
2004	42.60
2005	45.79
2006	40.59
2007	31.13
2008	23.63
2009	12.85
2010	24.38
2011	26.72
2012	25.75
2013	21.05
2014	17.85
2015	13.68

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 collected data were used as activity data.

The table below shows the CO_2 emissions estimated.

Table 4.28 CO_2 emissions for steel production in OHF

Year	**CO_2 emissions [kt CO_2 equivalent]**
1989	2,853.33
1990	1,739.96
1991	1,029.03

Year	CO_2 emissions [kt CO_2 equivalent]
1992	731.27
1993	1,644.32
1994	1,735.48
1995	1,664.96
1996	1,611.64
1997	1,608.20
1998	1,155.84

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 1989–2015, represent the sum of CO_2 emissions for the flows/technologies shown in the previous subchapters.

Table 4.29 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 4.29 CO_2 emissions from Iron and Steel Production for the 1989–2015 period

Year	CO_2 emissions [kt CO_2 equivalent]					Total CO_2 emissions [kt CO_2 equivalent]
	BOF	EAF	CI	Cupola furnace	OHF	
1989	11,661.95	342.74	0.00	0.00	2,853.33	14,858.01
1990	8,846.24	195.01	0.00	0.00	1,739.96	10,781.22
1991	6,718.28	139.80	0.00	0.00	1,029.03	7,887.11
1992	4,849.35	93.26	0.00	0.00	731.27	5,673.88
1993	5,015.37	108.12	0.00	0.00	1,644.32	6,767.82
1994	5,534.77	109.64	0.00	0.00	1,735.48	7,379.89
1995	6,872.59	98.82	0.00	0.00	1,664.96	8,636.37
1996	6,260.62	84.89	0.00	0.00	1,611.64	7,957.15

Year	CO_2 emissions [kt CO_2 equivalent]					Total CO_2 emissions [kt CO_2 equivalent]
	BOF	EAF	CI	Cupola furnace	OHF	
1997	7,625.33	77.82	0.00	0.00	1,608.20	9,311.35
1998	7,551.99	62.14	0.00	0.00	1,155.84	8,769.97
1999	5,517.22	39.36	0.00	0.00	557.28	6,113.86
2000	5,661.09	39.29	0.00	0.00	0.00	5,700.37
2001	6,011.36	39.24	0.00	0.00	0.00	6,050.59
2002	7,744.43	34.02	0.00	0.00	0.00	7,778.45
2003	7,921.69	34.45	0.00	0.00	0.00	7,956.14
2004	8,840.00	42.60	0.00	0.00	0.00	8,882.60
2005	8,618.03	45.79	0.00	0.00	0.00	8,663.81
2006	8,443.91	40.59	0.00	0.00	0.00	8,484.51
2007	7,998.31	31.13	0.00	0.00	0.00	8,029.44
2008	5,640.97	23.63	0.00	0.00	0.00	5,664.60
2009	3,528.20	12.85	0.00	0.00	0.00	3,541.04
2010	3,482.39	24.38	0.00	0.00	0.00	3,506.77
2011	3,232.41	26.72	0.00	0.00	0.00	3,259.13
2012	2,826.04	25.75	0.00	0.00	0.00	2,851.79
2013	2,912.20	21.05	0.00	0.00	0.00	2,933.25
2014	3,020.35	17.85	0.00	0.00	0.00	3,038.20
2015	3,745.65	13.68	0.00	0.00	0.00	3,759.34

Figure 4.14 The trend of CO_2 emissions from Iron and Steel Production (BOF, EAF and OHF) in the 1989–2015 period

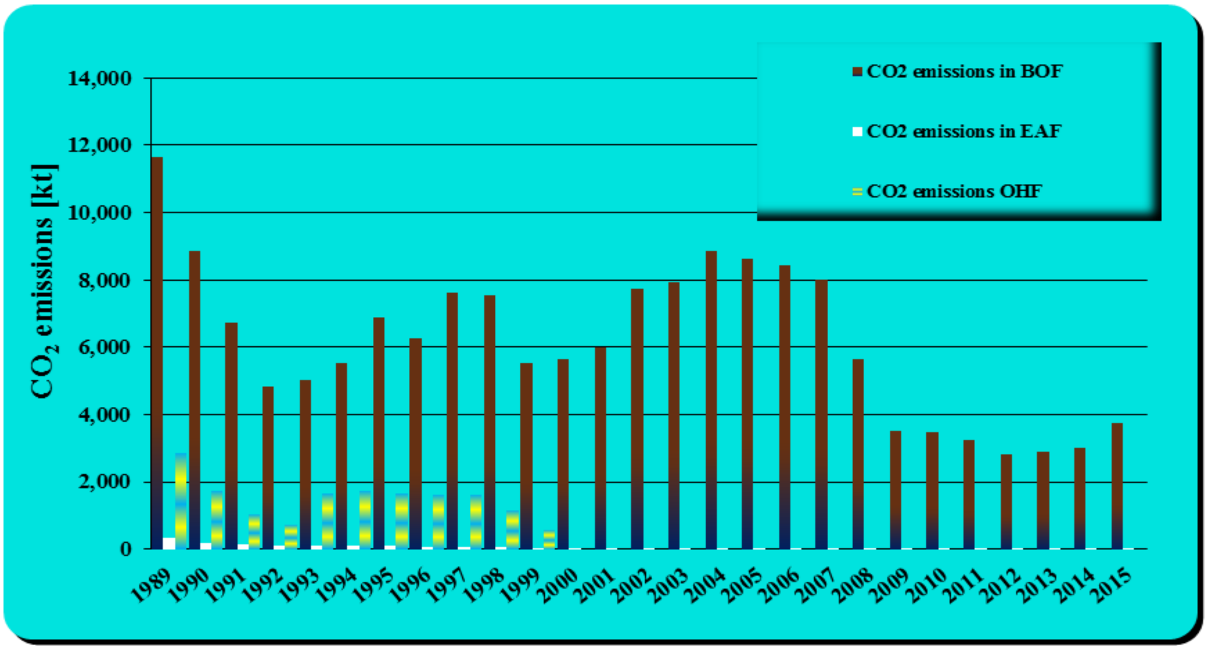
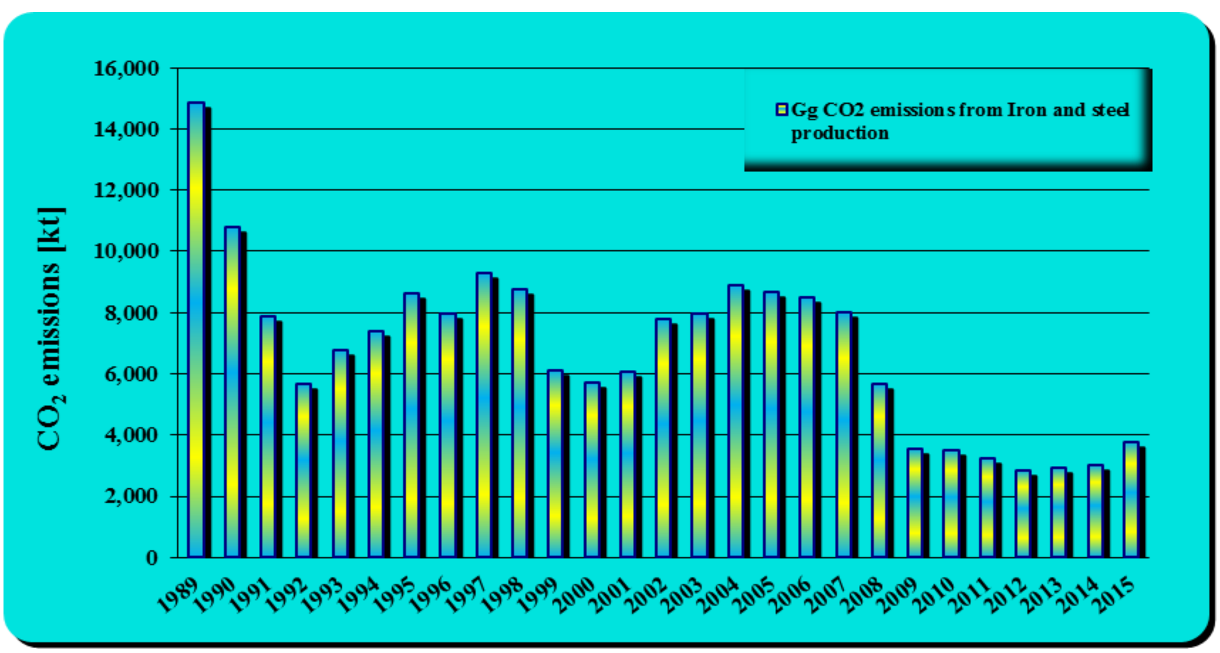


Figure 4.15 The trend of CO_2 emissions from Iron and Steel Production in the 1989–2015 period



Estimation of CH_4 Emissions for Iron and Steel Production (CRF 2.C.1) for the 1989–2015 period

The CH_4 emissions for the period 1989–2015 were estimated based on the Tier 1 methodology in IPCC 2006 (sinter production data x default emission factor). Table 4.30 shows the CH_4 emissions for category CRF 2.C.1 – Iron and Steel Production.

Table 4.30 CH_4 emissions for Iron and Steel production for the 1989-2015 period

Year	Sinter [kt]	Emission factor [kg/t]	CH_4 emissions [kt CO_2 equivalent]
1989	13,626.00	0.07	23.85
1990	11,357.00	0.07	19.88
1991	7,290.00	0.07	12.75
1992	4,761.00	0.07	8.33
1993	3,346.00	0.07	5.85
1994	5,452.00	0.07	9.55
1995	6,671.00	0.07	11.68
1996	5,449.00	0.07	9.53
1997	6,532.00	0.07	11.43
1998	6,514.00	0.07	11.40
1999	4,164.00	0.07	7.28
2000	3,875.00	0.07	6.78
2001	6,185.00	0.07	10.83
2002	6,799.00	0.07	11.90
2003	6,609.00	0.07	11.58
2004	6,601.00	0.07	11.55
2005	6,600.00	0.07	11.55
2006	5,780.00	0.07	10.13
2007	6,359.22	0.07	11.13
2008	3,445.55	0.07	6.03

Year	Sinter [kt]	Emission factor [kg/t]	CH_4 emissions [kt CO_2 equivalent]
2009	1,806.98	0.07	3.15
2010	1,977.60	0.07	3.45
2011	1,841.84	0.07	3.23
2012	1,705.94	0.07	2.98
2013	2,111.45	0.07	3.70
2014	2,165.68	0.07	3.80
2015	2,661.89	0.07	4.65

The NMVOC, NO_x, CO, SO_2 emissions are estimated using the default emission factors applied to the first fusion raw Pig Iron Production.

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 4.31 CO_2 emission from Ferroalloys Production in the 1989–2015 period

Years	Emissions from Ferroalloys Production Subsector
	CO_2 emissions [kt]
1989	451.72
1990	313.06
1991	233.20
1992	179.21
1993	132.39
1994	208.58
1995	213.79
1996	244.07
1997	142.27
1998	103.83
1999	0.80

Years	Emissions from Ferroalloys Production Subsector
	CO_2 emissions [kt]
2000	123.07
2001	124.48
2002	118.61
2003	198.92
2004	272.90
2005	165.55
2006	78.65
2007	37.62
2008	19.21
2009	19.99
2010	43.97
2011	32.98
2012	19.11
2013	NO
2014	NO
2015	NO

Table 4.32 CH_4 emission from Ferroalloys Production in the 1989–2015 period

Years	Emissions from Ferroalloys Production Subsector
	CH_4 emissions [kt]
1989	0.07
1990	0.05
1991	0.03
1992	0.02
1993	0.02
1994	0.03
1995	0.02

Years	**Emissions from Ferroalloys Production Subsector**
	CH_4 emissions [kt]
1996	0.02
1997	0.01
1998	0.01
1999	NO
2000	0.01
2001	0.01
2002	NO
2003	NO
2004	NO
2005	NO
2006	NO
2007	NO
2008	NO
2009	NO
2010	NO
2011	NO
2012	NO
2013	NO
2014	NO
2015	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 1989–2015:

- 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 (1989–2013), 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 4.33 The activity data, PFC and CO_2 emissions from Aluminium Production Sub–sector in the 1989–2015 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
1991	246.34	62.08	246.34	153.96

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]
1992	171.51	43.22	171.51	107.19
1993	178.78	45.05	178.78	111.74
1994	189.12	47.66	189.12	118.20
1995	224.96	56.69	224.96	140.60
1996	224.37	56.54	224.37	140.23
1997	229.51	52.88	261.93	163.70
1998	227.13	49.80	279.54	174.71
1999	209.59	43.76	278.53	174.08
2000	173.27	32.32	277.23	173.27
2001	145.29	24.05	287.71	179.82
2002	108.22	15.22	298.54	186.59
2003	34.35	4.16	334.96	198.05
2004	17.35	2.10	362.15	215.26
2005	10.75	1.30	372.62	239.01
2006	7.23	0.87	397.31	255.82
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

Emission factors

Along the period 1989–2013 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.

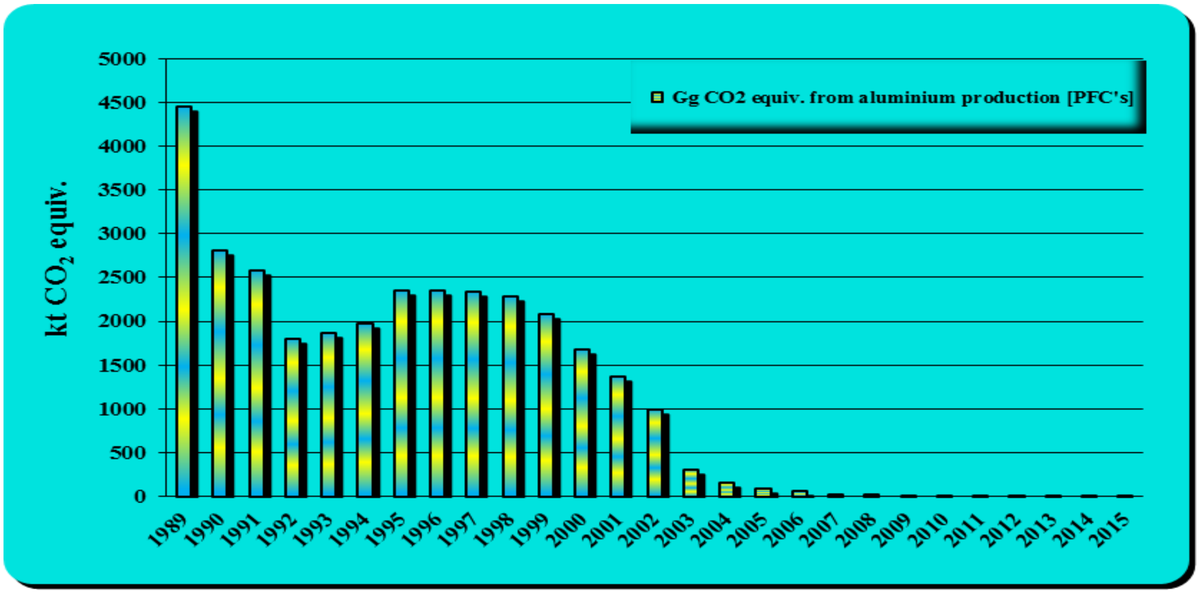
Measurement data are not available to determine smelter-specific Overvoltage coefficients, therefore default coefficients were used (an average parameters from measurements at numerous facilities), compliance with **IPCC 2006 Methodology (Tier 2 Method – Table 4.16 at page 4.54)**: Overvoltage Coefficient = **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 1989–2015 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.

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 1989–2015..

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 1989–2015.

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 Transport and Fugitive Emissions from Fuels subsectors,, 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 2015 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 4.4.5 – Category–specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend and at the Chapter 10 – Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 4.4.5 –

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

All noted unconformities following the UNFCCC review of the 2015 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

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

In order to improve the emissions estimates quality some important recalculations were made:

- ***emission factor:***
    - Aluminium Production (CRF 2.C.3).

Table 4.34 The effects of recalculations in Metal Industry Sector

The effects of recalculations in Metal Industry Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
1989	19,685.03	20,270.83	2.98
1990	13,847.78	14,217.82	2.67
1991	10,639.07	10,978.72	3.19
1992	7,617.11	7,853.58	3.10
1993	8,739.85	8,986.34	2.82
1994	9,546.60	9,807.35	2.73
1995	11,188.70	11,498.87	2.77
1996	10,529.68	10,839.03	2.94
1997	11,842.07	12,126.77	2.40
1998	11,239.62	11,508.55	2.39
1999	8,300.18	8,539.80	2.89
2000	7,692.10	7,884.82	2.51
2001	7,761.29	7,934.77	2.24
2002	9,099.15	9,270.29	1.88
2003	8,908.42	8,908.42	0.00
2004	9,787.22	9,787.22	0.00
2005	9,424.77	9,424.77	0.00
2006	9,124.96	9,124.96	0.00
2007	8,627.37	8,627.37	0.00
2008	6,232.22	6,232.22	0.00
2009	3,876.54	3,876.54	0.00
2010	3,884.31	3,884.31	0.00
2011	3,647.97	3,647.97	0.00
2012	3,218.26	3,218.26	0.00
2013	3,263.62	3,263.62	0.00

The effects of recalculations in Metal Industry Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
2014	3,366.67	3,366.67	0.00
2015		4,105.61	

Recalculation have been made for the period 1989-2002. Recalculations were made as a result of due to the improvements on estimating CO_2 emissions and PFC emissions. (CRF category 2.C.3).

Table 4.35 Recalculations of CO_2 emissions [kt] in the Aluminium Production Sub–sector

The effects of recalculations in Aluminium Production Sub–sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CO_2 emissions [kt]		
1989	4,285.07	4,870.87	13.67
1990	2,706.77	3,076.81	13.67
1991	2,484.50	2,824.15	13.67
1992	1,729.77	1,966.25	13.67
1993	1,803.07	2,049.56	13.67
1994	1,907.39	2,168.15	13.67
1995	2,268.86	2,579.03	13.67
1996	2,262.89	2,572.24	13.67
1997	2,318.42	2,603.12	12.28
1998	2,296.59	2,565.52	11.71
1999	2,121.60	2,361.23	11.29
2000	1,759.23	1,951.95	10.95
2001	1,481.39	1,654.87	11.71
2002	1,112.88	1,284.01	15.38
2003	639.50	639.50	0.00
2004	516.01	516.01	0.00

The effects of recalculations in Aluminium Production Sub–sector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	CO_2 emissions [kt]		
2005	467.89	467.89	0.00
2006	461.37	461.37	0.00
2007	430.32	430.32	0.00
2008	417.80	417.80	0.00
2009	307.19	307.19	0.00
2010	323.88	323.88	0.00
2011	348.69	348.69	0.00
2012	343.05	343.05	0.00
2013	325.72	325.72	0.00
2014	323.85	323.85	0.00
2015		340.60	

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 3.68% of the total Industrial Processes and Product Use Sector GHG emissions in 2015.

Figure 4.17 CO_2 emissions trend in the Non-energy products from fuels and solvent use Sub–sector for 1989–2015 period

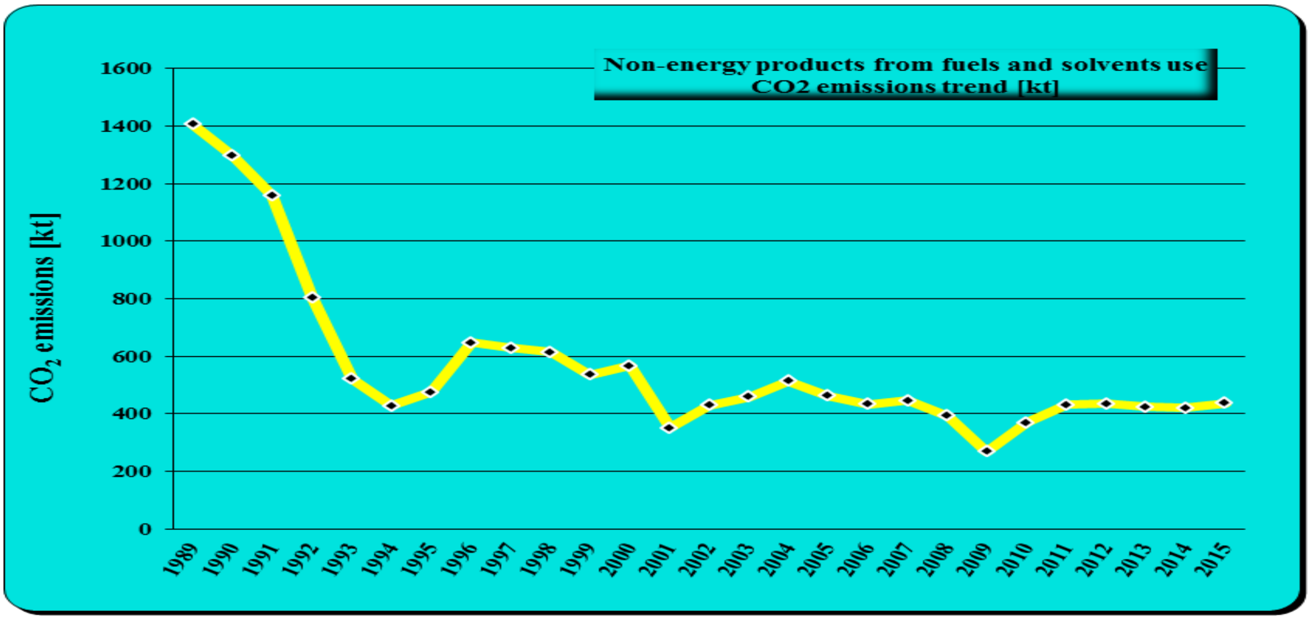


Table 4.36 CO_2 emissions from Non-energy products from fuels and solvent use Sub–sector, in the 2015 year

Sector	CO_2 emissions [kt]
2.D Non-energy products from fuels and solvent use	**436.70**
2.D.1 Lubricant use	255.26
2.D.2 Paraffin wax use	3.24
2.D.3 Other	178.20

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_2015_0000, Lubricants - Gross inland deliveries for non energy use.

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. For lubricants 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). 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_2015_0000, Paraffin waxes - Gross inland deliveries for non energy use.

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 CORINAIR methodology, using the correspondence between IPCC categories and SNAP codes (Table 4.37).

Table 4.37 Correspondence between IPCC categories and SNAP codes

IPCC categories	SNAP codes
Paint application	0601 Paint application
Degreasing and Dry Cleaning	0602 Degreasing, dry cleaning and electronics
Chemical Products, Manufacture and Processing	0603 Chemical products manufacturing and processing
Other	0604 Other use of solvents & related activities

Activity data

For 2017 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

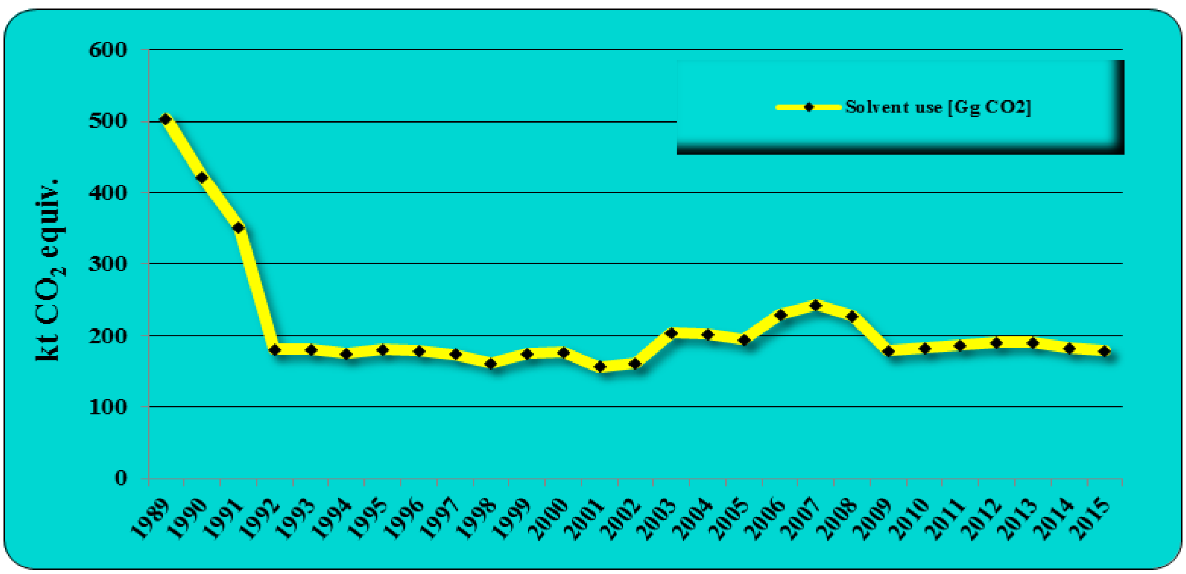
The CO_2 emissions from Solvent Use were calculated from NMVOC emissions of this sector and is calculated using the carbon content conversion factor (0.60) multiplying with (44/12) and multiplying with emissions of the NMVOC.

Table 4.38 CO_2 emissions resulted from Solvent Use in the 1989–2015 period

Solvents Use					
Year	**3A**	**3B**	**3C**	**3D**	**Total**
	CO_2 emissions [kt]				
1989	99.66	71.06	47.52	285.12	**503.36**
1990	78.76	62.26	39.60	240.46	**421.08**
1991	59.62	49.50	34.98	207.24	**351.34**
1992	36.74	21.87	11.88	109.12	**179.61**
1993	36.08	21.87	12.32	109.78	**180.05**
1994	29.26	21.85	15.40	108.02	**174.53**
1995	31.02	21.82	19.14	109.12	**181.10**
1996	27.94	21.80	19.14	109.34	**178.22**
1997	23.32	21.76	18.92	109.56	**173.56**
1998	22.22	21.74	4.84	112.64	**161.44**
1999	21.56	21.71	17.60	113.74	**174.61**
2000	23.10	21.71	18.04	113.52	**176.37**
2001	29.26	12.32	14.74	99.88	**156.20**
2002	32.12	12.54	3.30	112.20	**160.16**
2003	75.24	15.38	5.28	106.92	**202.82**
2004	70.42	18.18	5.81	107.17	**201.58**
2005	16.08	14.11	27.45	135.71	**193.34**
2006	14.58	14.05	64.55	135.35	**228.54**
2007	24.97	13.71	71.92	132.76	**243.35**
2008	17.76	19.20	58.30	131.35	**226.61**

Solvents Use					
Year	**3A**	**3B**	**3C**	**3D**	**Total**
	CO_2 emissions [kt]				
2009	7.80	17.15	19.44	133.44	**177.83**
2010	8.75	16.87	21.91	133.96	**181.49**
2011	10.43	18.05	23.17	134.32	**185.98**
2012	10.43	17.30	29.29	132.16	**189.17**
2013	7.90	17.35	33.09	132.34	**190.68**
2014	4.06	17.07	30.04	130.73	**181.89**
2015	5.15	16.29	25.75	131.01	**178.20**

Figure 4.18 The trend of CO_2 emissions resulted from Solvent Use Sector, in the 2015 year



The trend of emissions resulted from this sector follow the general emission trend: emissions have been seriously decreased after 1989, then the emissions are relatively stable from 1992 to 2002 and after 2002, emissions are started to increase, as an increase in economic activities (automobile manufacture, construction and buildings); after 2007 the emissions decreased and are relatively stable from 2009 to 2015.

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.

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 1989-2015 is consistent.

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 1989–2015.

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 1989–2015.

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 Transport and Fugitive Emissions from Fuels subsectors, 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 2015 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 4.5.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend and at the Chapter 10 - Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 4.5.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.

All noted unconformities following the UNFCCC review of the 2015 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

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:

Table 4.39 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 2016 v. 4	NGHGI 2017 v. 1.	Differences [%]
	CO_2 emissions [Gg]		
1989	1,406.83	1,406.83	0.00
1990	1,296.24	1,296.24	0.00
1991	1,159.58	1,159.58	0.00
1992	804.23	804.23	0.00
1993	520.73	520.73	0.00
1994	428.15	428.15	0.00
1995	475.45	475.45	0.00
1996	647.32	647.32	0.00
1997	630.07	630.07	0.00
1998	614.63	614.63	0.00
1999	536.52	536.52	0.00

The effects of recalculations in Non-energy products from fuels and solvent use Sector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1.	Differences [%]
	CO_2 emissions [Gg]		
2000	567.05	567.05	0.00
2001	351.99	351.99	0.00
2002	430.14	430.14	0.00
2003	459.47	459.47	0.00
2004	513.20	513.20	0.00
2005	462.12	462.12	0.00
2006	432.86	432.86	0.00
2007	445.85	445.85	0.00
2008	393.01	393.01	0.00
2009	269.93	269.93	0.00
2010	368.98	368.98	0.00
2011	431.39	431.39	0.00
2012	434.58	434.58	0.00
2013	424.32	424.32	0.00
2014	420.28	420.22	-0.01
2015		436.70	

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

Recalculation have been made for the 2014 year. 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.

Table 4.40 The effects of recalculations in Solvent use Sub–sector

The effects of recalculations in Solvent use Sub-sector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	CO_2 emissions [kt]		
1989	503.36	503.36	0.00
1990	421.08	421.08	0.00
1991	351.34	351.34	0.00
1992	179.61	179.61	0.00
1993	180.05	180.05	0.00
1994	174.53	174.53	0.00
1995	181.10	181.10	0.00
1996	178.22	178.22	0.00
1997	173.56	173.56	0.00
1998	161.44	161.44	0.00
1999	174.61	174.61	0.00
2000	176.37	176.37	0.00
2001	156.20	156.20	0.00
2002	160.16	160.16	0.00
2003	202.82	202.82	0.00
2004	201.58	201.58	0.00
2005	193.34	193.34	0.00
2006	228.54	228.54	0.00
2007	243.35	243.35	0.00
2008	226.61	226.61	0.00
2009	177.83	177.83	0.00
2010	181.49	181.49	0.00
2011	185.98	185.98	0.00
2012	189.17	189.17	0.00
2013	190.68	190.68	0.00

The effects of recalculations in Solvent use Sub-sector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	CO_2 emissions [kt]		
2014	181.94	181.89	-0.03
2015		178.20	

4.5.6 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.

4.6 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.

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 1989-2015 is consistent.

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 Transport and Fugitive Emissions from Fuels subsectors, 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.

In 2015 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 are described in the Chapter 4.6.5 – Category–specific recalculations, including changes made in response to the review process and impact on emission trend and at the Chapter 10 - Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 4.6.5 – Category–specific recalculations, including changes made in response to the review process and impact on emission trend.
All noted unconformities following the UNFCCC review of the 2015 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

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). Product uses as substitutes for ODS Sub–sector is responsible for 13.79% of the total Industrial Processes and Product Use Sector GHG emissions in 2015. In 2015 year, the actual emissions from CRF 2.F category equal to 1,636.76 kt CO_2eq. are presented in the Table 4.43.

Figure 4.19 GHG emissions trend in the Product uses as substitutes for ODS Sub–sector for 1995–2015 period

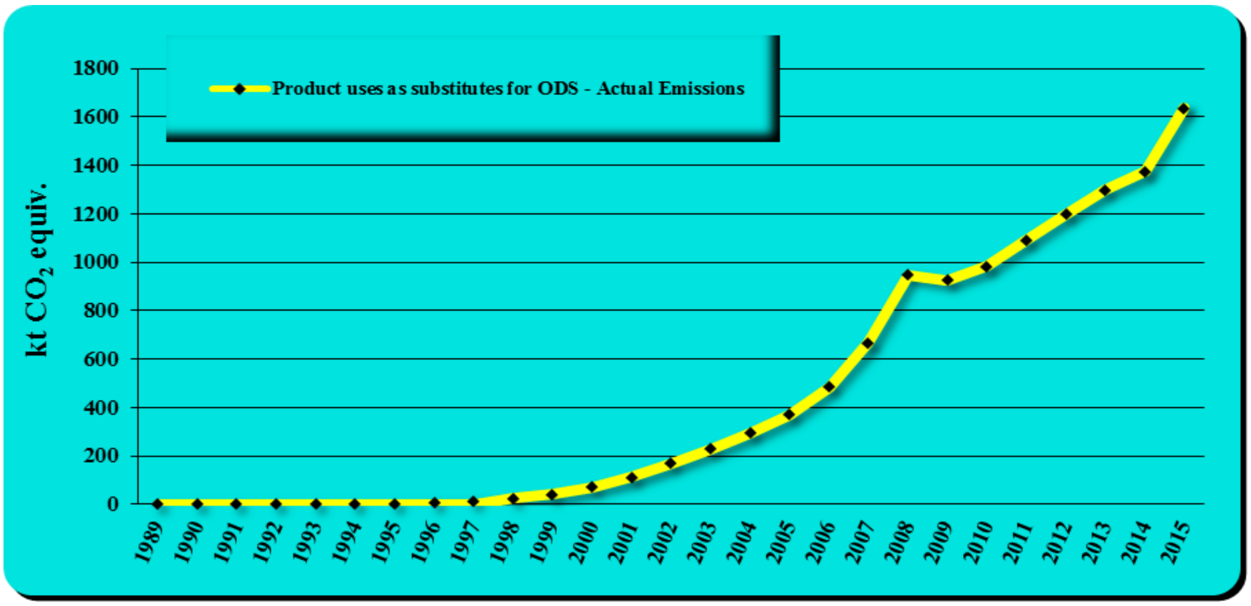


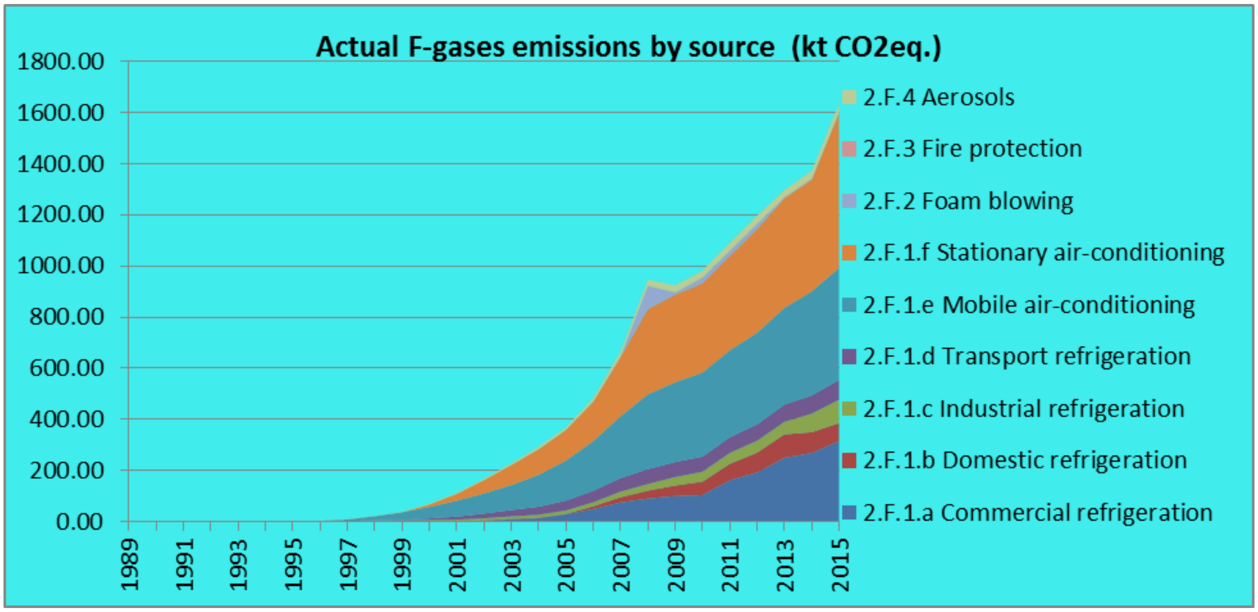
Table 4.41 The Actual emissions in the Product uses as substitutes for ODS Sub–sector for 1989 – 2015 period

Year	Actual emissions [kt CO_2eq.]
1989	0.16
1990	0.18
1991	0.29
1992	0.45
1993	0.73
1994	1.20
1995	2.53

Year	Actual emissions [kt CO_2eq.]
1996	4.72
1997	10.36
1998	23.88
1999	39.73
2000	70.82
2001	112.87
2002	168.16
2003	228.75
2004	293.93
2005	368.91
2006	484.20
2007	665.63
2008	946.95
2009	924.42
2010	982.46
2011	1,092.14
2012	1,197.29
2013	1,298.44
2014	1,373.08
2015	1,636.76

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.

Figure 4.20 Actual F–gases emissions by source for 1989–2015 period



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 bottom-up approach (Tier 2 method), while the choice of emission factors is mostly based on the default IPCC values or it is based on recent EU studies.

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

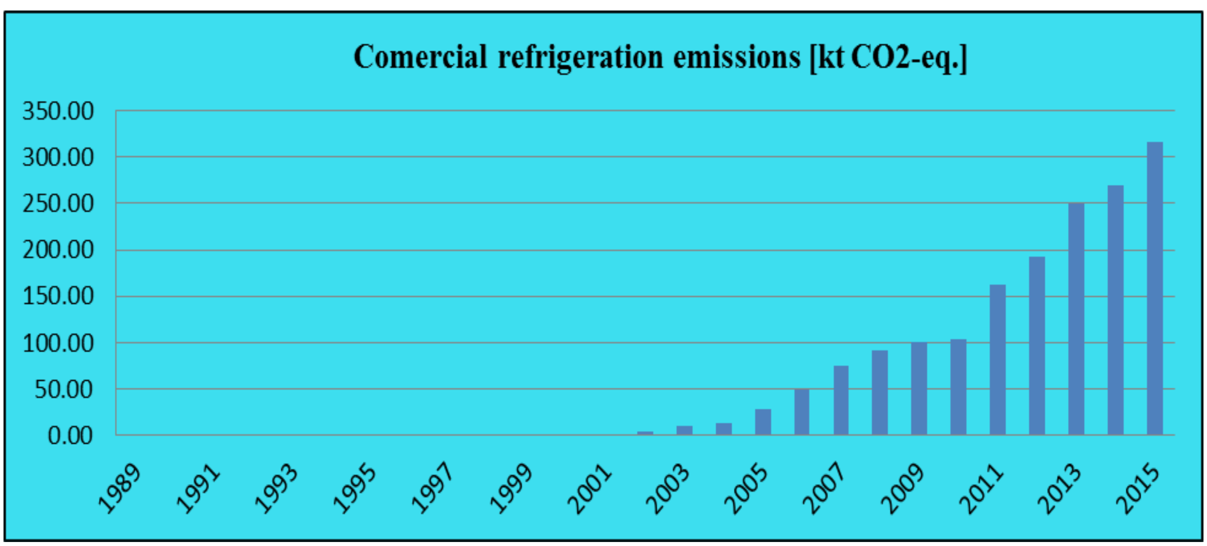
Commercial refrigeration is an increasingly important source of Greenhouse Gas (GHG) emissions, which started to develop after 2000 with the replacement of R-22.

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.

There is also a variety of HFC species, which are used for this sector, but most predominant are R-404A, R-410A, R-407C and HFC-134a. In order to estimate the emissions from this subcategory was applied a top-down Tier 2 approach, estimating the emissions from installation and operation of equipment. The aggregated actual emission estimates are equal to of 315.73 kt CO_2eq. for 2015 year.

The actual emissions for the period are represented on the Figure 4.21.

Figure 4.21 Actual emissions of the Comercial Refrigeration for 1989–2015 period



The quantity of banked HFCs for this subcategory is estimated at 638 t in 2015 year and is presented in Table 4.42.

Table 4.42 The quantity of banked HFC of the Commercial Refrigeration for 1989–2015 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**
1991	0	0	0	0	0	**0**
1992	0	0	0	0	0	**0**
1993	0	0	0	0	0	**0**
1994	0	0	0	0	0	**0**
1995	0	0	0	0	0	**0**
1996	0	0	0	0	0	**0**
1997	0	0	0	0	0	**0**
1998	0	0	0	0	0	**0**
1999	0	0	0	0	0	**0**
2000	0	0	0	0	0	**0**
2001	0	0	0	0	0	**0**
2002	6	7	0	1	0	4
2003	11	17	0	3	0	10
2004	12	26	0	4	0	14
2005	33	55	0	8	0	29
2006	48	94	0	14	0	50
2007	64	143	0	22	0	76
2008	56	178	0	27	0	91
2009	50	201	0	30	0	100
2010	41	211	0	32	0	104
2011	127	306	1	46	0	162
2012	111	370	1	56	0	193

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.]
2013	182	496	1	74	0	250
2014	122	542	0.5	81	0	268
2015	178	638	1	96	0	316

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 842/2006, 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. Most of the licensed companies (about 66%) provided the quantities of HFCs they used for servicing commercial refrigeration and air-conditioning equipment, but 27 companies did not provide any data. For the 2015 year the questionnaire has been sent to 108 companies, only 77 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 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.

Emission factors

The 2000 IPCC GPG and the 2006 IPCC Guidelines provide a very broad range regarding the annual leakage rate – between 10 and 30%. 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, the estimated equipment lifetime of 15 years (EC 2011) does not presume any emissions from disposal yet.

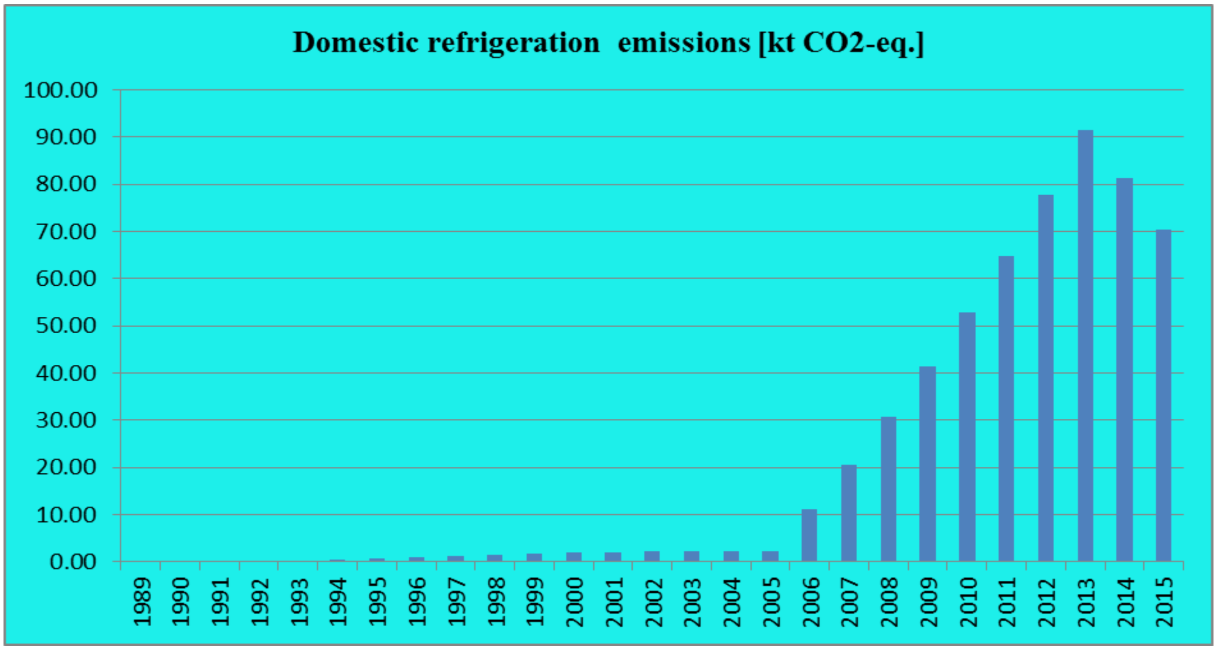
4.7.2.1.2 Domestic Refrigeration (CRF 2.F.1.b)

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 bottom-up Tier 2 approach, which considers the emissions from manufacturing, operation and disposal of domestic refrigeration equipment.

The actual emissions for the period 1989 – 2015 are represented on the Figure 4.22.

Figure 4.22 Actual emissions of the Domestic Refrigeration for 1989–2015 period



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.

The actual emissions for 2015 year from production, operation and decommissioning are equal to 70.38 kt CO_2eq., of which operation emissions are equal to 0.59 Gg.

The detailed results are presented in the Table 4.43.

Table 4.43 The result detailed of the Domestic Refrigeration for 1989–2015 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
1991	18,181.00	54,428.00	2.00	7.00	7.00	13.00	20.00	0.00	0.05

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.]
1992	41,027.00	112,806.00	5.00	14.00	20.00	30.00	60.00	0.00	0.13
1993	69,253.00	174,916.00	8.00	21.00	41.00	50.00	123.00	0.00	0.25
1994	103,852.00	240,959.00	12.00	29.00	70.00	75.00	209.00	0.00	0.41
1995	145,893.00	310,973.00	18.00	37.00	107.00	105.00	321.00	0.00	0.61
1996	196,894.00	385,532.00	24.00	46.00	153.00	142.00	458.00	0.00	0.86
1997	258,996.00	465,793.00	31.00	56.00	208.00	186.00	625.00	0.00	1.16
1998	333,580.00	551,042.00	40.00	66.00	274.00	240.00	821.00	0.00	1.52
1999	323,440.00	490,780.00	39.00	59.00	332.00	233.00	995.00	0.00	1.76
2000	305,233.00	425,453.00	37.00	51.00	382.00	220.00	1,146.00	0.00	1.95
2001	277,187.00	354,929.00	33.00	43.00	423.00	200.00	1,270.00	0.00	2.10
2002	237,472.00	279,335.00	28.00	34.00	456.00	171.00	1,367.00	0.00	2.20
2003	147,929.00	161,146.00	18.00	19.00	474.00	107.00	1,421.00	0.00	2.18
2004	121,632.00	114,059.00	15.00	14.00	486.00	88.00	1,457.00	0.00	2.21
2005	43,075.00	40,087.00	5.00	5.00	489.00	31.00	1,468.00	0.00	2.14
2006	59,806.00	43,971.00	7.00	5.00	487.00	43.00	1,460.00	6,244.00	11.08
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

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 4.44.

Table 4.44 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 provided data for the production of domestic refrigerators was for the period 2003-2015, and for the imports and exports it was for the period 2000–2015. 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 1989–2014.

For the last year the domestic production of refrigerators is around 2 mln. units, but the major part of those is exported. Around 960,000 units were placed on the market in 2015. 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 2011-2015 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 disposal emissions was assumed that the equipment lifetime is 15 y, which is the upper range according to the 2000 IPCC GL. 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 2000 IPCC GPG. 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 2000 IPCC GPG 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.

4.7.2.1.3 Industrial Refrigeration (CRF 2.F.1.c)

Methodology

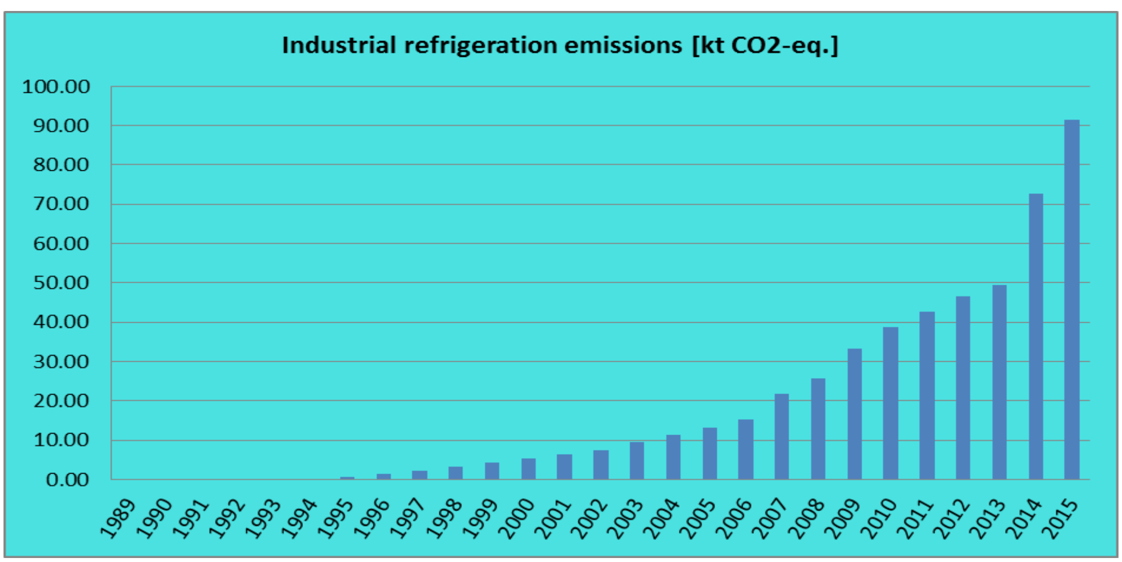
Industrial refrigeration is also an important source of HFC emissions. Similar to commercial refrigeration, after the ban on the CFCs use, imposed by the Montreal Protocol, the main substitute on the market became different types of HFCs. The transition seems to have started as early as 1995 for a limited 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.

The aggregated actual emission estimates are equal to of 91.42 kt CO_2eq. for 2015 year.

In order to estimate the emissions from this subcategory was applied a top-down Tier 2 approach, estimating the emissions from installation and operation of equipment.

The actual emissions for the period 1989–2015 are represented in the Figure 4.23.

Figure 4.23 Actual emissions of the Industrial Refrigeration for 1989–2015 period



The quantity of banked HFCs for this subcategory is estimated at 286 t in 2015 year and is presented in Table 4.45.

Table 4.45 The quantity of banked HFC of the Industrial Refrigeration for 1989–2015 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
1991	0	0	0	0	0	0.00
1992	0	0	0	0	0	0.00
1993	0	0	0	0	0	0.00
1994	0	0	0	0	0	0.00
1995	1	1	0	0	0	0.52
1996	2	3	0	0	0	1.40
1997	3	6	0	1	0	2.28
1998	3	8	0	1	0	3.19
1999	3	10	0	1	0	4.15
2000	4	13	0	1	0	5.21
2001	4	16	0	2	0	6.25
2002	5	20	0	2	0	7.38
2003	8	26	0.1	3	0	9.53
2004	8	32	0.1	3	0	11.31
2005	8	37	0.1	4	0	13.12
2006	10	43	0.1	4	0	15.32
2007	21	60	0.2	6	0	21.77
2008	19	72	0.1	7	0	25.80
2009	32	97	0.2	10	0	33.32
2010	28	115	0.2	12	0.18	38.78

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.]
2011	27	130.5	0.2	13	0.32	42.61
2012	27.5	144.4	0.14	14	0.33	46.66
2013	22.6	152.1	0.07	15.2	0.35	49.38
2014	76.7	213.2	0.61	21.3	0.37	72.74
2015	95.1	286.0	0.73	28.6	0.40	91.42

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. For a detailed description of the methodology please consult the commercial refrigeration subcategory.

Emission factors

The 2000 IPCC GPG and the 2006 IPCC 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 performed by trained personnel, the default assumption from the 2000 IPCC Guidelines about 85% recovery efficiency was adopted.

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.

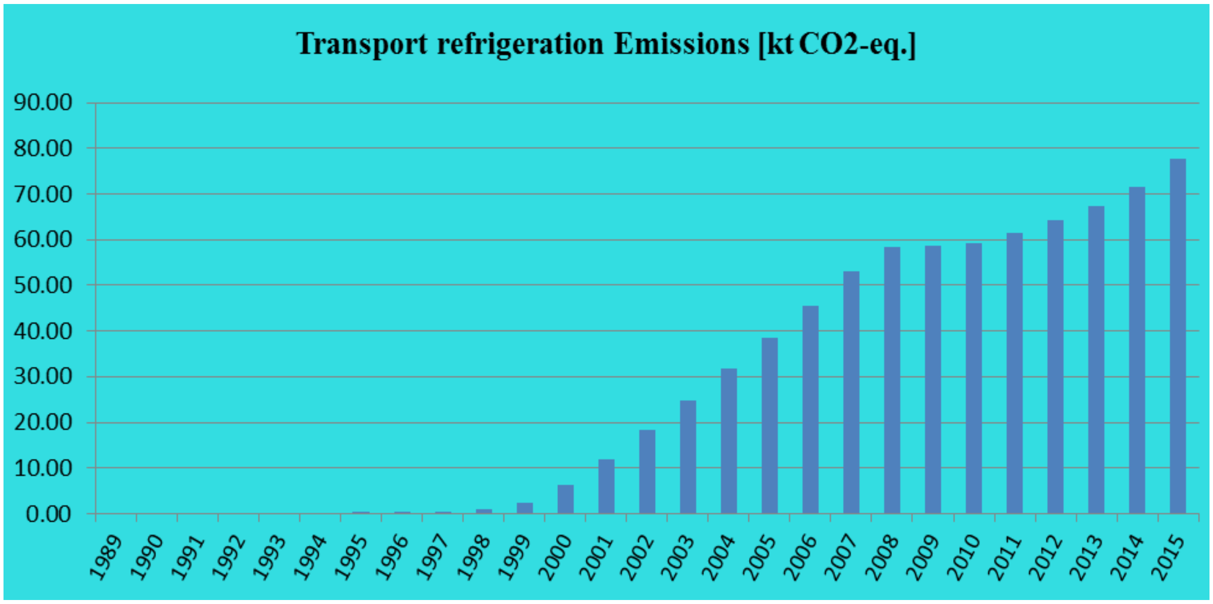
Transport refrigeration vehicles are not produced in the country, so no initial emissions were considered.

The aggregated emission estimates for the two subcategories result in total actual emissions of 77.72 kt CO_2eq. for 2015 year, the majority of which are from refrigerated trucks.

In order to estimate the emissions from this subcategory was applied a bottom-up Tier 2 approach, estimating the emissions from operation and disposal of equipment.

The actual emissions for the period 1989–2015 are represented on the Figure 4.24.

Figure 4.24 Actual emissions of the Transport Refrigeration for 1989–2015 period



The quantity of banked HFCs for this subcategory is estimated at 105.19 t in 2015 year and is presented in Table 4.46.

Table 4.46 The quantity of banked HFC of the Transport Refrigeration for 1989–2015 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
1991	0	0	0	0	0	0
1992	0	0	0	0	0	0
1993	0	0	0	0	0	0
1994	0	0	0	0	0	0
1995	20	0	0	9	0	0.01
1996	54	0	0	25	0	0.04

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.]
1997	215	0	0	97	0	0.14
1998	812	1	2	434	0	0.88
1999	1,596	1	4	947	0	2.22
2000	3,174	3	10	2,237	0	6.28
2001	5,221	4	17	3,968	0	11.84
2002	7,271	4	26	5,880	0	18.35
2003	9,376	3	35	7,805	0	24.83
2004	11,476	3	45	9,829	0	31.83
2005	13,591	3	54	11,815	0	38.61
2006	15,762	4	63	13,833	0	45.47
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
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

Activity data

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 National Environmental Protection Agency (NEPA). 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 2015 as about 15,000 refrigerated vans and 12,700 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 4.47).

Table 4.47 The total number of Refrigeration trucks with HFC-containing units for 1993–2015 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%**

Year	% N1 and N2 trucks with HFC units	% N3 trucks with HFC units
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	100%	100%
2010	100%	100%
2011	100%	100%
2012	100%	100%
2013	100%	100%
2014	100%	100%
2015	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).

For the estimate of the disposal emissions has to be considered the average vehicle lifetime. The 2000 IPCC GPG and 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

Both the 2000 IPCC GPG and 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

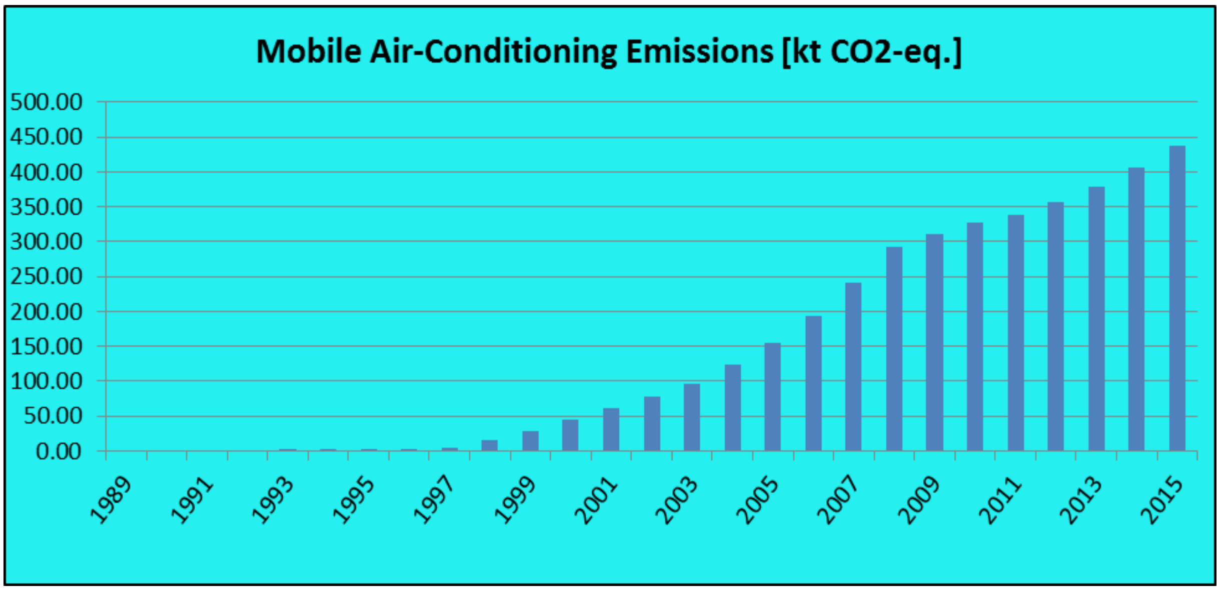
In general, the emissions from Mobile Air Conditioning (MAC) units contribute a significant share from the total F-gases emissions due to the large number of vehicles and the relatively high annual leakage rate. For MAC units there is only one type of HFC, which is used – HFC-134a.

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 437.52 kt CO_2eq. for 2015, the majority of which are from passenger cars. In order to estimate the emissions from the mobile air conditioning subcategory, was applied a bottom-up Tier 2 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 1989–2015 are represented on the Figure 4.25.

Figure 4.25 Actual emissions of the Mobile Air-Conditioning for 1989–2015 period



The initial emissions are estimated to be around 1.2 t of HFC-134a, while the operation emissions are around 304 t and the disposal emissions are around 0.511 t.

There is a large quantity of banked HFCs, estimated at 2,857.85 t in 2015 year and is presented in Table 4.48.

Table 4.48 The quantity of banked HFC of the Mobile Air-Conditioning for 1989–2015 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
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
1993	2,258	189	2	0	0	11	31	0	0
1994	5,384	1,012	5	0	1	24	146	0	0
1995	8,577	3,190	8	1	4	39	422	0	1
1996	13,870	8,001	12	2	8	60	967	0	1
1997	20,927	34,535	18	19	34	88	3,737	0	5
1998	30,029	106,180	24	58	103	122	11,317	0	16
1999	41,511	187,876	33	67	182	164	20,194	0	29
2000	55,817	270,570	43	85	269	213	30,695	0	44
2001	66,997	367,000	50	84	368	250	42,588	0	61
2002	80,388	477,597	58	60	470	291	54,383	0	78
2003	68,298	620,959	48	50	589	241	67,609	0	97
2004	92,405	838,813	63	67	762	317	86,190	0	124

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.]
2005	170,519	1,116,718	114	74	972	570	108,411	0	156
2006	194,802	1,465,572	128	110	1,223	642	134,412	0	193
2007	224,742	1,926,815	146	142	1,545	730	167,797	0	241
2008	225,569	2,423,527	146	212	1,888	728	203,594	0	292
2009	274,307	2,658,001	175	88	2,018	874	216,804	0	311
2010	323,105	2,870,474	204	34	2,129	1,021	228,299	0	328
2011	309,193	3,014,349	195	19	2,205	977	236,227	0	339
2012	318,853	3,228,814	201	88	2,329	1,003	249,056	0	358
2013	394,971	3,464,389	247	109	2,463	1.,236	263,034	0	378
2014	376,079	3,781,923	235.64	118.83	2,648	1,178	282,363	200.55	405.75
2015	371,806	4,140,719	233.39	142.10	2,858	1,167	304,281	511.12	437.52

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.

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 1989-2014.

Regarding passenger cars, for the period 2003-2012 around 30 to 50% of the newly registered vehicles were produced in Romania. From the imported cars around 80% are new cars, with 20% 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. 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 NEPA, 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 2012. 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. 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 4.49).

Table 4.49 The number of new cars, all cars, trucks and busses with HFC-containing units of MAC for1993–2015 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%

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
2005	**94%**	34%	**17%**	**31%**	**21%**	**36%**	**73%**	**88%**	**57%**	**53%**
2006	94%	40%	20%	34%	24%	37%	76%	88%	57%	54%
2007	95%	49%	24%	37%	27%	39%	79%	89%	57%	55%
2008	95%	54%	27%	39%	29%	40%	81%	89%	57%	55%
2009	96%	57%	31%	42%	32%	42%	84%	90%	57%	56%
2010	**96%**	60%	**34%**	**45%**	**35%**	**43%**	**87%**	**90%**	**57%**	**57%**
2011	96%	63%	36%	45%	36%	43%	88%	90%	57%	57%
2012	96%	65%	38%	45%	38%	43%	88%	90%	57%	57%
2013	96%	66%	40%	45%	39%	43%	89%	90%	57%	57%
2014	96%	69%	42%	45%	41%	43%	89%	90%	57%	57%
2015	96%	72%	44%	45%	42%	43%	90%	90%	57%	57%

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

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

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 4.50).

Table 4.50 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

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
2008	0.70	0.64	0.84	0.84	1.00	1.00	1.20	1.20	10.64	11.22
2009	0.68	0.63	0.82	0.82	1.00	1.00	1.20	1.20	10.52	11.06
2010	**0.67**	**0.63**	**0.80**	**0.80**	**1.00**	**1.00**	**1.20**	**1.20**	**10.40**	**10.90**
2011	0.66	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.82
2012	0.65	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.74
2013	0.64	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.66
2014	0.63	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.58
2015	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.50

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. 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). This is the reason why decommissioning emissions are expected to start occurring in 2013 or 2014 year. 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.

Emission factors

Only one vehicle production company 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% from the 2000 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%, which could also be explained by that fact that hardly any vehicle with MAC units are decommissioned.

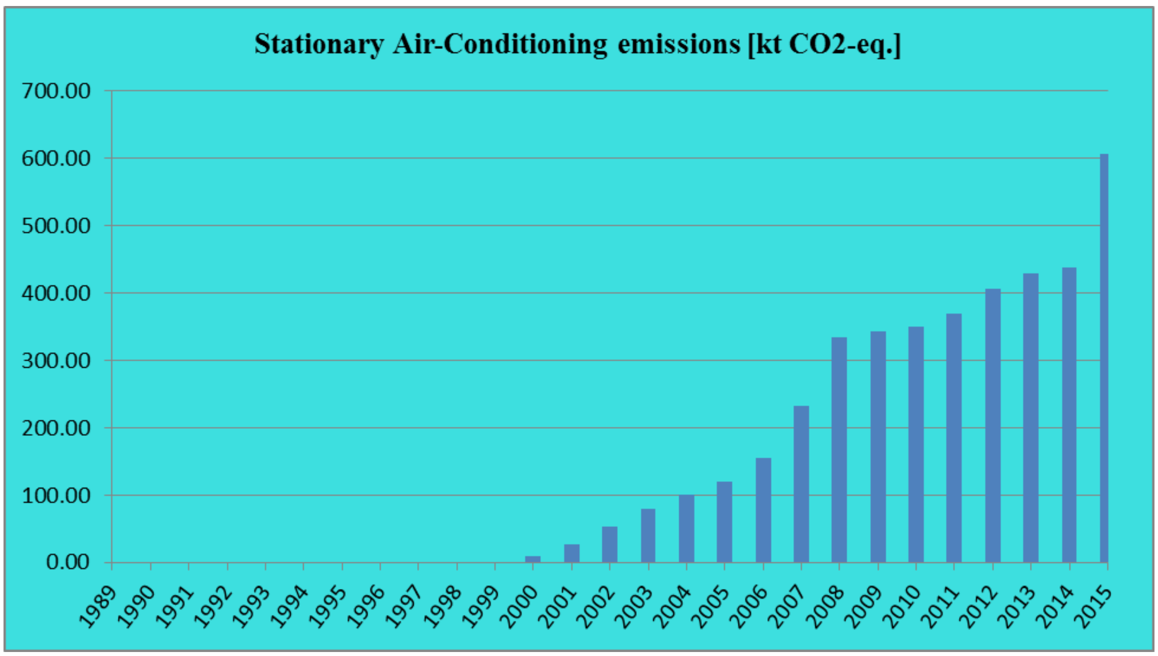
4.7.2.1.6 Stationary Air-Conditioning (CRF 2.F.1.f)

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 bottom-up Tier 2 approach, as for the domestic refrigeration. The actual emissions for the period are represented in the Figure 4.26.

Figure 4.26 Actual emissions of the Stationary Air-Conditioning for 1989–2015 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 2015 year banked quantities are equal to more than 4,100 tons, with additional 419 tons in heat pump units (see Table 4.53). Combined with a higher operation emission factor (related to domestic refrigeration), this leads to significant emission equal to 520.09 kt CO_2 eq. from AC equipment and 85.73 kt CO_2eq. from heat pumps, which are result of mostly operation emissions. Since this equipment is relatively new, it is not expected to produce decommissioning emissions until 2015, but after that the emissions from decommissioned stocks are expected to be significant, if the current decommissioning practices in Romania are not changed.

Table 4.51 The quantity of banked HFC of the Domestic Air-Conditioning for 1989–2015 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
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0
2000	28	63,241	0	109	109	0	4,952	0	10
2001	112	115,162	0	187	292	1	13,572	0	27
2002	251	173,496	0	281	559	2	26,237	0	53
2003	447	188,789	1	300	832	4	39,387	0	79
2004	46	174,358	0	283	1,076	1	50,888	0	101

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.]
2005	0	151,391	0	244	1,292	0	61,097	0	120
2006	0	239,787	0	385	1,657	0	78,446	0	155
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	86,633	605.82

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 4.52.

Table 4.52 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 145,000 AC units and 9,200 heat pumps were placed on the market in 2015 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 2015 year around 217 t of refrigerant have been introduced to the market as contained in AC equipment and 24 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

$$Banks_n = Banks_{n-1} + HFC\ in\ new\ units_n + HFC\ for\ servicing_n -$$
$$- Emissions\ from\ operation_{n-1} - Disposal_n$$

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. For the disposal emissions was assumed that the equipment lifetime is 15 years, which is the upper range according to the 2000 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 are expected to occur in 2015, when the first HFC-containing equipment introduced in the market is 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 4.53.

Table 4.53 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%

From 2009 year onwards, the refrigerant split remains constant.

Emission factors

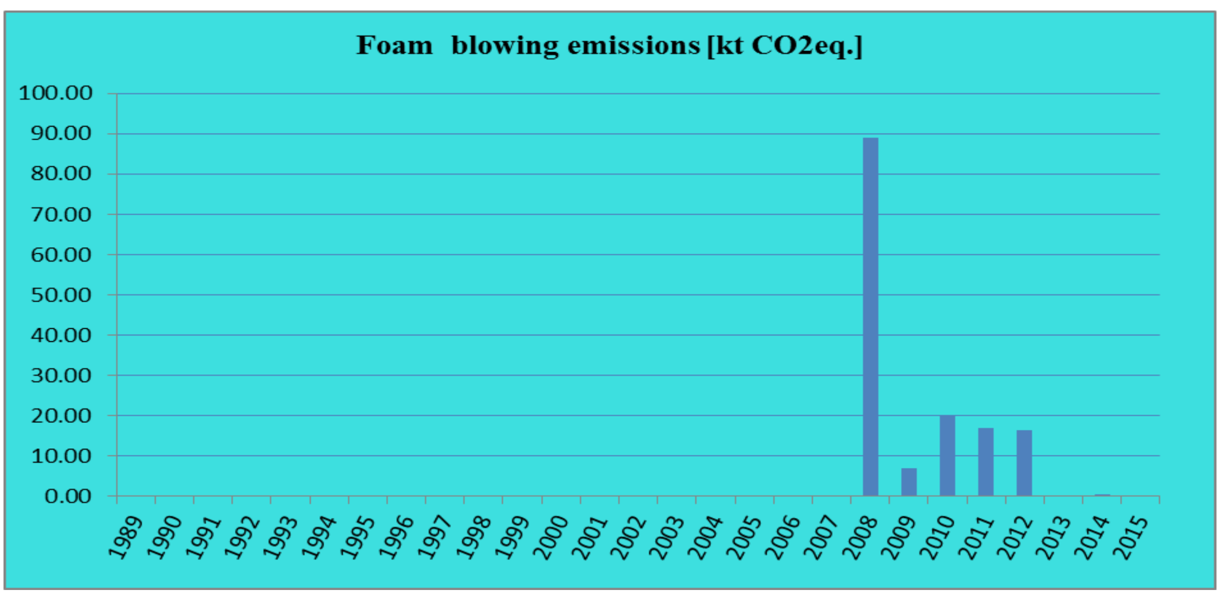
The emission factor used for estimating the manufacturing emissions is the default EF of 0.6% from the 2000 IPCC GPG. The operation emissions are calculated based on The EF for operation is 5.0% annual leak rate for AC units and 3.5% for heat pumps as a percentage of total charge (EC 2011). This is within the default EF range from the 2000 IPCC GPG. Regarding the disposal EF is taken the same conservative assumption as with refrigeration equipment, that 100% of all remaining F-gases contained in the disposed equipment are emitted.

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 bottom-up Tier 2 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. In 2015 the company is producing closed-cell (PU spray) foams with HFC-152a. The products manufactured were exported. In 2015 year, the actual emissions from foam blowing were 0.05 kt CO_2eq. (see Figure 4.27).

Figure 4.27 Actual emissions of the Foam Blowing for 1989–2015 period



The banked quantities of HFCs are estimated to be around 3.26 t in 2014 year and are shown in Table 4.54.

Table 4.54 The quantity of banked HFC of the Foam Blowing for 1989–2015 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
1991	0.0	0.0	0	0	0.0
1992	0.0	0.0	0	0	0.0
1993	0.0	0.0	0	0	0.0
1994	0.0	0.0	0	0	0.0
1995	0.0	0.0	0	0	0.0
1996	0.0	0.0	0	0	0.0
1997	0.0	0.0	0	0	0.0
1998	0.0	0.0	0	0	0.0
1999	0.0	0.0	0	0	0.0
2000	0.0	0.0	0	0	0.0
2001	0.0	0.0	0	0	0.0
2002	0.0	0.0	0	0	0.0
2003	0.0	0.0	0	0	0.0
2004	0.0	0.0	0	0	0.0
2005	0.0	0.0	0	0	0.0
2006	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
2012	12.2	1.09	11,528	16.43	16.45
2013	0.625	1.61	93.73	24.15	0.12

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFCs]	Operation emissions [kg HFCs]	Actual emissions [kt CO_2eq.]
2014	1.97	3.26	294.95	48.86	0.34
2015	0.00	3.21	0.00	48.12	0.05

Activity data

The data about quantities of HFCs were obtained from questionnaires sent to a large number of companies (above 500), which were chosen based on their NACE activity code. These included both companies from the chemical sector and from the industrial sector (like producers of matrasses, water heaters, etc.). 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. 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 2000 IPCC GPG and 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 26 t in 2015 year and while its usage in Romania started in 1996 year, the market started to grow significantly after 2006 year (see Table 4.55). In order to estimate the emissions from fire protection equipment subcategory, was applied a bottom-up Tier 2 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. The actual emissions in 2015 year are estimated to be about 4.18 kt CO_2eq (Figure 4.28).

Figure 4.28 Actual emissions of the Fire Protection for 1989–2015 period

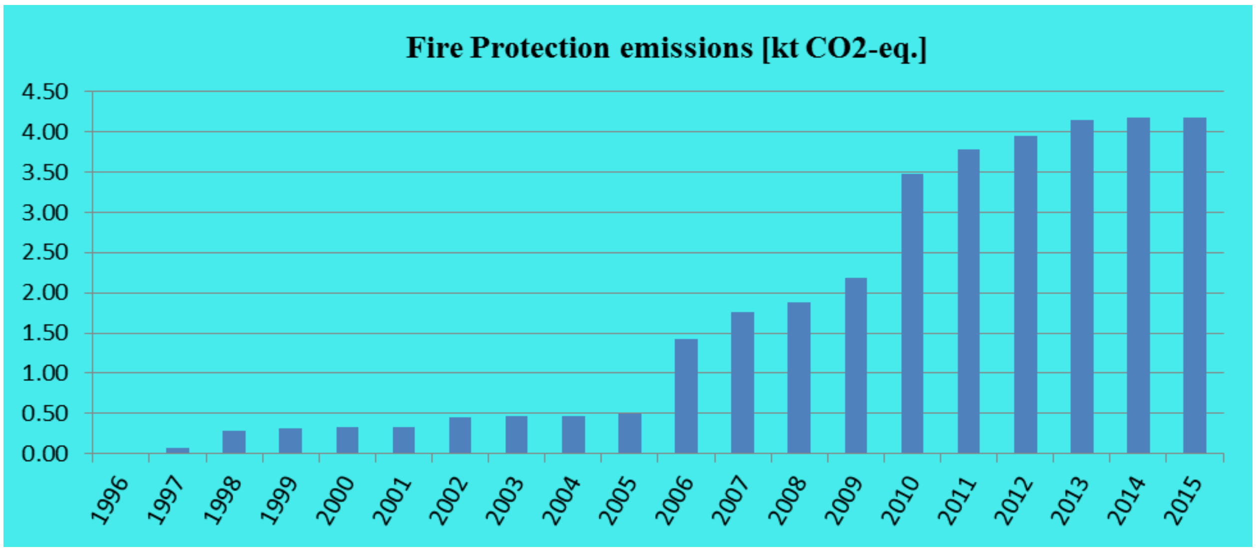


Table 4.55 The quantity of banked HFC of the Fire Protection for 1989–2015 period

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
1991	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00
1996	0.09	0.09	4.55	0.01

Year	HFCs placed on the market [t]	Quantity of banks [t]	Operation emissions [kg HFC]	Actual emissions [kt CO_2eq.]
1997	0.34	0.43	21.66	0.07
1998	1.37	1.81	90.33	0.29
1999	0.19	1.99	99.68	0.32
2000	0.08	2.07	103.61	0.33
2001	0.00	2.07	103.61	0.33
2002	0.78	2.85	142.40	0.46
2003	0.07	2.92	145.87	0.47
2004	0.00	2.92	145.87	0.47
2005	0.19	3.10	155.12	0.50
2006	5.74	8.84	441.89	1.42
2007	2.13	10.97	548.39	1.77
2008	0.68	11.65	582.39	1.88
2009	1.95	13.60	679.78	2.19
2010	8.01	21.60	1,080.20	3.48
2011	1.90	23.50	1,174.95	3.78
2012	1.03	24.53	1,226.25	3.95
2013	1.25	25.78	1,288.74	4.15
2014	0.17	25.95	1,297.34	4.18
2015	0.00	25.95	1,297.34	4.18

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/l1.

Emission factors

The 2000 IPCC GPG provide a default emission factor of 5% annually. The 2006 IPCC Guidelines provide an updated range of 2 to 6% annual leakage. 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%. 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.

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,

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

[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

although the research showed only the use of HFC-134a. The emissions from use of MDIs were estimated based on questionnaires provided by pharmaceutical companies – for 2015 more than 1.2 mln. MDIs were sold on the market, the emissions from which amount to 33.95 kt CO_2eq (see Table 4.56).

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 bottom-up Tier 2a approach, which considers the aerosol use emissions. This subcategory is a not a key category.

Figure 4.29 Actual emissions of the Aerosols/Metered Dose Inhalers for 1989–2015 period

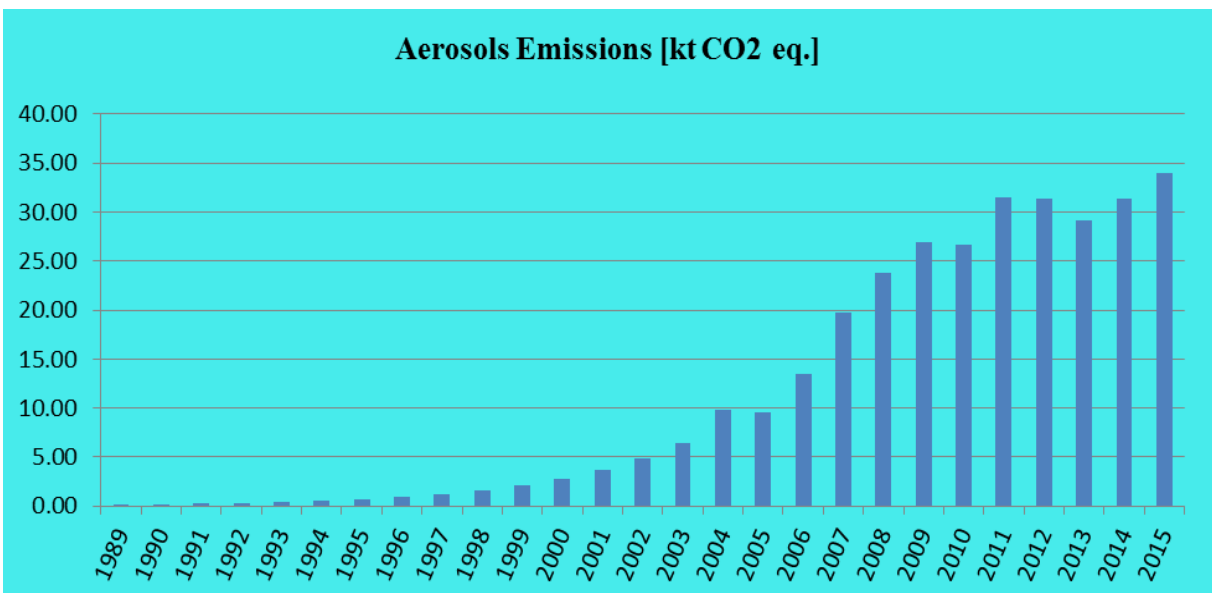


Table 4.56 The quantity of banked HFC of the Aerosols/Metered Dose Inhalers for 1989–2015 period

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFC]	Operation emissionsm [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
1991	0.19	0.10	95.68	72.11	0.24
1992	0.25	0.13	126.47	95.68	0.32
1993	0.33	0.17	166.19	126.47	0.42
1994	0.44	0.22	218.10	166.19	0.55
1995	0.57	0.29	285.74	218.10	0.72
1996	0.75	0.37	374.94	285.74	0.94
1997	0.99	0.49	494.80	374.94	1.24
1998	1.30	0.65	652.28	494.80	1.64
1999	1.72	0.86	858.22	652.28	2.16
2000	2.25	1.13	1,127.38	858.22	2.84
2001	2.96	1.48	1,478.44	1,127.38	3.73
2002	3.88	1.94	1,939.24	1,478.44	4.89
2003	5.09	2.54	2,543.40	1,939.24	6.41
2004	8.75	4.37	4,374.64	2,543.40	9.89
2005	4.56	2.28	2,279.06	4,374.64	9.51
2006	14.35	7.18	7,175.09	2,279.06	13.52
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

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFC]	Operation emissionsm [kg HFC]	Actual emissions [kt CO_2eq.]
2013	21.14	10.57	10,568.92	9,779.65	29.10
2014	22.66	11.33	11,328.28	10,568.92	31.31
2015	24.82	12.41	12,410.87	11,328.28	33.95

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. 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 3.35 form the 2000 IPCC GPG 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 1989–2015.

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 Transport and Fugitive Emissions from Fuels subsectors, 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 2015 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 4.7.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend and at the Chapter 10 - Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 4.7.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.

All noted unconformities following the UNFCCC review of the 2015 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

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:***
  - Domestic refrigeration sub-sector (CRF 2.F.1.b).
  - Industrial refrigeration sub-sector (CRF 2.F.1.b).

Recalculation of the HFC emissions have been made for the 2011-2014 year. Recalculations were made as a result of due to the changes in activity data for those years (CRF Category 2.F.1.b) and for 2014 year (CRF Category 2.F.1.c).

Table 4.57 The effects of recalculations in Product uses as substitutes for ODS Sub–sector

The effects of recalculations in Product uses as substitutes for ODS Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	HFC emissions [kt CO_2 equivalent]		
1989	0.16	0.16	0.00
1990	0.18	0.18	0.00
1991	0.29	0.29	0.00
1992	0.45	0.45	0.00
1993	0.73	0.73	0.00
1994	1.20	1.20	0.00
1995	2.53	2.53	0.00
1996	4.72	4.72	0.00
1997	10.36	10.36	0.00
1998	23.88	23.88	0.00
1999	39.73	39.73	0.00
2000	70.82	70.82	0.00
2001	112.87	112.87	0.00
2002	168.16	168.16	0.00
2003	228.75	228.75	0.00
2004	293.93	293.93	0.00
2005	368.91	368.91	0.00
2006	484.20	484.20	0.00
2007	665.63	665.63	0.00
2008	946.95	946.95	0.00
2009	924.42	924.42	0.00

The effects of recalculations in Product uses as substitutes for ODS Sector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	HFC emissions [kt CO_2 equivalent]		
2010	982.46	982.46	0.00
2011	1,092.24	1,092.14	-0.01
2012	1,197.43	1,197.29	-0.01
2013	1,298.59	1,298.44	-0.01
2014	1,373.28	1,373.08	-0.01
2015		1,636.76	

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

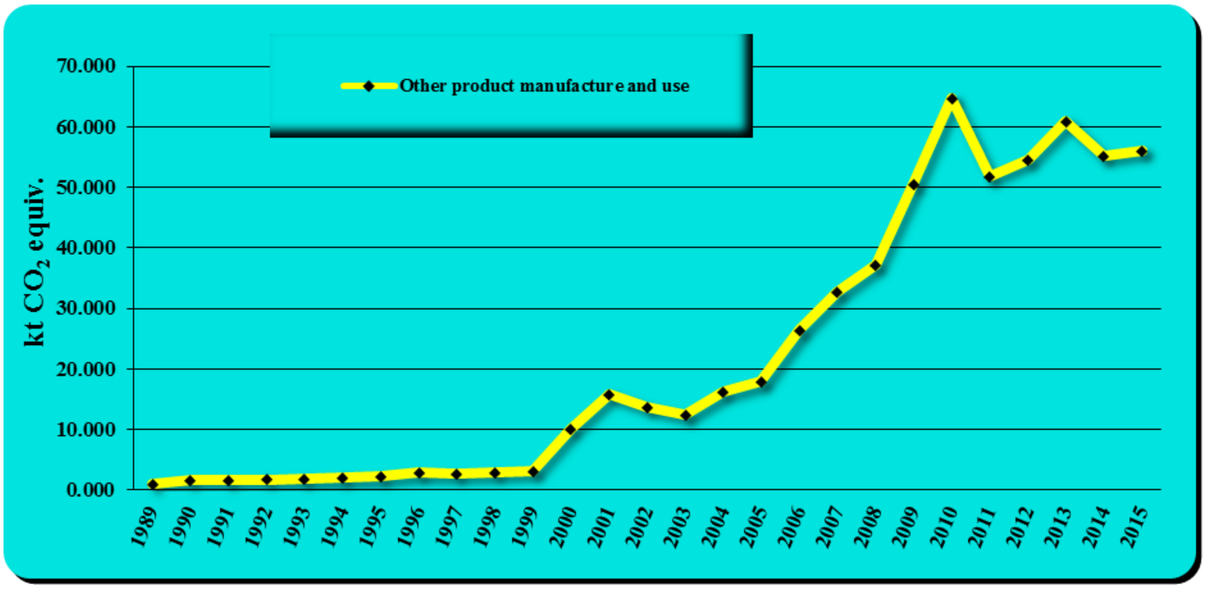
More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

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).

Figure 4.30 GHG emissions trend in the Other product manufacture and use Sub–sector for 1995–2015 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 recent years (2011 and 2012) the installation of new equipment has been slowing down, which leads to a decreasing trend in emissions. Most of the banked quantities of SF_6 are contained in closed pressure equipment (around 68% of the total quantity or 78 t in 2015 year), while the rest is banked in sealed pressure equipment (36 t in 2015 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 52.27 kt CO_2eq. in 2015 year (see Table 4.58). 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 4.31 Actual emissions of the Electrical Equipment for 1989–2015 period

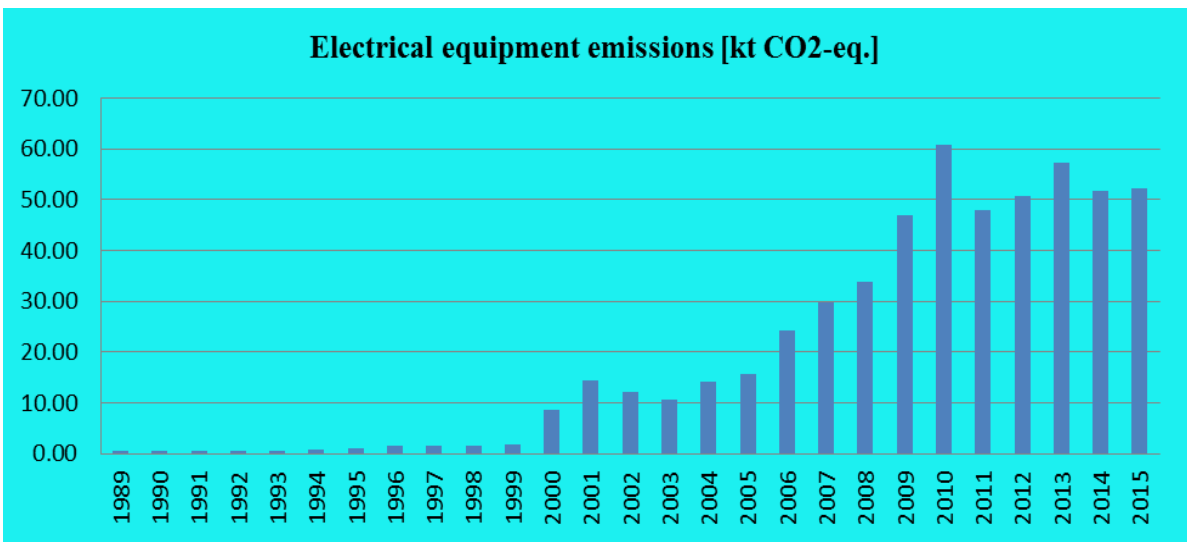


Table 4.58 The quantity of banked HFC of the Electrical Equipment for 1989–2015 period

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
1991	0.02	0.82	1.53	21.29	0.00	0.52
1992	0.00	0.82	0.00	21.29	0.00	0.49

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.]
1993	0.01	0.84	1.19	21.66	0.00	0.52
1994	0.10	0.93	8.16	24.15	0.00	0.74
1995	0.17	1.10	14.28	28.52	0.00	0.98
1996	0.36	1.47	29.87	37.66	0.00	1.54
1997	0.36	1.82	18.23	43.24	0.00	1.41
1998	0.31	2.14	17.34	48.54	0.00	1.51
1999	0.24	2.38	19.66	54.55	0.00	1.70
2000	3.06	5.44	249.26	130.80	0.00	8.68
2001	4.70	10.14	380.25	247.11	0.00	14.33
2002	2.95	13.10	215.28	312.96	0.22	12.10
2003	1.86	14.96	111.83	347.16	0.22	10.54
2004	3.06	18.02	203.46	409.40	0.90	14.10
2005	2.32	20.34	171.09	461.73	49.20	15.67
2006	6.08	26.41	419.06	589.92	41.93	24.13
2007	7.98	34.39	532.29	752.74	14.70	29.88
2008	9.19	43.58	530.79	915.09	21.15	33.83
2009	13.72	57.30	842.92	1,172.93	22.65	47.03
2010	21.35	78.65	1,105.83	1,511.18	4.45	60.71
2011	8.20	86.85	386.90	1,629.53	33.14	47.83
2012	8.03	94.88	393.46	1,749.88	27.68	50.76
2013	7.52	102.40	527.69	1,969.07	12.15	57.20
2014	5.38	107.78	212.74	2,039.89	18.48	51.78
2015	6.20	113.98	165.07	2098.90	28.61	52.27

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 2007-2015 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.F.8)

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 1989–2015.

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 Transport and Fugitive Emissions from Fuels subsectors, 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 2015 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 4.8.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend and at the Chapter 10 - Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 4.8.5 – Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.

All noted unconformities following the UNFCCC review of the 2015 submission of the NGHGI are described at the Improvements list level, their solving being envisaged as planned improvement.

4.8.5 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:***
    - N_2O from product uses (CRF 2.G.3).

Table 4.59 The effects of recalculations in Other Product Manufacture and Use Sector

The effects of recalculations in Other Product Manufacture and Use Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences**
	Emissions (kt CO_2 equivalent)		**[%]**
1989	0.97	0.98	1.50
1990	1.42	1.45	2.04
1991	1.51	1.54	1.92
1992	1.61	1.64	1.80

The effects of recalculations in Other Product Manufacture and Use Sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences**
	Emissions (kt CO_2 equivalent)		**[%]**
1993	1.64	1.67	1.77
1994	1.84	1.87	1.58
1995	2.12	2.15	1.37
1996	2.69	2.72	1.08
1997	2.59	2.62	1.12
1998	2.75	2.78	1.06
1999	2.96	3.05	3.32
2000	10.09	10.08	-0.06
2001	15.92	15.76	-1.04
2002	13.82	13.66	-1.13
2003	12.54	12.32	-1.76
2004	16.37	16.07	-1.83
2005	18.22	17.78	-2.39
2006	26.82	26.24	-2.14
2007	32.63	32.56	-0.21
2008	36.61	37.13	1.43
2009	49.97	50.43	0.92
2010	64.33	64.62	0.46
2011	51.63	51.79	0.30
2012	54.43	54.55	0.22
2013	60.74	60.74	0.00
2014	55.19	55.05	-0.26
2015		56.01	

Recalculation have been made for the entire period 1989-2014. Recalculations were made as a result of due to the improvements on estimating N_2O emissions. (CRF Category 2.G.3a and 2.G.3b).

Table 4.60 The effects of recalculations in N_2O from Product Uses Sub-sector

The effects of recalculations in N_2O from Product Uses Sub-sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences**
	N_2O emissions [kt CO_2 equivalent]		**[%]**
1989	0.49	0.51	2.95
1990	0.95	0.98	3.07
1991	0.99	1.02	2.94
1992	1.12	1.15	2.58
1993	1.12	1.15	2.59
1994	1.11	1.13	2.63
1995	1.14	1.17	2.55
1996	1.15	1.18	2.53
1997	1.18	1.21	2.46
1998	1.23	1.26	2.35
1999	1.25	1.35	7.85
2000	1.40	1.40	-0.44
2001	1.59	1.43	-10.44
2002	1.72	1.56	-9.11
2003	2.00	1.78	-11.08
2004	2.27	1.97	-13.17
2005	2.55	2.12	-17.05
2006	2.69	2.11	-21.39
2007	2.75	2.68	-2.51
2008	2.78	3.30	18.77
2009	2.94	3.40	15.65
2010	3.62	3.92	8.19
2011	3.80	3.96	4.03
2012	3.68	3.79	3.21
2013	3.54	3.54	0.02

The effects of recalculations in N_2O from Product Uses Sub-sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences**
	N_2O emissions [kt CO_2 equivalent]		**[%]**
2014	3.41	3.27	-4.19
2015		3.74	

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

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
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
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

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
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
3B.2.4.1. Rabbits	NA	NO	NA
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

IPCC category	Emissions estimation status		
	CH_4	N_2O	CO_2
3D.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	✓	NA
3.D.1.6 Cultivation of Organic Soils	NA	✓	NA
3.D.1.7.Other	NA	✓	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 GPG 2006 provisions, N_2O emissions from Daily spread and 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 1989–2015 period

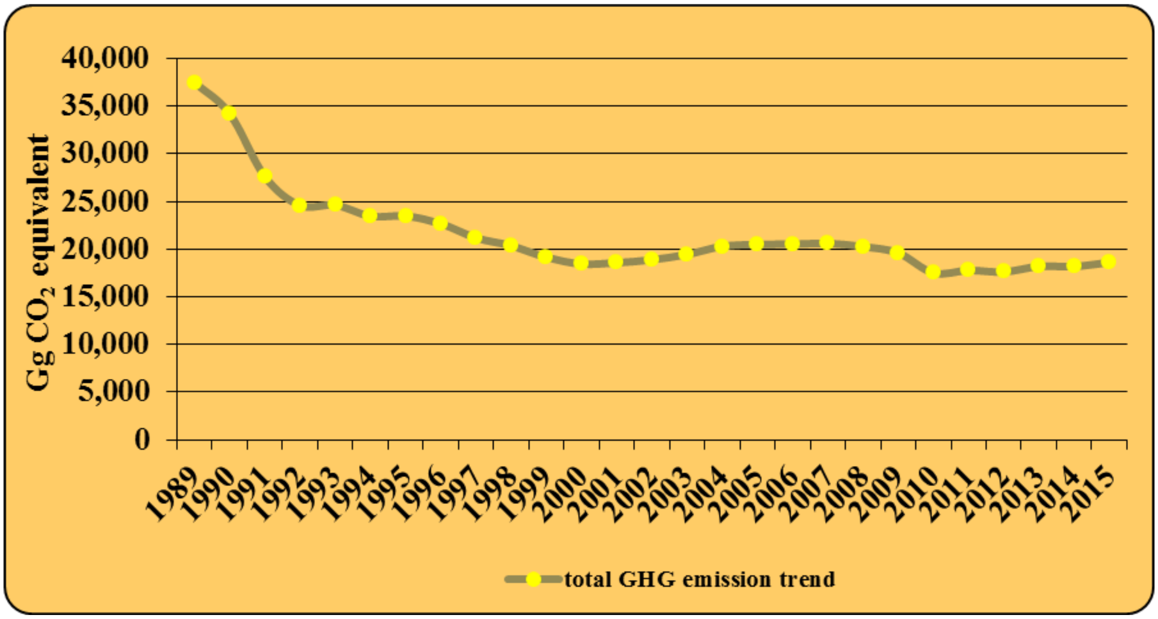
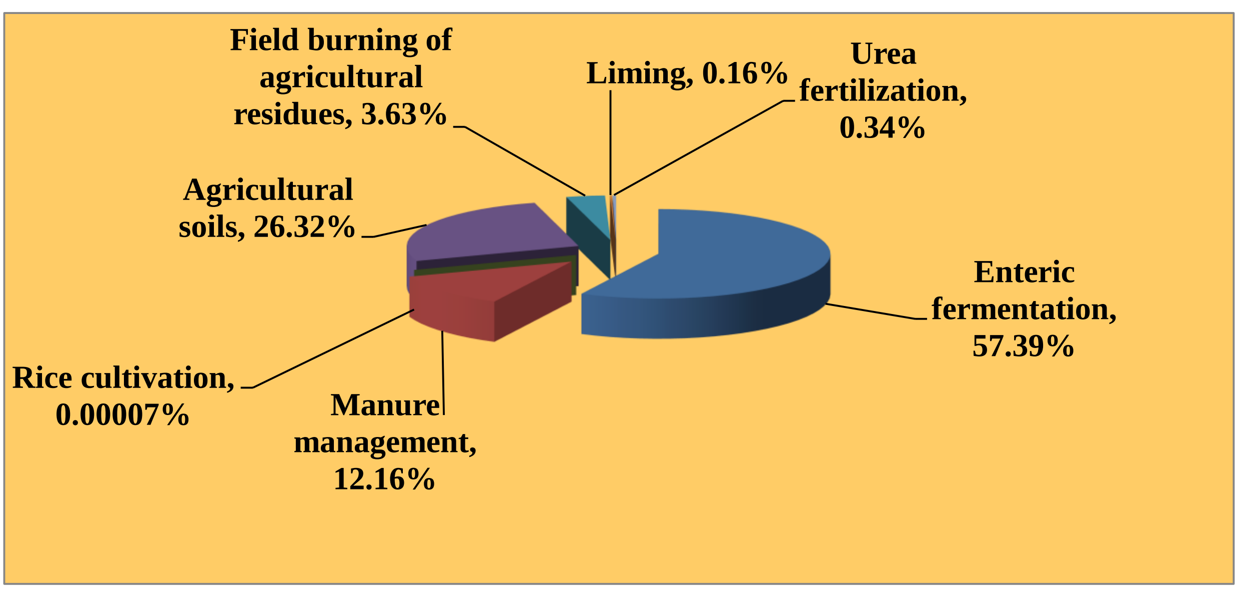


Figure 5.2 Contribution of the sub-sectors in the total GHG emissions from Agriculture, in 2015 year



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 1989-2015 period.

Emissions from prescribed burning of savannas do not occur in Romania.

The Agriculture Sector accounted for 15.99% of the total GHG emissions in 2015, reaching 18613.03 kt CO_2 equivalent (Table 5.2).

Within the GHG emissions from the agriculture sector, the CH_4 emissions have the largest contribution (in 2015, CH_4 emissions contribution is 68.67% to the total Agriculture Sector's CO_2 equivalent emissions), followed by the N_2O emissions (that account for the remaining 30.82%).

Over the period 1989 – 2015, the GHG emissions resulted from Agriculture Sector decreased by 50.37% (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 2015 there were registered 374,623 heads Annex 3.5 (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 2004-2015 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 2014 year, in 2015 were slowly increased some livestock categories for exemple: cattle, sheeps, goats and poultry.

The rice cultivation generated in 2015 a significantly reduced emission compared to the base year 1989 due to the decrease of areas (72.98% decrease comparing with the base year).

In case of agricultural soils, the emissions decreased over the period (48.48% decrease in 2015 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 2015 with 51.32% compared to basic (see Annex 3.5 - 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 2015 with 47.78% comparing with the base year (see Annex 3.3 - 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 1989–2015

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	301,359.00	37,508.85	12.45	26,256.03	70.00	10,986.52	29.29
1990	246,271.86	34,222.10	13.90	23,791.49	69.52	10,248.09	29.95
1991	203,183.45	27,612.83	13.59	20,092.59	72.77	7,441.13	26.95
1992	187,102.76	24,599.07	13.15	18,097.01	73.57	6,427.95	26.13
1993	177,799.21	24,635.64	13.86	17,534.19	71.17	7,011.11	28.46
1994	174,505.21	23,465.59	13.45	16,647.42	70.94	6,708.74	28.59
1995	181,112.91	23,484.56	12.97	16,483.46	70.19	6,903.39	29.40
1996	183,883.61	22,673.56	12.33	16,289.76	71.84	6,286.07	27.72
1997	171,745.73	21,190.96	12.34	14,691.28	69.33	6,412.95	30.26
1998	152,203.29	20,365.59	13.38	14,415.25	70.78	5,861.12	28.78
1999	134,361.24	19,147.67	14.25	13,587.52	70.96	5,486.42	28.65
2000	140,163.06	18,456.03	13.17	13,359.96	72.39	4,993.17	27.05
2001	147,244.17	18,580.83	12.62	12,833.16	69.07	5,626.57	30.28
2002	145,935.95	18,892.92	12.95	13,477.21	71.33	5,309.74	28.10
2003	150,525.60	19,451.89	12.92	13,906.91	71.49	5,422.14	27.87
2004	149,161.45	20,302.75	13.61	13,796.04	67.95	6,370.62	31.38
2005	146,454.48	20,505.81	14.00	14,124.64	68.88	6,242.63	30.44
2006	147,841.16	20,522.75	13.88	14,709.69	71.68	5,683.40	27.69
2007	150,878.01	20,613.75	13.66	15,145.94	73.47	5,350.38	25.96

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 [%]
2008	145,828.88	20,261.46	13.89	14,435.09	71.24	5,689.39	28.08
2009	126,571.89	19,605.96	15.49	13,973.41	71.27	5,509.49	28.10
2010	120,899.59	17,505.79	14.48	12,168.56	69.51	5,230.02	29.88
2011	126,992.67	17,774.04	14.00	12,142.80	68.32	5,540.59	31.17
2012	124,418.24	17,623.42	14.16	12,527.18	71.08	5,019.61	28.48
2013	115,389.18	18,193.88	15.77	12,380.27	68.05	5,723.71	31.46
2014	115,413.19	18,190.23	15.76	12,549.87	68.99	5,558.21	30.56
2015	116,426.72	18,613.03	15.99	12,781.24	68.67	5,737.45	30.82

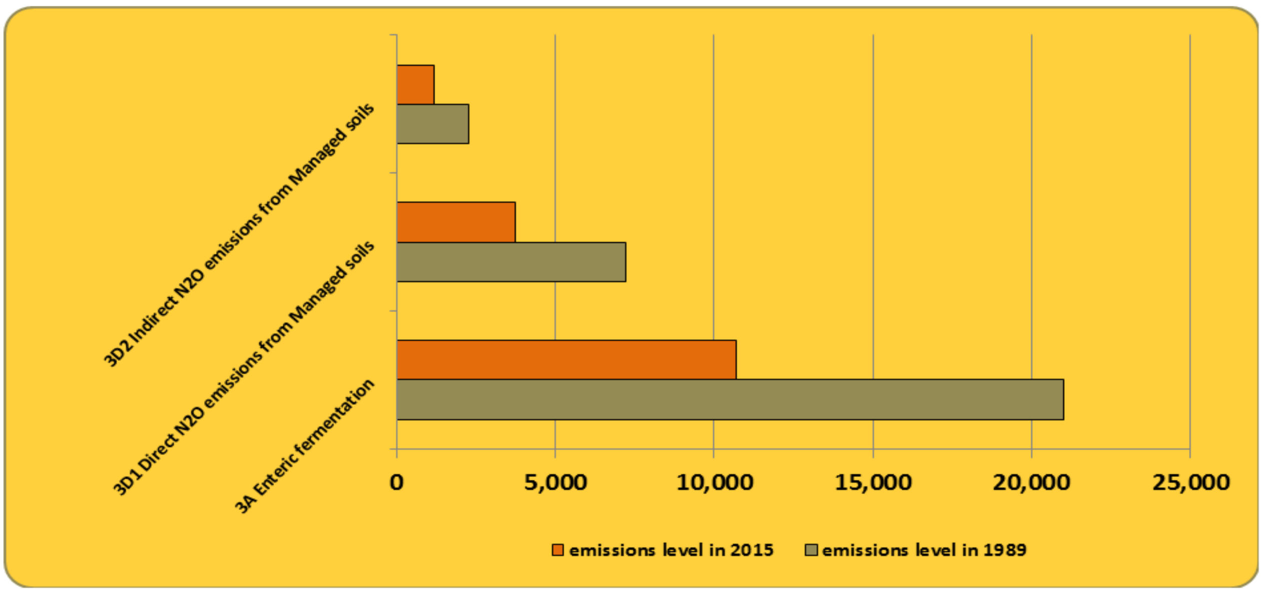
Table 5.3 and Figure 5.3 describe Key categories in Agriculture, both from level and trend and including and excluding LULUCF views.

Table 5.3 Key categories overview – Agriculture, 2015

Key categories	GHG	Criteria	Contribution in total GHG emissions [%]
3.A Enteric fermentation	CH_4	L,T (Tier 1, excluding and including LULUCF)	**9.17**
3.D.1 Direct N_2O emissions from Managed soils	N_2O	L,T (Tier 1, excluding and including LULUCF)	**3.20**

Key categories	GHG	Criteria	Contribution in total GHG emissions [%]
3.D.2 Indirect N_2O emissions from Managed soils	N_2O	L,T (Tier 1, excluding and including LULUCF)	**1.00**

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 main source of CH_4 emissions in the Agriculture sector (in 2015, CH_4 emissions from Enteric Fermentation represented 83.57% of total CH_4 emissions in the Agriculture sector);
- is the second source in the Agriculture sector (in 2015, CH_4 emissions from Enteric Fermentation as CO_2 equivalent represented 57.39% from Total Agriculture emissions);
- contributed with 9.17% to Total GHG emissions of Romania.

Compared to 1989, total CH_4 emissions from Enteric Fermentation decreased with 49.19 % in 2015 (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

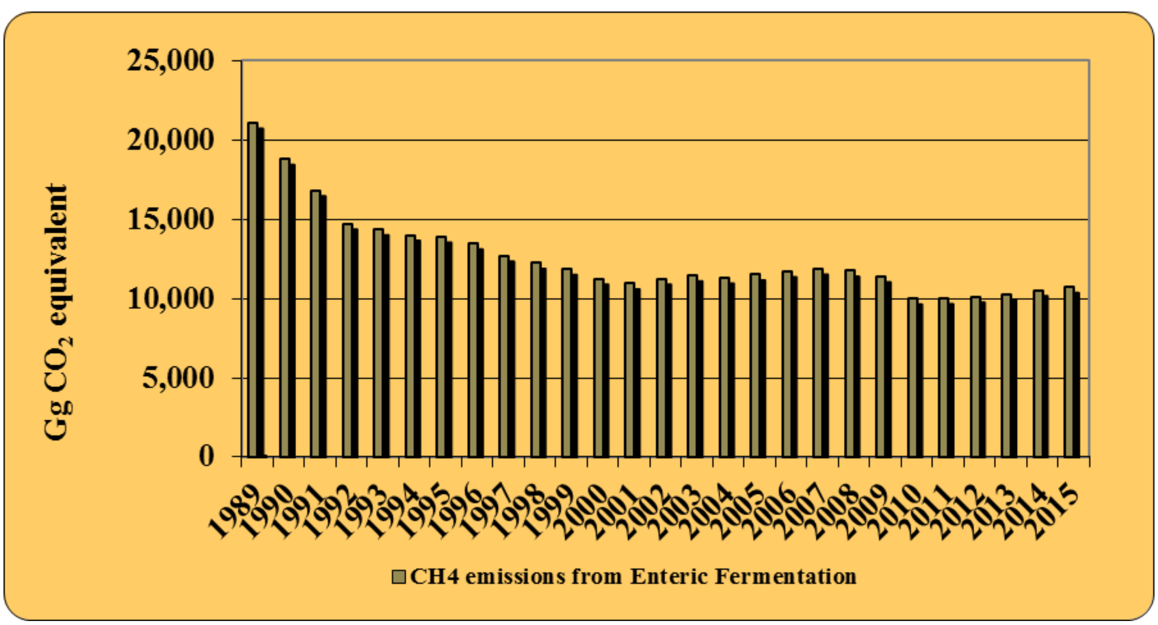


Table 5.4 Observations on source category 3A – "Enteric Fermentation"

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, 2004-2015 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, 2004-2015; EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
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, 2004-2015 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, 2004-2015; EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
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, 2004-2015; EF: IPCC 2006, IPCC GPG 2000,

Source indicative	Source (livestock) type	Observation	Data source
3.A.4	Horses		AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2015; EF:IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	Mules and asses		AD: FAO, 2011; EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	Poultry	Includes livestock data from two different *poultry*: *adult poultry for eggs, poultry for meat*	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2015 EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	Rabbits		AD: NIS, 1989-2015 EF: 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 all species, according to the provisions in the IPCC 2006 decision tree. There are national data available for every species and subcategory for to estimate the methane emission according with the level 2 method.

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).

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 cattle, buffalo, sheep, goats and horses productions. For poultry and 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 (unnitrous substances extractable) = 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 = unnitrous substances extractable

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). 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) 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), 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:				
Cattle	5.79	8.15	4.42	4.06
Swine	5.78	9.42	4.4	4.07
Poultry	5.72	9.5	4.23	4.23
Equation for calculating	$x_1 \cdot e_1$	$x_2 \cdot e_2$	$x_3 \cdot e_3$	$x_4 \cdot e_4$

The categories and subcategories for which were the calculated rations are given below:

- For ***calves for slaughter younger than 1 year***, with an average weight of 250 kg and average daily gain of 1000 g/day, it was considered a ration that may contain 3 kg mountain hay, 10 kg pickled corn, mixture of farm 3 kg, ration which corresponds to an energy intake of 143.07 MJ, DE (MJ) = 81.23 and DE (%)= 56.77.
- For ***young cattle of breeding under 1 year***, with an average weight of 250 kg and average daily gain of 600 g/day can be given a ration consisting of : 2 kg hill hay, 10 kg corn silage, 2.3 kg mixture of farm, meaning GE = 115.5 MJ, DE = 65.8 MJ and DE (%) =56.97.
- For ***young cattle of breeding between 1 and 2 years,*** with an average weight of 350 kg and average daily gain of 600 g/day, can be given a ration of type: 2 kg hill hay, 10 kg corn silage, 2 kg clover hay and 2.3 kg mixture of farm, with a GE = 146.83 MJ, DE = 81.49 MJ and DE (%) = 55.49.

- For ***young cattle of slaughter between 1 and 2 years*** was considered a subcategory**,** with an average weight of 400 kg and average daily gain of 1100 g/day. The ration contains 6 kg hay mountain, 2 kg clover hay, 10 kg pickled corn and 3 kg mixture of farm. The ration total caloricity is 531,36.58 kcal, equivalent to 222.33 MJ, DE = 152.63 MJ, DE (%) = 68.65.
- ***Cattle 2 years and over- Breeding bulls*** (815 kg average weight) ingest a ration of 8 kg hay of lucerne, 11 kg pickled corn, 4 kg feed carrots, 3.3 kg mixture of farm, ration, with a caloricity average GE = 241.68 MJ, DE = 132.94MJ, DE (%) = 55.
- For **cattle 2 years and over** - ***heifers*** with an average weight of 490 kg, ration used is composed of 3 kg hill hay, 4 kg hay of lucerne, 13 kg pickled corn, 10 kg fodder beet, 1 kg mixture of farm, GE = 211.12 MJ, DE = 124.23 MJ, DE (%) = 58.84.

For dairy cattle gross energy (GE) necessary in the calculation the emission factor was calculated using the equation 10.16 in IPCC 2006, pg.10.21.
Was taken the default values for DE (%) = 60 and weight (kg)= 550 in IPCC 2006 (Table 10A.1, pg.10.72).

In the Table 5.6 are presented the milk productions per year, for the period 1989-2015 for dairy cows and, respectively, buffaloes.

Table 5.6 Milk production in cows and buffalo in the period 1989-2015 (NIS)

Year	Dairy cattle production (thousand hl)	Milk buffalo production (thousand hl)
1989	40,477	717
1990	39,698	613
1991	41,326	497
1992	40,659	420
1993	43,097	410
1994	49,235	397

Year	Dairy cattle production (thousand hl)	Milk buffalo production (thousand hl)
1995	52,431	399
1996	53,085	392
1997	52,212	369
1998	50,544	358
1999	48,901	348
2000	48,191	327
2001	49,717	319
2002	51,472	328
2003	53,869	330
2004	55,107	337
2005	54,976	357
2006	57,981	326
2007	54,517	358
2008	52,761	327
2009	48,234	304
2010	42,585	239
2011	43,728	218
2012	41,823	212
2013	42,381	210
2014	43,713	302
2015	42,401	262

❖ ***Males and females for sacrificed older than 2 years*** with an average weight of 500 kg, and average daily gain of 600 g/day, ingest a ratio of 3 kg mountain hay, 15 kg pickled corn, 3 kg mixture of farm, providing an caloricity average 166.72 MJ, DE = 95.15 MJ, DE (%) = 57.

- ***Cattle for work*** (800 kg average weight) ingest a ration of 10 kg hill hay, 5 kg coarse (oat straw), 15 kg fodder beet, 2 kg mixture of farm, ration with average caloricity 303.08 MJ, DE = 173.22 MJ, DE (%) = 57.15.
- The ratio ***buffalo female*** (500 kg average weight) considered is composed: 4 kg hill hay, 6 kg coarse chopped (oat straw), 20 kg succulents (corn silage), 1 kg concentrates, ration with an average caloricity 269.74 MJ, DE = 145 MJ, DE (%) = 53.75. Average milk production is 4.2 l/head/day, including calves consumption.
- The category ***other buffalo*** (400 kg average weight) has a ration composed of: 1 kg legumes hay, 1 kg hill hay, 2 kg coarse (oat straw), 6.8 kg corn silage, 4 kg root (fodder beet) and 1 kg mixture of farm. GE = 128.85 MJ, DE = 71.3 MJ, DE (%) = 55.34.
- For subcategory ***ewes of milk and fitted***, with an average weight of 60 kg and milk production 1.3 l/head/day were used ration: 1.6 kg clover hay, 0.4 kg oat straw, 2.5 kg fodder beet and 0.36 kg mixed fodder. The total caloricity of the ration is 42.78 MJ/head/day, DE = 19.7 MJ, DE(%) = 44.57.
- For subcategory ***reproducers rams*** (77 kg average weight) was used a ration composed of 2.5 kg hay hill, 2 kg succulents (corn silage) and 0.4 kg mixed fodder. GE = 50.23 MJ, DE = 30.07 MJ, DE (%) = 59.86.
- The ***other sheep*** subcategory (48 kg average weight) ingest a ration of 1.6 kg clover hay, 0.4 kg oat straw, 2.5 kg fodder beet and 0.516 kg mixed fodder, resulting GE = 45.27 MJ, DE = 20.84 MJ, DE (%) = 46.04.
- For ***female goats for milk and females by first mount*** (48 kg average weight and 1.8 l/head/day milk production) the ration contains: 2 kg clover of hay, 2.5 kg beet, 0.5 kg mixed fodder, 0.5 kg oat straw. The caloricity total is 52.88 MJ/head/day, DE = 23.91 MJ, DE(%) = 45.21.
- The ration for ***other goats*** (50 kg average weight) is: 0.27 mixed fodder, 2 kg clover of hay, 2.5 kg fodder beet, 0.5 kg oat straw, obtaining GE = 49.25 MJ, DE = 20.82 MJ, DE (%) = 42.27.]
- For ***pigs under 20 kg,*** GE = 8.18 MJ, DE = 6.7 MJ, DE (%) = 82.88, use are the ration 0-1, 0-2. Was chose a weight (14 kg).
- For ***pigs between 20 and 50 kg,*** GE = 13.49 MJ, DE = 11.70 MJ, DE (%) = 86.75, was used are the ration 0-3. Was chose an average weight (35kg).

- ***Pigs fattening*** (110 kg average weight) has GE = 46.86 MJ, DE = 40.66 MJ, DE(%) = 86.77, was used the ration 0-7.
- The was used ration 0-5 to ***boars*** (270 kg average weight), with a caloricity 15.62 Mj/1 kg ration (animal consume an average 2.9 kg mixed fodder/head/day), GE = 45.32 MJ, DE = 39.3 MJ, DE(%) = 86.72.
- For the ***sows of breeding*** (125 kg average weight) were used the ration 0-6 for ***breeding sows*** weight exceeding 110 kg, the ration with a total caloricity 16.19 MJ/1 kg ration (the animal consume in average 2.8 kg mixed fodder/head/day), so GE = 45.34 MJ, DE = 37.7 MJ, DE(%) = 83.14.
- For **horses** (500 kg average weight) the ration is: 10 kg hill hay, 7 kg fodder beet and 3.3 kg mixed fodder. The caloricity of ration is 53965.7 kcal, equivalent to 225.79 MJ , DE = 121.84 MJ, DE(%) = 53.96.
- For the category ***mules and asses*** (300 kg average weight) the ration is: 5 kg hay hill, 5 kg oat straw, 10 kg fodder beet, resulting a caloricity of GE = 181.18 MJ, DE = 99.2 MJ and DE (%) = 53.96.
- For the ***adult poultry for eggs*** (1.9 kg average weight) was used the ration 21-5, contains maize, barley, soy grits, sunflower meal, meat meal, oil, 10% premix hill and P.V.M A 6, resulting a caloricity 1872.38 kcal/1kg ration, respective 7.83 MJ/1 kg ration. An animal consumes on average 120 g of prescription/head/day), that is 1.83 MJ/head/day. DE = 1.5 MJ, DE (%) = 81.96.
- For ***poultry for meat*** (1.8 kg average weight) the rations contain maize, barley, wheat, soy grits, sunflower meal, meat meal, oil and animal protein/plant. For ration 1 kg, caloricity is 4122.97 kcal, equivalent to 17.25 MJ/1 kg ration. For an increase of 35 g, specific to this type of exploatation, average amount ingested is 75g/head/day, equivalent to 1.3 MJ, DE = 1.086 MJ, DE (%) = 83.53.

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 categories, 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 other categories Y_m values were used from IPCC 1996 - Reference Manual, Table A-4 (Y_m values for goats, horses and mules and asses are similar for developed countries and 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 livestock are presented in Table 5.7.

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 1989-2015 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	62.59	146.83	0.065

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)
	1 and 2 years			
	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	0.06
3.A.2	***SHEEP***			
	Ewes of milk and fitted	18.23	42.78	0.065
	Reproducers rams	21.41	50.23	0.065
	Other sheep	19.29	45.27	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

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)**
	Breeding sows	1.78	45.34	0.006
3.A.4.1	***BUFFALO***			
	Female buffalo	114.99	269.74	0.065
	Other buffalo	54.93	128.85	0.065
3.A.4.3	***GOATS***			
	Female goats for milk and females by first mount	17.34	52.88	0.05
	Other goats	16.15	49.25	0.05
3.A.4.4	***HORSES***	37.02	225.79	0.025
3.A.4.5	***MULES AND ASSES***	29.70	181.18	0.025
3.A.4.6	***POULTRY***			
	Adult poultry for eggs	0	1.83	0
	Poultry for meat	0	1.3	0

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 1989-2015 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	87.64	205.57	0.065
1990	89.55	210.05	0.065
1991	93.82	220.08	0.065
1992	96.96	227.44	0.065
1993	98.87	231.91	0.065
1994	103.25	242.18	0.065
1995	104.97	246.23	0.065
1996	105.90	248.40	0.065
1997	107.29	251.66	0.065
1998	107.17	251.38	0.065
1999	107.06	251.13	0.065
2000	108.60	254.75	0.065
2001	110.56	259.33	0.065
2002	110.82	259.94	0.065
2003	112.26	263.32	0.065
2004	114.35	268.22	0.065
2005	112.81	264.61	0.065
2006	114.56	268.72	0.065
2007	113.76	266.84	0.065
2008	114.79	269.25	0.065
2009	113.00	265.07	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			
2010	115.42	270.74	0.065
2011	117.41	275.40	0.065
2012	115.80	271.62	0.065
2013	116.06	272.24	0.065
2014	116.69	273.73	0.065
2015	115.33	270.53	0.065

In the Table 5.9 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 where the values for DE% and animal weight (kg) are default.

Table 5.9 The values energy digestible expressed in Mj/day and percent and weight (kg) for livestock, in the 1989-2015 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*	154.46	60	550
3.A.1.2	*Non dairy cattle*			
	Calves for slaughter younger than 1 year	81.23	56.77	250

Source indicative	**Livestock (source) type**	**Energy digestible DE (Mj/day)**	**Percentage of digestible energy DE(%)**	**Animal weight (kg)**
	Young cattle of breeding under 1 year	65.8	56.97	250
	Young cattle of breeding between 1 and 2 years	81.49	55.49	350
	Young cattle of slaughter between 1 and 2 years	152.63	68.65	400
	Cattle 2 years and over Breeding bulls	132.94	55	815
	Cattle 2 years and over Heifers for breeding	124.23	58.84	490
	Males and females for sacrificed older than 2 years	95.15	57	500
	Cattle for work	173.22	57.15	800
3.A.2	***SHEEP***			
	Ewes of milk and fitted	19.7	44.57	60
	Reproducers rams	30.07	59.86	77
	Other sheep	20.84	46.04	48
3.A.3	***SWINE***			
	Pigs under 20 kg	6.7	82.88	14
	Pigs between 20 and 50 kg	11.7	86.75	35

Source indicative	Livestock (source) type	Energy digestible DE (Mj/day)	Percentage of digestible energy DE(%)	Animal weight (kg)
	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	145	53.75	500
	Other buffalo	71.3	55.34	400
3A.4.3	***GOATS***			
	Female goats for milk and females by first mount	23.91	45.21	48
	Other goats	20.82	42.27	50
3.A.4.4	***HORSES***	121.84	53.96	500
3.A.4.5	***MULES AND ASSES***	99.2	54.75	300
3.A.4.6	***POULTRY***			
	Adult poultry for eggs	1.5	81.96	1.9
	Poultry for meat	1.086	83.53	1.8

Activity data

Primary livestock data

1989-2003

The primary data on all categories of animals have been provided by NIS through the Statistical Yearbook.

2004-2015

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 (sheet *Primary data)* raw data on livestock in the period 1989-2015, 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 (sheet - Data obtained through the study) and for which are official data for 2004-2015. 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 (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 1989-2015 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 2015), 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.

2004-2015

In the Annex 3.5 (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 (sheet – *Primary data*), the values of *young cattle breeding* is the sum of *males* and *females* from Annex 3.5 (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 (sheet – *Primary data*). For *young cattle for slaughter* were used the values from in according with Annex 3.5 (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 (sheet - *Data obtained through the study*) are used in according with the Annex 3.5 (sheet – *Primary data*).

Sheep

The values for *ewes of milk and fitted* were taken from the Annex 3.5 (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 (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 (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 1989-2015 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 checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating LULUCF, 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

For the improve of the quality of emissions were made some recalculations:

- ***activity data:***
  - the activity data on milk production from National Institute of Statistics was used for the calculation the values on gross energy intake for dairy cattle.

The implications of all changes made on emission estimates are described in the Table 5.10.

- ***emissions factors:***
  - the emissions factors has been recalculated for the 1989-2015 period after using milk production from National Institute of Statistics for dairy cattle.

Table 5.10 Implication of recalculations on emission estimates

Year	Changes at the level of the activity data and emission factor for consideration of the differences				The changes impacts on estimating CH_4 emissions		
	Gross energy intake (GE)		Emission factor		CH_4 emissions (kt)		Difference
	NGHGI 2016 v.4	NGHGI 2017 v1	NGHGI 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1	
1989	227.37	205.57	96.93	87.64	8505.31	7690.09	-815.21
1990	227.37	210.05	96.93	89.55	7275.00	6721.04	-553.96
1991	227.37	220.08	96.93	93.82	5887.87	5699.22	-188.65
1992	227.37	227.44	96.93	96.96	4979.34	4981.01	1.67
1993	227.37	231.91	96.93	98.87	4863.07	4960.35	97.27
1994	227.37	242.18	96.93	103.25	4706.24	5012.93	306.69
1995	227.37	246.23	96.93	104.97	4726.52	5118.78	392.26
1996	227.37	248.40	96.93	105.90	4644.05	5073.76	429.71
1997	227.37	251.66	96.93	107.29	4373.65	4840.97	467.31
1998	227.37	251.38	96.93	107.17	4249.27	4698.13	448.85
1999	227.37	251.13	96.93	107.06	4124.89	4555.99	431.10
2000	227.37	254.75	96.93	108.60	3880.18	4347.57	467.38
2001	227.37	259.33	96.93	110.56	3785.54	4317.81	532.26

Year	Changes at the level of the activity data and emission factor for consideration of the differences				The changes impacts on estimating CH_4 emissions		
	Gross energy intake (GE)		Emission factor		CH_4 emissions (kt)		Difference
	NGHGI 2016 v.4	NGHGI 2017 v1	NGHGI 2016 v.4	NGHGI 2017 v.1	NGHGI 2016 v.4	NGHGI 2017 v.1	
2002	227.37	259.94	96.93	110.82	3891.00	4448.54	557.53
2003	227.37	263.32	96.93	112.26	3916.68	4535.99	619.30
2004	227.37	268.22	96.93	114.35	3795.91	4477.97	682.06
2005	227.37	264.61	96.93	112.81	3939.57	4584.86	645.29
2006	227.37	268.72	96.93	114.56	3972.73	4695.23	722.50
2007	227.37	266.84	96.93	113.76	3811.73	4473.50	661.76
2008	227.37	269.25	96.93	114.79	3594.49	4256.69	662.19
2009	227.37	265.07	96.93	113.00	3438.78	4009.00	570.22
2010	227.37	270.74	96.93	115.42	2856.06	3400.93	544.87
2011	227.37	275.40	96.93	117.41	2796.63	3387.46	590.83
2012	227.37	271.62	96.93	115.80	2779.41	3320.42	541.00
2013	227.37	272.24	96.93	116.06	2798.51	3350.87	552.36
2014	227.37	273.73	96.93	116.69	2843.11	3422.81	579.70

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.

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:

- ❖ is the second source of CH_4 and the third source of N_2O emissions in the Agriculture sector (in 2015, CH_4 emissions from Manure Management represented 12.55% of total CH_4 emissions while N_2O accounted for 11.47% of total N_2O emissions in the Agriculture sector);
- ❖ is the third source in the Agriculture sector (in 2015, CH_4 and N_2O emissions from Manure Management as CO_2 equivalent represented 12.16% from Total Agriculture emissions);
- ❖ contributed with 1.37% 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 5.11.

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

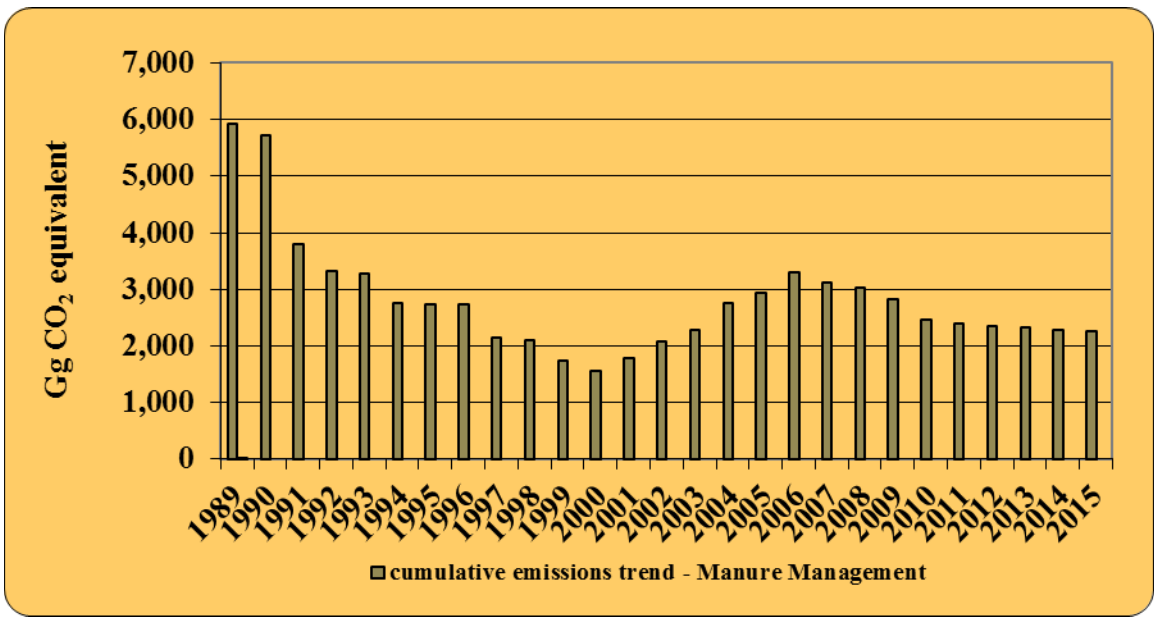


Table 5.11 Observations on source category 4B – "Manure Management"

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	AD: NIS and expert judgment, 1989-2003; NIS, 2004-2015

Source indicative	Source type	Observation	Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"			
		categories: dairy cows and non-dairy cattle	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, 2004-2015; EF: IPCC 2006, expert judgment
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, 2004-2015 EF: IPCC 2006, expert judgment
3B.1.4.1	**Rabbits**		AD: NIS, 1989-2015; EF: IPCC 2006
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, 2004-2015; EF: IPCC 2006, expert judgment
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, 2004-2015; EF: IPCC 2006, expert judgment
3.B.1.4.4	**Horses**		AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2015; EF: IPCC 2006,

Source indicative	Source type	Observation	Data source
Observations on source category 3B – "Manure Management – CH_4 and N_2O emissions"			
			expert judgment
3.B.1.4.4	**Mules and asses**		AD: FAO, 2011; EF: IPCC 2006, expert judgment
3.B.1.4.5	**Poultry**	Includes livestock data from two different poultry: adult poultry for eggs, poultry for meat	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2015 EF: IPCC 2006, expert judgment
3.B.2.1	**Cattle**	Includes following type of systemes of management: - 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
3.B.2.2	**Sheep**	Includes following type of systemes of management: - Anaerobic Lagoon - Liquid/Slurry - Daily Spread	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"			
		- Solid storage and dry lot - Pasture/range/paddock - Pit storage - Poultry manure with bedding - Poultry manure without bedding	
3.B.2.3	**Swine**	Includes following type of systemes of management: - 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
3.B.2.4.1	**Buffalo**	Includes following type of systemes of management: - Anaerobic Lagoon - Liquid/Slurry - Daily Spread	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"			
		- Solid storage and dry lot - Pasture/range/paddock - Pit storage - Poultry manure with bedding - Poultry manure without bedding	
3.B.2.4.3	**Goats**	Includes following type of systemes of management: - 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
3.B.2.4.4	**Horses**	Includes following type of systemes of management: - Anaerobic Lagoon - Liquid/Slurry - Daily Spread	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"			
		- Solid storage and dry lot - Pasture/range/paddock - Pit storage - Poultry manure with bedding - Poultry manure without bedding	
3.B.2.4.5	**Mules and asses**	Includes following type of systemes of management: - 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
3.B.2.4.6	**Poultry**	Includes following type of systemes of management: - Anaerobic Lagoon - Liquid/Slurry - Daily Spread	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"			
		- Solid storage and dry lot - Pasture/range/paddock - Pit storage - Poultry manure with bedding - Poultry manure without bedding	
Observations on source category 3B – "Manure Management – N_2O indirect emissions"			
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 all species excepting rabbits where was calculated using a Tier 1 method.

For these are available national data (GE, DE, VS, MS) for each category and 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 all livestock 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*`.

The gross energy intake (GE) and digestible energy (DE) calculation was presented detail in section 5.2.2 - "Enteric fermentation".

The volatile solid excretion per day (VS) was calculated with equation 10.24 from IPCC 2006.

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 other categories of animals, was choosing the default value. For mules and asses were used the ASH value of 4%.

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, 0.1 for buffalo, 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, horses, goats and mules and asses 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 poultry were chose the values for countries developing, because the VS value is close of the value these country.

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 5.12.

In the Table 5.12 are summarized the values used in the calculation of emissions factors for 1989-2015 period for each livestock (non dairy cattle, sheep, goats, swine, horses, mules and asses and poultry). In the table 5.13 are summarized the values used in the calculation of emissions factors for 1989-2015 period for dairy cattle and in the Table 5.14 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.

Table 5.12 The values used in the calculation of emissions factors from Manure management for 1989-2015

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	8	2.71	0.17	4.62

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**
	1 year				
	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.2	***SHEEP***				
	Ewes of milk	8	1.26	0.13	1.71

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
	and fitted				
	Reproducers rams	8	1.10	0.13	2.00
	Other sheep	8	1.30	0.13	1.81
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
3.B.4.1	***BUFFALO***				
	Buffalo milk	8	6.76	0.1	10.78
	Other buffalo	8	3.12	0.1	5.15
3.B.4.3	***GOATS***				
	Female goats for milk and females by first mount	8	1.55	0.13	2.11
	Other goats	8	1.51	0.13	1.97
3.B.4.4	***HORSES***	8	5.87	0.26	9.03

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.4.5	***MULES AND ASSES***	8	4.64	0.26	7.24
3.B.4.6	***POULTRY***				
	Adult poultry for eggs	8	0.02	0.24	0.03
	Poultry for meat	8	0.02	0.24	0.02

Table 5.13 The values used in the calculation of emissions factors from Manure management for 1989-2015 period for dairy cattle

Years	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy expressed as fraction of GE
3.B.1.1 Dairy cattle		
1989	4.51	8.22
1990	4.60	8.40
1991	4.82	8.80
1992	4.99	9.09
1993	5.08	9.27
1994	5.31	9.68
1995	5.40	9.84
1996	5.45	9.93
1997	5.52	10.06

Years	Volatile solid excretion per day on a dry-matter weight basis, kg-dm/day (VS)	Urinary energy expressed as fraction of GE
3.B.1.1 Dairy cattle		
1998	5.51	10.05
1999	5.50	10.04
2000	5.58	10.19
2001	5.69	10.37
2002	5.70	10.39
2003	5.77	10.53
2004	5.88	10.72
2005	5.80	10.58
2006	5.89	10.74
2007	5.85	10.67
2008	5.90	10.77
2009	5.81	10.60
2010	5.94	10.82
2011	6.04	11.01
2012	5.95	10.86
2013	5.97	10.88
2014	6.00	10.94
2015	5.93	10.82

Table 5.14 The values MCF used in calculation of emissions factor for each manure system management for all livestock in the 1989-2015 period

The period 1989-2015	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 (sheet- *Values 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 1989-2015 period, and in the Annex 3.5 (sheet- *Emission factor manure management*) are found emissions factors necessary for calculation of methane emissions from manure management.

The values of emission factors increases for sheep in the 1989-2015 period (from 0.3 to 0.58 kg CH_4/head/year) due to the variation in MS level associated to the Solide Storage, Daily spread and Pasture Range/Paddock AWMS.

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 the default method, for all species, according to the provisions in 2006 *IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006).* For these 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 default method, using and default values (EF_3 - the Table 10.21 from 2006 *IPCC Guidelines for National Greenhouse Gas Inventories*).
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 the values 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) and default values for emissions factor from IPCC, respectively EF_3 (Table 10. 21 of IPCC 2006).

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 5.15 depending to manure management system.

Table 5.15 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.

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 according to solid manure and liquid manure using following equation:

Equation 5.2 Nitrogen excretion

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

The MS values were established by expert opinion in the context of the above study.

In the Table 5.16 are presented the values for N_{ex} and the data on the amount of solid manure, N% from solid manure, the amount of liquid manure, 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 5.16 Data necessary for calculating the rate of excretion of nitrogen, in the 1989-2015 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 B1	***CATTLE***					
3 B.1.1.a	***Dairy cattle***	23.5	9	0.4031	0.58	53.63
3 B1. 1.b	***Non dairy cattle***					
	Calves for slaughter younger than 1 year	6.5	1.69	0.4031	0.58	13.14
	Young cattle of breeding under 1 year	13	3	0.4031	0.58	25.5
	Young cattle of breeding between 1 and 2 years	13	3	0.4031	0.58	25.5
	Young cattle of slaughter between 1 and 2 years	13	3	0.4031	0.58	25.5
	Cattle 2 years and over - Breeding bulls	24.26	9	0.4031	0.58	54.75
	Cattle 2 years and over- Heifers	23.5	9	0.4031	0.58	53.63
	Males and females	23.5	9	0.4031	0.58	53.63

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)
	for sacrificed older than 2 years					
	Cattle for work	23.5	9	0.4031	0.58	53.63
3 B.1.2	***SHEEP***					
	Ewes of milk and fitted	1.1	0.7	0.8	0.43	4.3
	Reproducers rams	1.183	0.7	0.8	0.43	4.55
	Other sheep	1.183	0.7	0.8	0.43	4.55
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.1.4.3	***GOATS***					

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)
	Female goats for milk and females by first mount	1.39	0.8	0.8	0.43	5.3
	Other Goats	1.4	0.78	0.8	0.43	5.3
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

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 1989-2015 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 1989-2015 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 checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating LULUCF, 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

CH_4 and N_2O emissions

The recalculations at the level of activity data in Section 5.2.5. have impact and on estimation of CH_4 emissions from Manure management.

Due to errors transcription of the value energy digestibility (DE%) for sheep and goats and for the non estimation of the emissions for rabbits was made recalculation on CH_4 emissions and due to of the errors calculation on Direct N_2O emissions for poultry was made recalculation.

The implications of all changes made on emission estimates are described in the Table 5.17.

Table 5.17 Recalculations on CH_4 and Direct N_2O emission estimates

Year	2016 v. 4 submission CH_4 (Gg) emissions	2017 v. 1 submission CH_4 (Gg) emissions	Difference	2016 v. 4 submission Direct N_2O (Gg) emissions for poultry	2017 v. 1 submission Direct N_2O (Gg) emissions for poultry	Difference
1989	4612.64	4661.26	48.61	40.02204219	40.02204232	0.00000013
1990	4454.02	4505.86	51.83	42.88034227	42.88034218	-0.0000001
1991	2715.40	2764.18	48.78	33.68337746	33.68337746	0.00
1992	2384.54	2427.92	43.37	22.85331008	22.85331015	0.0000001
1993	2351.19	2398.32	47.13	18.61773059	18.61773049	-0.0000001
1994	1932.47	1987.62	55.15	13.10131551	13.10131559	0.0000001
1995	1903.34	1961.15	57.80	16.11932302	16.11932299	0.0000000
1996	1929.67	1988.49	58.82	13.10725882	13.1072587	-0.0000001
1997	1406.31	1464.06	57.75	6.735834954	6.735834826	-0.0000001
1998	1371.17	1427.51	56.33	6.409789876	6.409789961	0.0000001
1999	1100.86	1155.09	54.22	2.523407082	2.52340721	0.0000001
2000	1009.34	1064.81	55.46	0.947907604	0.947907689	0.0000001
2001	1183.55	1252.50	68.95	7.552219662	7.55221979	0.0000001
2002	1415.16	1498.02	82.85	12.96947196	12.9694720	0.0000000
2003	1541.66	1636.86	95.19	16.41236162	16.41236158	0.0000000
2004	1878.31	1978.09	99.78	25.68433154	25.68433162	0.0000001
2005	2050.47	2125.30	74.83	31.24658825	31.24658813	-0.0000001
2006	2377.72	2489.48	111.76	31.02199459	31.02199474	0.0000001
2007	2218.43	2311.09	92.65	32.56090235	32.56090223	-0.0000001
2008	2140.93	2224.94	84.01	34.73215658	34.73215671	0.0000001
2009	1997.88	2068.88	71.00	34.72623204	34.72623214	0.0000001
2010	1728.40	1786.54	58.15	32.60510171	32.60510184	0.0000001

Year	2016 v. 4 submission CH_4 (Gg) emissions	2017 v. 1 submission CH_4 (Gg) emissions	Difference	2016 v. 4 submission Direct N_2O (Gg) emissions for poultry	2017 v. 1 submission Direct N_2O (Gg) emissions for poultry	Difference
2011	1681.15	1741.23	60.08	32.12009479	32.12009477	0.00000003
2012	1635.56	1692.80	57.24	32.25062654	32.25062658	0.0000000
2013	1621.01	1679.05	58.03	32.10242965	32.10242978	0.0000001
2014	1581.66	1641.61	59.95	30.36392805	30.36392792	-0.00000013

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).

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 the smallest source of CH_4 emissions in the Agriculture sector (in 2015, CH_4 emissions from Rice Cultivation represented 0.0001% of total CH_4 emissions in the Agriculture sector);
- is the smallest source in the Agriculture sector (in 2015, CH_4 emissions from Rice Cultivation as CO_2 equivalent represented 0.000003% from Total Agriculture emissions);
- contributed with 0.000012% 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 2015 the rice area cultivated is 11.1 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

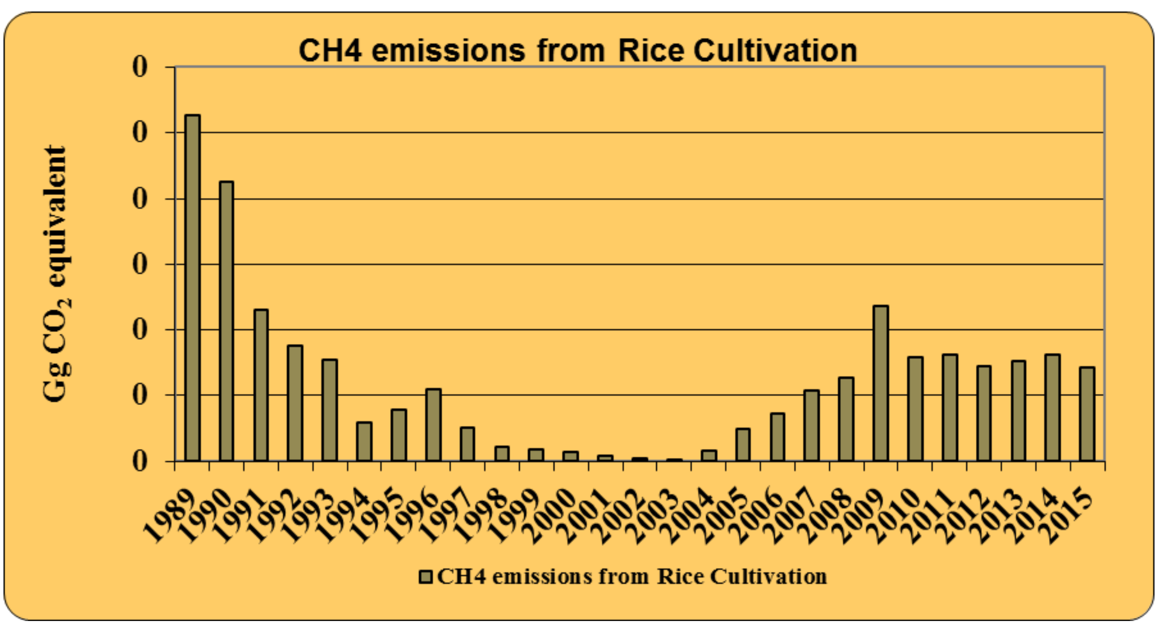


Table 5.18 Observations on source category 4C – "Rice Cultivation"

Source indicative	Source type	Observation	Data source
3.C.1.2	Rice harvested area		AD: SY, NIS, 1989-2015; 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};
- a default value of 0.78 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;
- yearly default values for the scaling factor to account for both type and amount of amendment applied (SF_O). Default values were selected after the estimation of the rice residues productivity values, considering that all rice residues were incorporated into the soil following the harvesting. Rice residues productivity values and default values for the scaling factor to account for the type and amount of amendment applied are presented in the Table 5.19.

Table 5.19 Rice residues productivity values and default values for the scaling factor to account for the type and amount of amendment applied (SF_O)

Year	Rice residues productivity [tones d.m./ha]	Scaling factor to account for the type and amount of amendment applied (SF_O)
1989	1.07	1.5
1990	1.25	1.5
1991	1.09	1.5
1992	1.78	1.5
1993	2.28	1.8
1994	2.48	1.8
1995	2.92	1.8
1996	2.04	1.8
1997	2.01	1.8
1998	2.25	1.8
1999	1.78	1.5
2000	1.93	1.5
2001	0.94	1
2002	0.90	1
2003	2.25	1.8
2004	3.13	1.8
2005	2.75	1.8
2006	2.46	1.8
2007	2.46	1.8
2008	3.70	1.8
2009	4.08	2.5
2010	3.72	1.8
2011	3.86	1.8

Year	Rice residues productivity [tones d.m./ha]	Scaling factor to account for the type and amount of amendment applied (SF_O)
2012	3.37	1.8
2013	3.43	1.8
2014	2.66	1.8
2015	3.36	1.8

Activity data

Total rice cultivated area is provided by Romanian National Institute for Statistics (NIS) being released through Statistical Yearbook 1989-2015.

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 5.20.

Table 5.20 Harvested area data series for 1989-2015

Year	Harvested area [10^8 m^2]
1989	4.93
1990	3.99
1991	2.16
1992	1.64
1993	1.2
1994	0.46
1995	0.62
1996	0.85
1997	0.4
1998	0.17
1999	0.16

Year	Harvested area [10^8 m^2]
2000	0.14
2001	0.12
2002	0.05
2003	0.01
2004	0.12
2005	0.39
2006	0.56
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

5.4.3 Uncertainties and time-series consistency

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

- AD: 5 %;
- EF: 50%;
- 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 1989-2015 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 LULUCF, 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.

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

It was not made any recalculation compared to the last transmission.

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 2015, N_2O Direct soil emissions represented 65.09% of total N_2O emissions in the Agriculture sector);
- is the first source in the Agriculture sector (in 2015, N_2O Direct soil emissions as CO_2 equivalent represented 20.06% from Total Agriculture emissions);
- contributed with 3.21% 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 9.41 kt N_2O in 1989, to 5.05 kt N_2O in 2015.

The quantity of synthetic fertilizer has decreased considerably after the 1989 year from 665,300 tonnes/year to 357,000 tonnes/year. This decrease is reflected in the decrease of the nitrogen fraction volatilized into the atmosphere as N_2O. The main cause was a decrease of crop production and the inability of farmers to use the agricultural technology correctly.

The amount of N_2O emissions from annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils have decreased from 5.63 kt N_2O in 1989, to 2.35 kt N_2O in 2015.

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

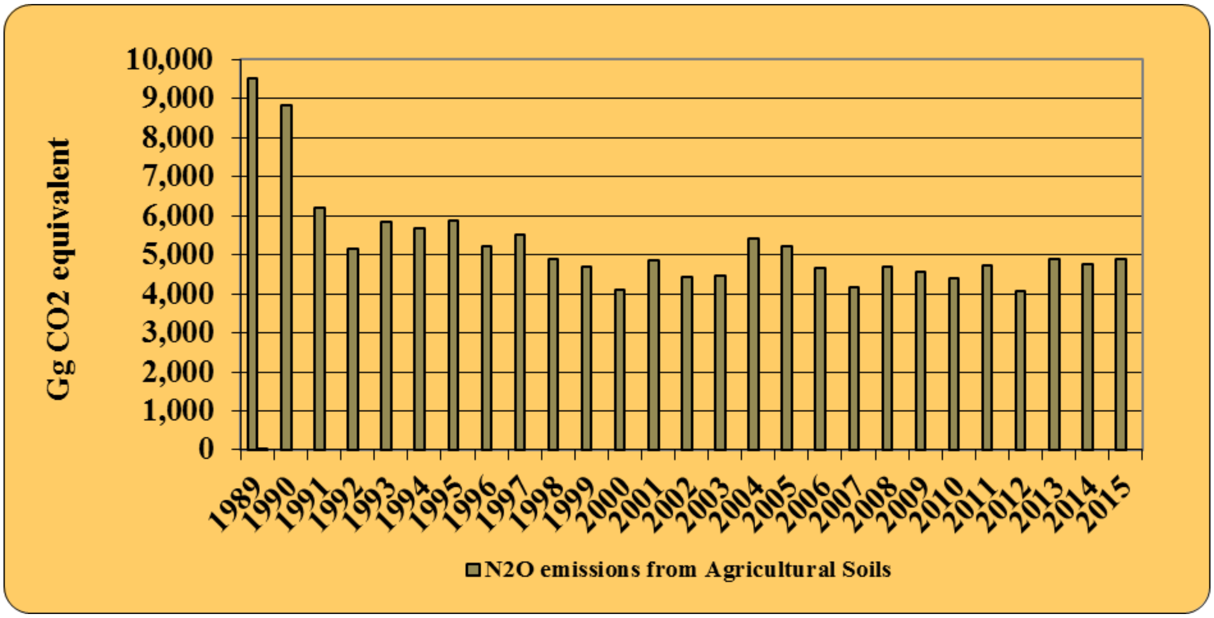


Figure 5.8 Direct N_2O emissions trends – Agricultural Soils

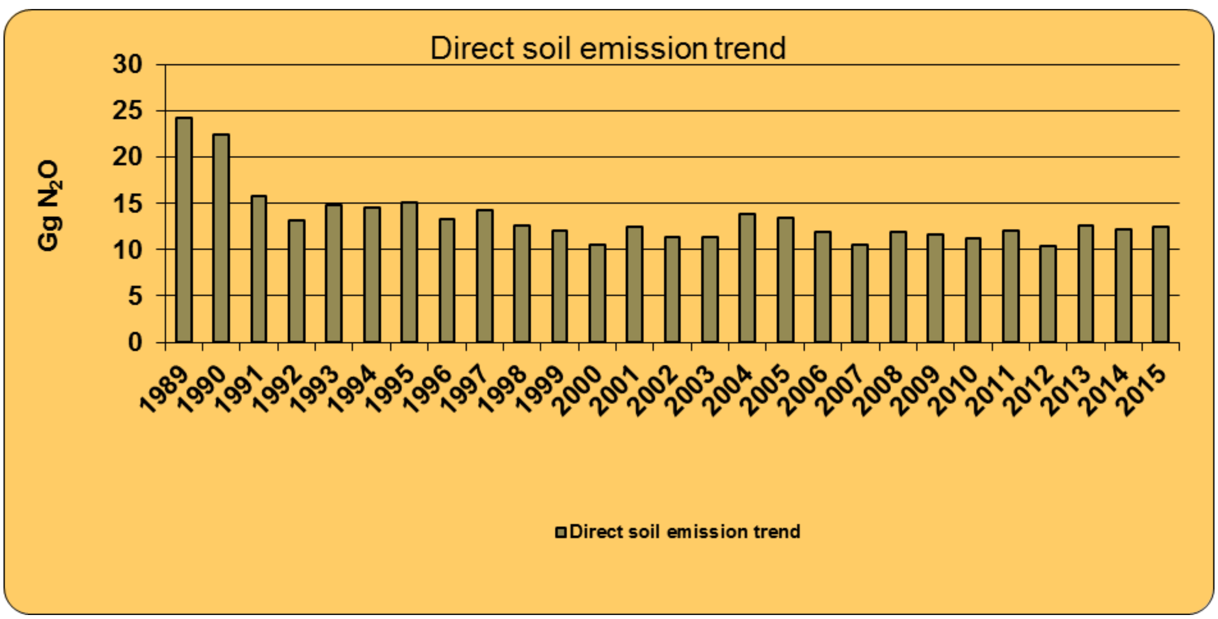


Table 5.21 Observations on source category 3D – "Managed Soils"

Source indicative	Source (livestock) type	Observation	Data source
3.D.1, 3.D.2	Amount of N synthetic fertilizer used		AD: SY, NIS, 1989-2015; 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, 2004-2015; The study „*Elaboration of national emission factors /other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods*" EF: IPCC 2006, Country specific, expert judgment
3.D.1.4	Production crops	Includes following crops: *rye, wheat, barley and two-row barley, oats, maize, sorghum, rice, other grains, rape, sunflower, flax for oil, other oilseed plants (castor), in fiber-textile plants, hemp for fiber - plant textiles, other textile plants – cotton, tobacco, hop, medicinal aromatic plants/spices grown, other industrial crops (sorghum for*	AD: SY, other correspondence, NIS, 1989 -2015; The study „*Elaboration of national emission factors /other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and*

Source indicative	Source (livestock) type	Observation	Data source
		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.	*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, 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 -2015; EF: IPCC 2006

Source indicative	Source (livestock) type	Observation	Data source
	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 -2015; 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 could not be applied, due to the lack of detailed data needed. 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, 11.6 and 11.7 in IPCC 2006 and the equation 4.22 in IPCC GPG 2000.

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 adjusted to account for the amount that volatilizes as NH_3 and NO_x (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 1989-2015.

Data series are presented in Table 5.22.

Default value of $\mathbf{Frac_{GASF}}$ used is 0.1 (Reference Manual, 1996).

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 $\mathbf{F_{ON}}$ 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.

For parameters annual amount of total sewage N that is applied to soils **(F_{SEW})** and annual amount of total compost N applied to soils **(F_{OOA})** have been used values 0 because no known the values.

Amount of managed manure nitrogen for livestock category that is lost in the manure management system **($Frac_{LossMS}$)** is used the default value from IPCC 2006 (Table 10.23), and the amount of nitrogen from bedding **(Nbedding)** is used the value 0, it is not known organic bedding.

For fractions of managed manure used for feed **($Frac_{FEED}$),** fraction of managed manure used for fuel **($Frac_{FUEL}$)** and fraction of managed manure used for construction **($Frac_{CNST}$)** were used the 0 value, because were not identified sources of national statistical data (the expert opinion).

The use or recycling manure by the introduction in manufacturing processes of materials building, although it is known the technique, not was used.

Table 5.22 Activity data series used for calculation of F_{SN}, for 1989-2015

Year	**Amount of synthetic fertilizer applied to soil [thousands tonnes/year]**
1989	665.3
1990	656.0
1991	275.0
1992	258.0
1993	346.0

Year	Amount of synthetic fertilizer applied to soil [thousands tonnes/year]
1994	313.0
1995	306.0
1996	268.0
1997	262.0
1998	254.0
1999	225.0
2000	239.0
2001	268.0
2002	239.0
2003	252.0
2004	270.0
2005	299.0
2006	252.0
2007	265.0
2008	279.8
2009	296.06
2010	306.0
2011	313.0
2012	289.9
2013	344.0
2014	303.0
2015	357.0

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 1989-2015 and data base. Crop production of nitrogen fixing crop are presented in Table 5.23.

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 5.23 The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989-2015 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
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
1991	32,292	46,019	79,491	178,593	5,645,816	5,390,442	11,036,258	9,661,207
1992	33,180	41,184	74,678	126,159	4,077,623	3,047,204	7,124,827	6,409,569
1993	36,406	48,421	85,232	95,370	3,971,900	3,029,541	7,001,441	6,879,385
1994	38,091	37,379	76,112	100,078	4,155,947	2,335,423	6,491,370	6,944,354
1995	54,262	41,769	97,017	107,861	4,127,358	1,892,078	6,019,436	7,081,202
1996	33,705	42,078	77,016	113,084	3,930,367	2,084,169	6,014,536	6,984,832
1997	27,263	50,194	78,560	121,148	3,741,430	1,602,720	5,344,150	7,727,622

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
1998	24,382	46,856	72,497	200,820	3,773,666	1,145,649	4,919,315	7,004,112
1999	27,011	47,698	76,755	183,403	4,334,489	1,028,431	5,362,920	7,737,980
2000	14,159	21,803	36,929	69,473	2,840,370	476,958	3,317,328	5,120,710
2001	21,661	36,492	61,174	72,688	3,146,175	579,428	3,725,603	6,476,805
2002	20,450	33,592	55,313	145,932	3,816,927	565,477	4,382,404	6,887,361
2003	23,497	36,679	60,645	224,908	4,118,584	606,706	4,725,290	7,237,492
2004	58,036	53,517	112,331	298,506	IE	IE	1,923,528	4,655,262
2005	39,096	41,733	80,913	312,781	IE	IE	2,454,958	6,274,555
2006	36,147	34,942	71,574	344,909	IE	IE	3,182,639	6,381,270
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

Table 5.23 (continued) The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989-2015 period

Year	Crop production of nitrogen fixing crop (tonnes/year)		
	Clover in equivalent green fodder	Other perennial forage	Perennial forage
1989	2,937,100	3,988,200	18,057,000
1990	1,926,004	2,980,701	12,963,924
1991	2,054,329	3,513,112	15,228,648
1992	1,792,567	2,787,324	10,989,460
1993	1,988,099	2,890,764	11,758,248
1994	2,059,289	2,665,781	11,669,424
1995	2,367,015	2,761,694	12,209,911
1996	2,400,569	2,702,844	12,088,245
1997	2,725,409	2,848,141	13,301,172
1998	2,632,031	2,695,283	12,331,426
1999	2,863,116	2,908,083	13,509,179
2000	2,018,423	2,072,818	9,211,951
2001	2,494,521	2,564,330	11,535,656
2002	2,534,648	3,047,404	12,469,413
2003	2,421,292	2,955,120	12,613,904
2004	866,398	1,087,129	6,608,789
2005	1,601,385	2,251,574	10,127,514
2006	1,779,417	2,461,604	10,622,291
2007	1,463,864	1,700,004	7,330,212
2008	1,751,484	2,016,050	9,273,329
2009	1,786,509	2,032,409	9,461,506
2010	1,949,735	2,224,993	9,974,033
2011	2,001,723	2,644,119	10,661,681
2012	1,598,254	2,047,590	8,482,250

Year	Crop production of nitrogen fixing crop (tonnes/year)		
	Clover in equivalent green fodder	Other perennial forage	Perennial forage
2013	1,873,522	2,345,173	9,699,211
2014	1,888,412	2,534,297	10,493,941
2015	1,633,300	2,400,600	9,687,800

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 5.23 (NIS) for the calculation F_{CR} are used the data on Crop production of nitrogen fixing crop presented in the Table 5.24.

The values for pea beans, dry bean, soybeans, lucerne and clover were used in the primary data table (Table 5.23).

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 5.24 The data on Crop production of nitrogen fixing crop obtained through the dedicated study (tonnes/year), in the 1989-2015 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
1991	32,292	46,019	1,180	178,593	9,661,207	2,054,329	3,310,877	1,405,245
1992	33,180	41,184	314	126,159	6,409,569	1,792,567	2,137,448	1,114,930
1993	36,406	48,421	405	95,370	6,879,385	1,988,099	2,100,432	1,156,306
1994	38,091	37,379	642	100,078	6,944,354	2,059,289	1,947,411	1,066,312
1995	54,262	41,769	986	107,861	7,081,202	2,367,015	1,805,831	1,104,678
1996	33,705	42,078	1,233	113,084	6,984,832	2,400,569	1,804,361	1,081,138
1997	27,263	50,194	1,103	121,148	7,727,622	2,725,409	1,603,245	1,139,256
1998	24,382	46,856	1,259	200,820	7,004,112	2,632,031	1,475,795	1,078,113
1999	27,011	47,698	2,046	183,403	7,737,980	2,863,116	1,608,876	1,163,233
2000	14,159	21,803	967	69,473	5,120,710	2,018,423	995,198.4	829,127.2
2001	21,661	36,492	3,021	72,688	6,476,805	2,494,521	1,117,681	1,025,732
2002	20,450	33,592	1,271	145,932	6,887,361	2,534,648	1,314,721	1,218,962
2003	23,497	36,679	469	224,908	7,237,492	2,421,292	1,417,587	1,182,048
2004	58,036	53,517	778	298,506	4,655,262	866,398	577,058.4	434,851.6
2005	39,096	41,733	84	312,781	6,274,555	1,601,385	736,487.4	900,629.6
2006	36,147	34,942	485	344,909	6,381,270	1,779,417	954,791.7	984,641.6
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

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 1989-2015 and data base are presented in Table 5.25.

Table 5.25 The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-2015 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
1991	85,753	5,473,156	2,950,698	258,160	10,497,338	6,004	31,449	19,306,621
1992	21,232	3,206,382	1,677,956	507,733	6,828,270	4,532	38,920	12,288,452

Year	Productions of non-N-fixing crops (tonnes/year)							
	Rye	Wheat	Barley and two-row barley	Oats	Maize grains	Sorghum	Rice	Total Cereal grains
1993	40,409	5,314,104	1,552,793	553,577	7,987,450	5,481	36,448	15,493,074
1994	51,201	6,135,299	2,133,563	496,803	9,343,224	7,128	15,229	18,183,777
1995	42,728	7,666,538	1,816,267	404,428	9,923,132	4,408	24,066	19,882,827
1996	20,240	3,143,818	1,107,547	290,505	9,607,944	4,295	23,100	14,199,688
1997	29,413	7,156,188	1,889,343	325,389	12,686,700	4,776	10,669	22,107,300
1998	26,088	5,181,823	1,238,001	362,137	8,623,370	11,369	5,142	15,452,719
1999	21,092	4,661,439	1,018,586	389,556	10,934,815	2,535	3,813	17,037,346
2000	21,802	4,434,438	867,018	243,830	4,897,603	1,479	3,551	10,477,506
2001	28,631	7,735,136	1,580,048	382,354	9,119,194	5,584	1,459	18,870,926
2002	20,079	4,420,995	1,160,387	327,444	8,399,779	2,557	597	14,356,504
2003	17,358	2,479,052	540,849	323,060	9,576,985	4,991	253	12,964,404
2004	55,000	7,812,428	1,405,996	447,079	14,541,564	28,374	4,963	24,403,005
2005	48,962	7,340,664	1,079,148	377,456	10,388,499	1,912	14,251	19,345,464
2006	35,720	5,526,190	772,929	346,918	8,984,729	1,331	18,420	15,759,324
2007	20,583	3,044,465	531,420	251,633	3,853,918	1,193	27,518	7,814,825
2008	31,446	7,180,984	1,209,411	382,030	7,849,083	20,899	48,917	16,826,441
2009	32,959	5,202,526	1,182,062	295,832	7,973,258	14,440	72,418	14,872,952
2010	34,281	5,811,810	1,311,035	304,462	9,042,032	18,677	61,588	1,6712,883
2011	31,382	7,131,590	1,329,692	375,855	11,717,591	39,696	65,261	20,842,160
2012	18,236	5,297,748	986,361	338,998	5,953,352	37,481	50,862	12,824,138
2013	23,812	7,296,400	1,542,200	373,800	11,305,100	49,800	54,600	20,897,100
2014	24,400	7,584,800	1,712,500	381,600	11,988,600	51,500	45,200	22,070,700
2015	24,300	7,962,400	1,623,200	344,200	8,984,700	31,700	49,800	19,286,200

Table 5.25 (continued) The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-2015 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
1991	5,558,909	0	8,764	611,956	22,766	823,375	178,593	15,438
1992	3,227,614	0	1,372	773,986	17,877	920,295	126,159	25,648
1993	5,354,513	0	1,355	695,833	28,036	820,786	95,370	7,237
1994	6,186,500	0	322	763,697	6,457	874,093	100,078	4,821
1995	7,709,266	0	357	932,932	4,744	1,055,371	107,861	7,246
1996	3,164,058	0	1,867	1,095,596	4,517	1,218,725	113,084	4,108
1997	7,185,601	3,657	11,646	858,060	4,758	1,001,845	121,148	1,884
1998	5,207,911	3,435	28,742	1,073,316	3,019	1,317,567	200,820	735
1999	4,682,531	3,634	108,221	1,300,929	2,773	1,606,642	183,403	690
2000	4,456,240	7,431	76,126	720,871	994	868,531	69,473	881
2001	7,763,767	17,055	101,789	823,549	1,985	1,005,541	72,688	388
2002	4,441,074	23,006	35,906	1,002,813	1,760	1,194,506	145,932	794
2003	2,496,410	19,473	8,080	1,506,398	1,498	1,760,436	224,908	710
2004	7,867,428	100,997	98,661	1,557,813	2,465	1,995,056	298,506	1,060
2005	7,389,626	94,142	147,566	1,340,940	55	1,803,080	312,781	538
2006	5,561,910	71,285	175,050	1,526,232	321	2,050,088	344,909	1,522
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

Table 5.25 (continued) The primary data on Crop production of non- nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-2015 period

Year	Productions of non-N-fixing crops (tonnes/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
1991	58,345	200	13,919	2,626	20,867	6,001	1,872,767	4,702,693
1992	38,554	75	7,574	2,638	21,517	9,272	2,601,648	2,896,691
1993	7,433	0	10,503	2,470	12,092	6,517	3,708,903	1,776,327
1994	4,492	40	12,993	1,559	6,257	7,387	2,946,721	2,763,783
1995	5,862	21	13,358	1,823	12,114	11,156	3,019,921	2,654,610
1996	12,953	0	12,092	1,455	6,565	9,875	3,591,378	2,848,169
1997	9,590	0	18,119	534	9,200	7,913	3,206,058	2,725,512
1998	11,137	0	17,536	206	19,876	9,155	3,319,150	2,361,359

Year	Productions of non-N-fixing crops (tonnes/year)							
	Hemp for fiber-Plant textiles	Cotton	Tobacco	Hop	Medicinal aromatic plants/spices grown	Sorghum for brooms	Potatoes	Sugar beet
1999	7,343	0	14,754	184	5,191	10,007	3,957,115	1,414,928
2000	1,398	0	10,869	142	1,397	6,300	3,469,805	666,870
2001	2,769	0	10,088	155	6,463	7,803	3,997,057	875,485
2002	5,586	0	15,979	142	5,351	7,342	4,077,633	954,630
2003	3,163	0	7,862	209	5,404	7,097	3,947,177	764,475
2004	1,868	0	7,471	37	9,240	11,813	4,230,210	672,723
2005	4,698	0	3,682	194	3,297	6,712	3,738,594	729,658
2006	2,415	0	1,686	435	16,969	8,716	4,015,899	1,152,200
2007	479	0	1,128	374	2,857	5,437	3,712,410	748,839
2008	181	0	2,366	257	7,488	3,170	3,649,020	706,660
2009	2	0	1,566	245	7,063	6,006	4,003,980	816,814
2010	45	0	2,971	232	15,828	5,392	3,283,866	837,895
2011	9	0	2,562	117	11,157	7,288	4,076,570	660,497
2012	0	0	1,341	173	4,293	5,793	2,465,150	719,788
2013	31	0	1,357	172	4,397	6,191	3,289,722	1,029,209
2014	2,253	0	1,405	268	4,219	6,290	3,519,329	1,398,570
2015	1,900	0	1,100	224	4,200	11,600	2,625,000	1,040,600

Table 5.25 (continued) The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-2015 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
1991	2,139,294	692,828	39,902	218,525	32,210	616,530	166,840	0
1992	1,343,408	830,980	59,659	339,266	43,537	676,197	181,660	901
1993	1,465,107	798,859	72,898	344,013	48,931	853,948	176,287	638
1994	1,245,305	716,354	73,759	310,938	56,387	711,335	163,154	570
1995	1,332,449	730,945	88,506	362,969	69,476	824,412	195,648	600
1996	1,301,142	689,325	90,360	305,610	54,108	857,435	186,575	587
1997	1,247,927	463,294	78,984	337,015	63,341	761,183	167,375	401
1998	1,119,479	677,517	91,180	365,162	71,960	837,824	191,376	176
1999	1,174,612	708,616	119,008	401,057	84,542	885,407	212,294	34
2000	800,587	628,675	94,823	296,297	68,338	731,897	174,836	3
2001	1,035,203	651,733	112,192	396,527	82,901	819,184	184,815	2
2002	1,042,467	658,777	121,576	340,784	72,423	821,419	197,442	5
2003	985,637	818,936	131,030	350,400	76,523	1,019,234	248,732	80
2004	280,348	1,330,085	149,681	332,827	65,884	919,092	237,240	7,050
2005	711,939	626,960	97,902	363,625	68,374	1,009,430	203,751	563
2006	776,951	834,968	101,159	390,694	64,222	1,106,006	279,126	2,559
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

Year	Productions of non-N-fixing crops (tonnes/year)							
	Fodder roots	Tomatoes	Eggplant	Dry onion	Dry garlic	Cabbage	Green peppers	Cultivated mushrooms
2013	417,182	749,128	123,278	391,837	62,156	1,156,436	227,690	8,785
2014	417,612	706,200	127,578	386,989	62,773	1,123,132	228,576	9,758
2015	393,800	695,200	126,755	353,600	62,400	1,066,300	222,400	10,955

Table 5.25 (continued) The primary data on Crop production of non- nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-2015 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
1991	193,047	740,464	3,246,400	5,645,816	5,390,442	11,036,258	15,228,648
1992	214,880	623,036	3,461,200	4,077,623	3,047,204	7,124,827	10,989,460
1993	256,907	601,429	3,992,100	3,971,900	3,029,541	7,001,441	11,758,248
1994	244,890	611,102	3,548,700	4,155,947	2,335,423	6,491,370	11,669,424
1995	281,339	639,352	3,868,500	4,127,358	1,892,078	6,019,436	12,209,911
1996	253,148	693,883	3,934,400	3,930,367	2,084,169	6,014,536	12,088,245
1997	273,629	625,663	3,559,600	3,741,430	1,602,720	5,344,150	13,301,172
1998	284,708	689,620	3,939,900	3,773,666	1,145,649	4,919,315	12,331,426
1999	308,408	853,231	4,365,600	4,334,489	1,028,431	5,362,920	13,509,179
2000	253,853	531,127	3,381,100	2,840,370	476,958	3,317,328	9,211,951
2001	301,749	550,503	3,848,300	3,146,175	579,428	3,725,603	11,535,656
2002	303,279	651,317	3,973,400	3,816,927	565,477	4,382,404	12,469,413
2003	332,795	764,585	4,684,500	4,118,584	606,706	4,725,290	12,613,904

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
2004	351,183	765,118	4,773,916	IE	IE	1,923,528	6,608,789
2005	229,569	691,760	3,624,612	IE	IE	2,454,958	10,127,514
2006	292,579	641,791	4,138,862	IE	IE	3,182,639	10,622,291
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

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 5.25 (NIS) were considered the data on Crop production of non - nitrogen fixing crop presented in the Annex 3.5 – 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 5.25.

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 5.25).

By expert opinion, the values for other grains were obtained from the difference between total cereal grains and the sum wheat and rye, barley and two-row barley, oats, maize, sorghum, rice and triticale.

The values for other oilseed plants (castor) were obtained from the difference between total oilseed plants and the sum rape, sunflower, flax for oil and soya beans.

By expert opinion, the values of *other textile plants* were taken from *castor*.

In the context of the study above, by expert opinion were taken from *sorghum for brooms*.

The values for *other vegetable* were obtained from the difference between *total vegetables* and the sum *tomatoes, eggplant, dry onion, dry garlic, cabbage, green peppers, cultivated mushrooms, root vegetables – edible roots, water melons and melons.*

In the context of the study above, by expert opinion, were considered that the *annual green fodder new* the values of *annual grasses* represent 70%.

The productions of *annual green fodder new* were obtained from the of sum *annual green fodder* and *plant used for silage*.

In the context of the study above, by expert opinion, were considered that the *other perennial forage* the values of *other perennial grasses* represent 60%.

The values for *other perennial forage* were obtained from the difference between *total perennial forage* and the sum *the lucerne in equivalent green fodder* and *clover in equivalent green fodder.*

The values associated the nitrogen fixing crop used in the calculation $\mathbf{F_{CR}}$ are presented in the Table 5.26.

Above-ground residues dry matter $(\mathbf{AG_{DM}})$ *has calculated with the formula in Table 11.2 in IPCC 2006, pg.11.17 using the default value for* $\mathbf{AG_{DMslope}}$ *and* $\mathbf{AG_{DM}intercept}$ in the same table *and for the N content of above-ground residues for crop* $(\mathbf{N_{AG}})$, *N content of below-ground residues for crop* $(\mathbf{N_{BG}})$ and *ratio of below-ground residues above-ground biomass* $(\mathbf{R_{BG-BIO}})$, dry matter has fraction $(\mathbf{Frac_{DM}})$ used the default value in Table 11.2 (IPCC 2006).

Data on **Area crops** (ha) and **Area burnt** were presented in Anexe 3.5.

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 5.26 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 1989-2015 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**
AG_{DM} slope	1.13	1.13	1.13	0.93	0.29	0.3	1.13	0.3
AG_{DM} intercept	0.85	0.85	0.85	1.35	0	0	0.85	0
R_{BG-BIO} (kg d. m.)	0.19	0	0.19	0.19	0.4	0.8	0.4	0.4
N_{AG} (kg d.m.)	0.008	0.01	0.008	0.008	0.027	0.025	0.027	0.027
N_{BG}	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
$Frac_{Remove}$	0.10	0.03	0.10	0	0	0	0	0

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**
$Frac_{DM}$	0.91	0.91	0.91	0.91	0.90	0.90	0.90	0.90
$Frac_{RENEW}$	1	1	1	1	0.2	0.5	1	0.5

In the Table 5.27 are presented the values associated the nitrogen non fixing crop used in the calculation **F_{CR}**.

Table 5.27 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 1989-2015 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	1.51	0.98	0.91	1.03	0.88	0.95	1.43
AG_{DM} intercept	0.88	0.52	0.59	0.89	0.61	1.33	2.46	0.14
R_{BG-BIO} (kg d. m.)	0	0.24	0.22	0.25	0.22	0	0.16	0
N_{AG} (kg d.m.)	0.005	0.01	0.007	0.007	0.006	0.007	0.007	0.007
N_{BG}	0.011	0.01	0.01	0.01	0.01	0.01	0	0

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**
$Frac_{Remove}$	0	0.25	0	0.20	0.20	0	0	0
$Frac_{DM}$	0.88	0.89	0.89	0.89	0.87	0.89	0.89	0.9
$Frac_{RENEW}$	1	1	1	1	1	1	1	1

Table 5.27 (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 1989-2015 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	0	0	0	0
AG_{DM} intercept	1.35	1.35	1.35	1.35	0	0	0	0
R_{BG-BIO} (kg d. m.)	0.19	0.19	0.19	0.19	0	0	0	0
N_{AG} (kg d.m.)	0.008	0.008	0.008	0.008	0	0	0	0
N_{BG}	0.01	0.01	0.01	0.01	0	0	0	0
$Frac_{Remove}$	0.40	0.40	0.10	0	0.30	0.30	0.30	0

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**
$Frac_{DM}$	0.91	0.91	0.91	0.91	0.85	0.85	0.85	0.85
$Frac_{RENEW}$	1	1	1	1	1	1	1	1

Table 5.27 (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 1989-2015 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	0	0	0.88	0.1	1.07	1.07	0.1	0.1	0
AG_{DM} intercept	0	0	1.33	1.06	1.54	1.54	1.06	1.06	0
R_{BG-BIO} (kg d. m.)	0	0	0	0.2	0.2	0.2	0.2	0.2	0
N_{AG} (kg d.m.)	0	0	0.007	0.019	0.016	0.016	0.019	0.019	0
N_{BG}	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0
$Frac_{Remove}$	0	0	0.10	0	0.40	0	0	0	0

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**
$Frac_{DM}$	0.85	0.85	0.89	0.22	0.94	0.94	0.85	0.22	0.85
$Frac_{RENEW}$	1	1	1	1	1	1	1	1	1

Table 5.27 (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 1989-2015 period

Parameters	*The values associated the nitrogen non fixing crop in the calculation F_{CR}*								
	Dry garlic	**Cabbage**	**Green peppers**	**Cultivated mushrooms**	**Root vegetables – Edible roots**	**Water melons and melons**	**Other vegetables**	**Annual grasses**	**Other perennial grasses**
AG_{DM} slope	0	0	0.1	0	1.07	0	0.1	0.3	0.3
AG_{DM} intercept	0	0	1.06	0	1.54	0	1.06	0	0
R_{BG-BIO} (kg d. m.)	0	0	0.2	0	0.2	0	0.2	0.8	0.8
N_{AG} (kg d.m.)	0	0	0.019	0	0.016	0	0.019	0.015	0.015
N_{BG}	0	0	0.01	0	0.01	0	0.01	0.01	0.01
$Frac_{Remove}$	0	0	0	0	0.10	0	0	0	0
$Frac_{DM}$	0.85	0.85	0.22	0.85	0.94	0.85	0.22	0.90	0.90

Parameters	The values associated the nitrogen non fixing crop in the calculation F_{CR}								
	Dry garlic	Cabbage	Green peppers	Cultivated mushrooms	Root vegetables – Edible roots	Water melons and melons	Other vegetables	Annual grasses	Other perennial grasses
$Frac_{RENEW}$	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 1989-2015 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 amount of urine and dung N deposited by grazing animals on pasture, range and paddock and by grazing animals (FracPRP)

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.

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 1989-2015 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 checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating LULUCF, 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

It was not made any recalculation compared to the last transmission.

5.5.6 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:

- ❖ 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 2015 are lower than emissions in 1989 with 12.84%, due to the lower agricultural yields.

Figure 5.9 Cumulative emissions trend - Field Burning of Agricultural Residues

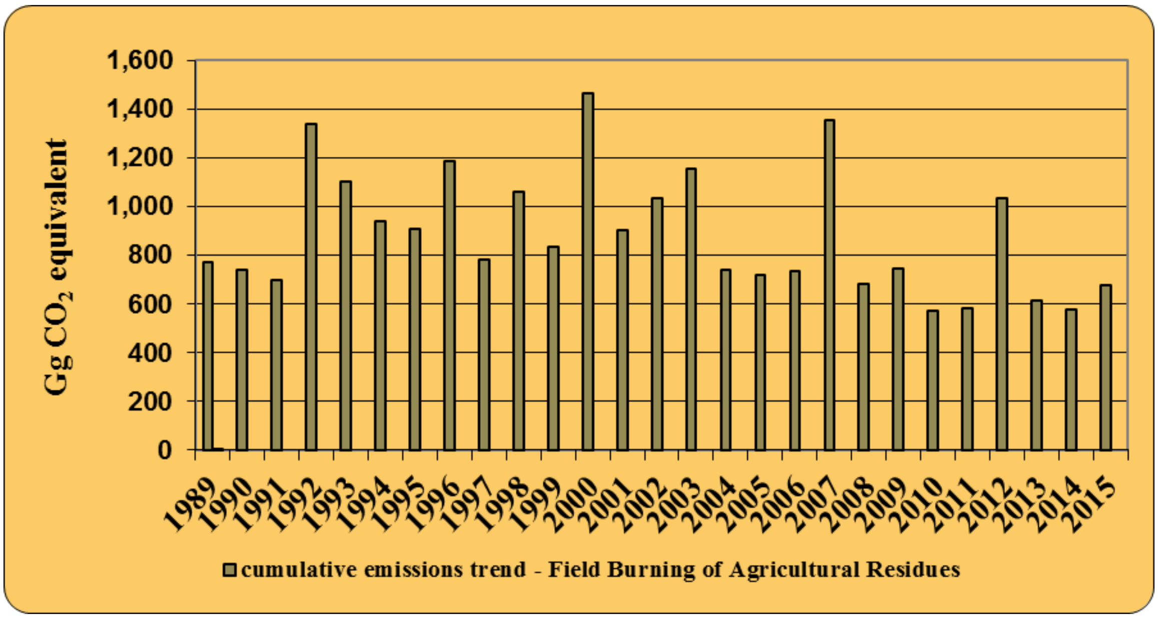


Table 5.28 Observations on source category 4F – "Field Burning of Agricultural Residues"

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, 1989-2015; the study „*Elaboration of national emission factors/ other parameters relevant to NGHGI Sectors Energy, Industrial Process,*

Source indicative	Source (livestock) type	Observation	Data source
			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 5.29 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.

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 1989-2015 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 checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating LULUCF, 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

Compared with last submission not made any recalculation.

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

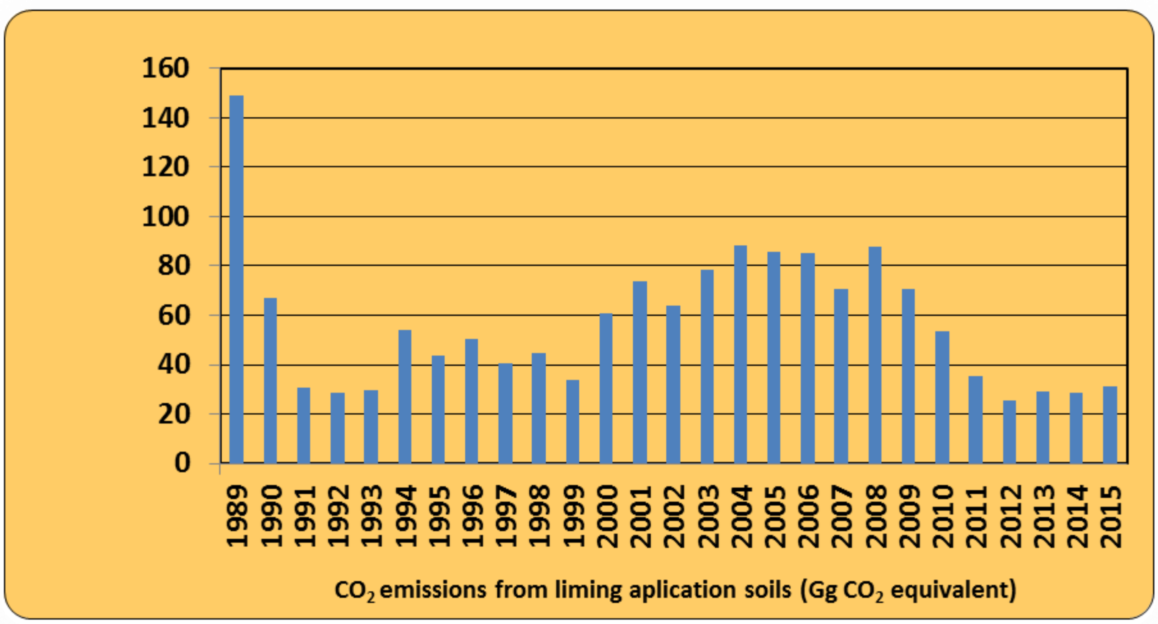
Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality, for to significant species, is envisaged.

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 5.10 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.

- 0.47 % 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 checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating LULUCF, 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

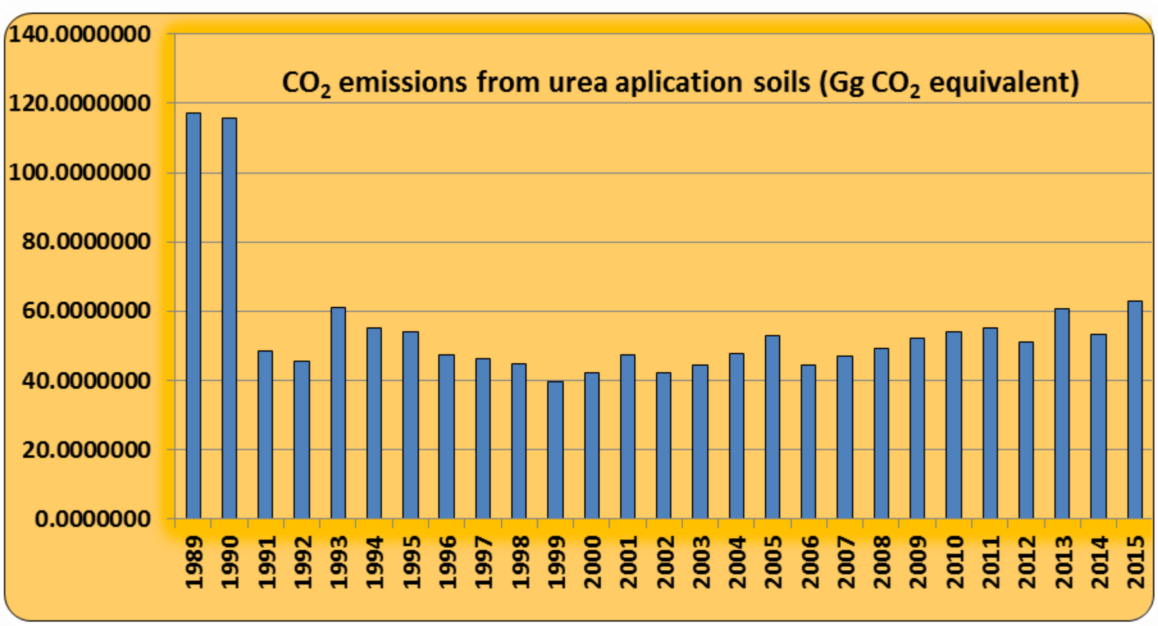
Aiming to their incorporation into next inventory submissions, the development of national values for activity data in totality.

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 5.11 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 checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating LULUCF, 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

Was made recalculations at the level estimation of CO_2 emissions due to was divided annual amount of urea fertilization by 0.46 being the percentage of N in uree.

The implications of all changes made on emission estimates are described in the Table 5.30.

Table 5.30 Recalculations on CO_2 emission estimates

Years	2016 v. 4 submission CO_2 (Gg) emissions	2017 v. 1 submission CO_2 (Gg) emissions	Difference
1989	53.960265	117.3049	-63.3447
1990	53.213597	115.6817	-62.4681
1991	22.299143	48.4764	-26.1773
1992	20.905973	45.44777	-24.5418
1993	28.034276	60.94408	-32.9098
1994	25.389225	55.19397	-29.8047
1995	24.808664	53.93188	-29.1232
1996	21.723204	47.22436	-25.5012
1997	21.261383	46.2204	-24.959
1998	20.579357	44.73773	-24.1584
1999	18.264086	39.70453	-21.4404
2000	19.407122	42.1894	-22.7823
2001	21.774626	47.33614	-25.5615
2002	19.390252	42.15272	-22.7625

Years	2016 v. 4 submission CO_2 (Gg) emissions	2017 v. 1 submission CO_2 (Gg) emissions	Difference
2003	20.450154	44.45686	-24.0067
2004	21.909425	47.62918	-25.7198
2005	24.266709	52.75372	-28.487
2006	20.455182	44.46779	-24.0126
2007	21.532766	46.81036	-25.2776
2008	22.700621	49.34918	-26.6486
2009	24.012034	52.20007	-28.188
2010	24.798931	53.91072	-29.1118
2011	25.413395	55.24651	-29.8331
2012	23.517932	51.12594	-27.608
2013	27.900693	60.65368	-32.753
2014	24.575320	53.42461	-28.8493

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

Agricultural lands, including arable, orchards, vineyards, pastures and hayfields makes up 61.3% of Romania's total national area. Forests cover 28.3% while constructed areas and road/railways, cover some 4.8%, humid areas, water and lakes some 3.5% and other land 2.1%. The official statistics provide annual data on land use categories for entire country territory since 1989. All of Romania's territory is included in the national GHG inventory. Estimating emissions and removals of greenhouse gas (GHG) from the land use, land use change and forestry (LULUCF) follows methodologies presented in *2006 IPCC Guidelines for National Greenhouse Gas Inventory* (IPCC, 2006) and *2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement)* (IPCC, 2014). The net GHG emissions for LULUCF in Romania are presented in Table 6.1

Table 6.1 GHGs emissions and removals for the LULUCF Sector in 1989 (BY), 2000, 2010, 2014 and 2015

IPCC Subcategories	Emission ("+") / removal ("-"), in GgCO_2eq				
	BY(1989)	**2000**	**2010**	**2014**	**2015**
4.A.1. Forest land remaining Forest Land (+4G. Harvested Wood Products)	-18391	-20928	-19314	-19959	-19959
4.A.2. Land converted to Forest Land	-3685	-3874	-3874	-3874	-3874
4.B.1. Cropland remaining Cropland	-3033	-2805	-2885	-2917	-2917
4.B.2. Land converted to Cropland	1803	1833	1833	1833	1833
4.C.1. Grassland remaining Grassland	-1161	-1222	-1222	-1222	-1222
4.C.2. Land converted to Grassland	7393	7407	7407	7407	7407
4.D.1. Wetlands remaining Wetlands	0	0	0	0	0
4.D.2. Land converted to Wetlands	1520	1537	1537	1537	1537
4.E.1.Settlements remaining	0	0	0	0	0

IPCC Subcategories	Emission (“+”) / removal (“-“), in $GgCO_2eq$				
	BY(1989)	2000	2010	2014	2015
Settlements					
4.E.2. Land converted to Settlements	3591	3700	3700	3700	3700
4.F.1. Other land remaining Other Land	0	0	0	0	0
4.F.2. Land converted to Other Land	794	811	811	811	811
CH_4 emissions	0	3	0	1	1
N_2O emissions	879	887	862	862	862

CO_2 removals have increased in forestland while CO_2 emissions from land converted to settlements have decreased compared to base year (1989). The major GHG is CO_2, with non-CO_2 GHG having insignificant contributions (Table 6.2).

Table 6.2 LULUCF GHG emissions and removals for the period 1989-2015 ("-"CO_2 removals, "+" GHG emissions, in kt)

Reported year	CO_2	CH_4	N_2O	NOx, CO, NMVOC	SO_2
BY (1989)	-11170	0.00	2.89	NA, NE	NA
1990	-13884	0.02	3.03	NA, NE	NA
1991	-13878	0.01	3.03	NA, NE	NA
1992	-14515	0.03	3.03	NA, NE	NA
1993	-15644	0.02	3.03	NA, NE	NA
1994	-14673	0.01	3.03	NA, NE	NA
1995	-13926	0.01	3.03	NA, NE	NA
1996	-12751	0.01	3.03	NA, NE	NA
1997	-12826	0.00	3.03	NA, NE	NA
1998	-14910	0.01	3.03	NA, NE	NA
1999	-13968	0.01	3.03	NA, NE	NA
2000	-13541	0.13	3.03	NA, NE	NA
2001	-14832	0.04	3.03	NA, NE	NA

Reported year	CO_2	CH_4	N_2O	NOx, CO, NMVOC	SO_2
2002	-12320	0.13	3.03	NA, NE	NA
2003	-12078	0.03	3.03	NA, NE	NA
2004	-11602	0.00	3.03	NA, NE	NA
2005	-13474	0.01	3.03	NA, NE	NA
2006	-12641	0.03	3.03	NA, NE	NA
2007	-11987	0.11	3.03	NA, NE	NA
2008	-12780	0.03	3.03	NA, NE	NA
2009	-12371	0.04	3.03	NA, NE	NA
2010	-12007	0.01	3.03	NA, NE	NA
2011	-12157	0.04	3.03	NA, NE	NA
2012	-13213	0.05	3.03	NA, NE	NA
2013	-12753	0.05	3.03	NA, NE	NA
2014	-12684	0.04	3.03	NA, NE	NA
2015	-12684	0.04	3.03	NA, NE	NA

Emission factors are based on country specific data for forestland, while for the other land categories on a both default and country specific factors and parameters. The GHG emissions estimates include all land categories and GHG (Table 6.3).

Table 6.3 Status of estimating emissions by sources/ removals by sinks in the LULUCF Sector (for completeness on C pools and GHG sources more information is available within the specific chapters in the NIR, R-reported, shaded cells – not relevant)

GHG source and sink categories	CO_2	CH_4	N_2O
4.A. Forest Land			
4.A.1. Forest Land remaining Forest Land	**R**	**R**	**R**
Living biomass	R		
Dead Wood	NO		
Litter	NO		

GHG source and sink categories	CO_2	CH_4	N_2O
SOMmin	NO		
SOMorg	NO		
4.A.2. Land converted to Forest Land	**R**	**NO**	**IE, NO**
4.A.2.1. Cropland converted to Forest Land			
Living biomass	R		
Dead Wood	NO		
Litter	R		
SOMmin	R		
SOMorg	NO		
4.A.2.2. Grassland converted to Forest Land			
Living biomass	R		
Dead Wood	NO		
Litter	R		
SOMmin	R		
SOMorg	NO		
4.A.2.3. Wetlands converted to Forest Land			
Living biomass	R		
Dead Wood	NO		
Litter	NO		
SOMmin	NO		
SOMorg	NO		
4.A.2.4. Settlements converted to Forest Land			
Living biomass	NO		
Dead Wood	NO		
Litter	NO		
SOMmin	NO		
SOMorg	NO		
4.A.2.5. Other Land converted to Forest Land			
Living biomass	R		

GHG source and sink categories	CO_2	CH_4	N_2O
Dead Wood	NO		
Litter	R		
SOMmin	R		
SOMorg	NO		
4.B. Cropland			
4.B.1. Cropland remaining Cropland	**R**	**NO**	**NO**
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	R		
4.B.2. Land converted to Cropland	**R**	**NO**	**R**
4.B.2.1. Forest Land converted to Cropland			
Living biomass	NO		
Dead Wood	NO		
Litter	R		
SOMmin	NO		
SOMorg	NO		
4.B.2.2. Grassland converted to Cropland			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
4.B.2.3. Wetlands converted to Cropland			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	IE		
4.B.2.4. Settlements converted to Cropland			
Living biomass	NO		

GHG source and sink categories	CO_2	CH_4	N_2O
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.B.2.5. Other Land converted to Cropland			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.C. Grassland			
4.C.1. Grassland remaining Grassland	**NO**	**NO**	**NO**
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	R		
4.C.2. Land converted to Grassland	**R**	**NO**	**NO**
4.C.2.1. Forest Land converted to Grassland			
Living biomass	NO		
DOM	R		
SOMmin	R		
SOMorg	NO		
4.C.2.2. Cropland converted to Grassland			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.C.2.3. Wetlands converted to Grassland			
Living biomass	NO		
DOM	NO		
SOMmin	NO		

GHG source and sink categories	CO_2	CH_4	N_2O
SOMorg	NO		
4.C.2.4. Settlements converted to Grassland			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.C.2.5. Other Land converted to Grassland			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.D. Wetlands			
4.D.1. Wetlands remaining Wetlands	**NO**	**NO**	**NO**
4.D.1.1. Peat extraction remaining peat extraction			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.1.2. Flooded land remaining flooded land			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.1.3 Other wetlands remaining other wetlands			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.2. Land converted to Wetlands	**R**	**NO**	**NO**

GHG source and sink categories	CO_2	CH_4	N_2O
4.D.2.1. Land converted to peat extraction			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.2.2. Land converted to flooded land			
4.D.2.2.1. Forest Land converted to flooded land			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
4.D.2.2.2. Cropland converted to flooded land			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.D.2.2.3. Grasslands converted to flooded land			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.2.2.4. Settlements converted to flooded land			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.2.3. Other Land converted to flooded land			
Living biomass	NO		
DOM	NO		

GHG source and sink categories	CO_2	CH_4	N_2O
SOMmin	R		
SOMorg	NO		
4.D.2.4. Land converted to other wetlands			
4.D.2.4.1. Forest Land converted to other wetlands			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
4.D.2.4.2. Cropland converted to other wetlands			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.D.2.4.3. Grasslands converted to other wetlands			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.2.4.4 Settlements converted to other wetlands			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.D.2.4.5 Other Land converted to other wetlands			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.E Settlements			

GHG source and sink categories	CO_2	CH_4	N_2O
4.E.1 Settlements remaining Settlements	**NO**	**NE**	**NE**
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
4.E.2 Land converted to Settlements	**R**	**NE**	**NE**
4.E.2.1 Forest Land converted to Settlements			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
4.E.2.2 Cropland converted to Settlements			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.E.2.3 Grassland converted to Settlements			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.E.2.4 Wetlands converted to Settlements			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.E.2.5. Other Land converted to Settlements			
Living biomass	NO		
DOM	NO		

GHG source and sink categories	CO_2	CH_4	N_2O
SOMmin	R		
SOMorg	NO		
4.F. Other Land			
4.F.1. Other Land remaining Other Land			
4.F.2. Land converted to Other Land	**R**	**NO**	**NO**
4.F.2.1. Forest Land converted to Other Land			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
4.F.2.2. Cropland converted to Other Land			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.F.2.3. Grassland converted to Other Land			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.F.2.4. Wetlands converted to Other Land			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
4.F.2.5. Settlements converted to Other Land			
Living biomass	NO		
DOM	NO		
SOMmin	R		

GHG source and sink categories	CO_2	CH_4	N_2O
SOMorg	NO		
4.G. Other			
Harvested Wood Products	R		
GHG sources			
4 (I) Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils			R
4 (II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils		R	R
4 (III) Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils			R
4 (IV) Indirect nitrous oxide (N_2O) emissions from managed soils			R
4 (V) Biomass burning	R	R	R

* R- reported

Key categories in the national GHG inventory are 4.A.1 Forest Land remaining Forest Land, 4.A.2 Land converted to Forest Land, 4.B.1 Cropland remaining Cropland, 4.E.2 Land converted to Settlements and 4.F.2 Land converted to Other Land.

Table 6.4 describes the key categories in the LULUCF Sector, based on level and trend assessment, showing also the change of the annual removals compared to the base year.

Both land sub-categories of Forest Land are key categories for CO_2 in the national GHG inventory, thus higher methodological levels is required.

Table 6.4 Key categories overview – LULUCF, 2015

Key categories	GHG	Criteria
4.A.1 Forest Land remaining Forest Land	CO_2	**L, T**

Key categories	GHG	Criteria
4.A.2 Land converted to Forest Land	CO_2	**L, T**
4.B.1 Cropland remaining Cropland	CO_2	**L, T**
4.E.2 Land converted to Settlements	CO_2	**L, T**
4.F.2 Land converted to Other Land	CO_2	**L, T**

6.2 Land-use definitions and classification systems used and their correspondence to the land use, land-use change and forestry categories

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 implemented by National Forest Inventory, as follows:

- Forest vegetation land, associates to "*Forest land*". It includes land covered with forest vegetation according to the following parameters: canopy cover 10%, minimum area 0.25ha and tree height at maturity of 5m, as well as forest belts wider than 20 m. It comprises deciduous forest, coniferous forest, mixed forests, clear-cut areas and nurseries, as defined by presence of deciduous trees, coniferous trees, deciduous and resinous trees, dead trees, clear-cuts and forest nursery activity.
- Agricultural land associate to „*Cropland*". This class includes agricultural lands, i.e. lands covered or temporary uncovered by agricultural crops (major crops and horticultural plants cultures). It includes 3 groups (non-woody crops, woody crops and other wooded land and trees outside forests (which do not meet the forest definition parameters, e.g. forest belts which are narrower than 20m) with 9 categories: orchard, vineyard, shrubs, cultivated land, temporary fallow land, deciduous tree, coniferous tree, deciduous and resinous trees and dead trees.
- Grassland class associates to „*Grassland*" which includes land whose destination such as grazing or mowing hay for livestock production, as well as other wooded land and trees outside forests (which do not meet the forest definition parameters, e.g. forest belts which are narrower than 20m). It includes pastures, hayfields in hilly and mountainous areas and meadows in lowlands.

- Water bodies and wet areas, associates to „*Wetlands*". It includes all lands covered by water (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 (waters and wetlands) and 11 categories (permanent streams, temporary streams, lakes, dams, floating vegetation, hydrophilic vegetation (stubble etc), harbors, temporarily flooded areas, bogs, channels and piers.
- Buildings/constructions/infrastructure in urban, rural and infrastructure across the country, associates to „*Settlements*". It has 3 groups (urban/rural, buildings and infrastructure) and includes: fenced and constructed areas, sealed lands (e.g. car parks, roundabouts, platforms), urban/rural lawns, playgrounds in green areas, beach lawn and other areas with lawn, dwellings, industrial and administration buildings (e.g. banks, churches, railway stations, restaurants), warehouses, huts, ruins, greenhouses, graveyards, dirt roads, trails, rail roads and roads (street, sidewalk, square), bridges and dams.
- "*Other land*" includes following categories: rocky areas, excavations, stone quarries (active, closed), stony debris, gravel/sand/earth pits, drilling perimeters and locally degraded lands.
- *Unmanaged forests* - Following comprehensive assessment by NFI all forests are assumed managed, either through a forest management plan or under wood collection so under anthropogenic impact, thus all forest are assumed managed land. Also, current assumption is that all grasslands are assumed managed, while wetlands unmanaged.

Each of these categories is further divided into two subcategories:

i. Land remaining in the same category during the inventory year;
ii. Land converted from one category to another.

Land use matrix is developed based on only two existing land assessments in 1980 and 2005 (for current process on developing data please sees more info under next title). Land conversions are interpolated and extrapolated back/forward linearly starting from the change between two moments in time. Complete matrix can be found in CRF Table 4.1. The advantage of the new land classification and area estimation method is that it provides sampling error for the area estimates for each land class in the primary classification, land sub-category and category.

6.3 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

For the purpose of the national GHG inventory a new reporting system is being put in place starting submission 2015. This new approach intends to make use of any spatial explicit information existing in the country, either for land classification or for classification quality check. It strives to assess consistently in time within the national territory the land according harmonized classifications. This information was already incorporated in the submission 2015 and expected to be updated while analysis progresses. Improved reporting of land categories is based on multiple data sources:

a. National Forest Inventory (NFI) statistical sampling grid which was expanded for LULUCF purpose to cover entire country territory and captures all land uses (1st cycle 2008-2012, 2nd cycle for 2014-2016)(details for http://roifn.ro/site/);

b. Military Topographic Maps for 1970 (edition I), 1980 (edition II), and 1990 (edition III), (1:25000, assessed at 2x2km grid of the NFI grid);

c. Ortophotoplans for 2003-2005 (edition I), 2007-2011 (edition II), 2010-2014 (edition III), and 2014-2015 (edition IV) (1:5.000, assessed at 0.5 x 0.5 km)

d. Other spatially explicit maps used especially for QAQC purpose (e.g. Corine Land Cover).

Harmonization and consistency of the legend of the maps was ensured at the most disaggregated division, and finally aggregated up to IPCC land use categories.

The work of historical reconstruction of data is expected to lasts 2 more years (to be included in 2018 submission), including QAQC. QAQC would be achieved by ancillary data (Landsat, various available GIS maps and field checks for share of deforested areas and conversions to forest, e.g. orchards and vineyards after incorporating LPIS data).

Table 6.5 Land use matrix for 1989 – 2015 (kHa)

Year	**1989**	**2000**	**2010**	**2014**	**2015**
Land sub-category					
4a1	**6602.0**	**6615.0**	**6642.7**	**6653.7**	**6653.7**
4a2.1	**330.0**	**347.3**	**347.3**	**347.3**	**347.3**

Year	1989	2000	2010	2014	2015
Land sub-category					
4a2.2	56.0	58.9	58.9	58.9	58.9
4a2.3	218.5	230.0	230.0	230.0	230.0
4a2.4	23.4	24.6	24.6	24.6	24.6
4a2.5	19.3	20.3	20.3	20.3	20.3
4b1	**12.8**	**13.5**	**13.5**	**13.5**	**13.5**
4b2.1	**8530.3**	**8083.5**	**7727.4**	**7585.0**	**7585.0**
4b2.2	1049.1	1104.3	1104.3	1104.3	1104.3
4b2.3	66.0	69.5	69.5	69.5	69.5
4b2.4	747.1	786.5	786.5	786.5	786.5
4b2.5	73.4	77.3	77.3	77.3	77.3
4c1	**150.1**	**158.0**	**158.0**	**158.0**	**158.0**
4c2.1	12.4	13.0	13.0	13.0	13.0
4c2.2	3452.6	3421.9	3462.5	3478.7	3478.7
4c2.3	1429.0	1504.2	1504.2	1504.2	1504.2
4c2.4	63.6	67.0	67.0	67.0	67.0
4c2.5	1205.2	1268.6	1268.6	1268.6	1268.6
4d1	**59.2**	**62.3**	**62.3**	**62.3**	**62.3**
4d2.1	87.7	92.3	92.3	92.3	92.3
4d2.2	13.3	14.0	14.0	14.0	14.0
4d2.3.1	398.2	502.5	616.8	662.5	662.5
4d2.3.2	379.6	399.5	399.5	399.5	399.5
4d2.3.3	NO	NO	NO	NO	NO
4d2.3.4	NO	NO	NO	NO	NO
4d2.3.5	67.0	70.5	70.5	70.5	70.5
4e1	**168.0**	**176.8**	**176.8**	**176.8**	**176.8**
4e2.1	144.6	152.2	152.2	152.2	152.2
4e2.2	14.7	15.5	15.5	15.5	15.5
4e2.3	11.0	11.6	11.6	11.6	11.6

Year	1989	2000	2010	2014	2015
Land sub-category					
4e2.4	792.0	916.4	1055.2	1110.8	1110.8
4e2.5	538.3	566.7	566.7	566.7	566.7
4f1	**62.9**	**66.2**	**66.2**	**66.2**	**66.2**
4f2.1	281.8	296.6	296.6	296.6	296.6
4f2.2	179.9	189.4	189.4	189.4	189.4
4f2.3	11.5	12.1	12.1	12.1	12.1
4f2.4	2.3	2.4	2.4	2.4	2.4
4f2.5	200.3	232.7	267.5	281.4	281.4
Total area	**112.0**	**117.9**	**117.9**	**117.9**	**117.9**

6.4 Forest Land (CRF 4.A)

6.4.1 Category description

At the end of 2015, forest land area in Romania was about **7001.1 kha**, which represents about 28% of the country area. The total area of forest land has increased by about 1% since 1990. The deciduous forests comprise 74% of forest area, while the Coniferous comprise 26%. In the deciduous forest, beech is the most common species (31% of the forest land), oak (17%), hardwood species (hornbeam, locust, maple, ash, etc. - 20%) and softwood species (poplar, willow, lime, etc. - 6%).

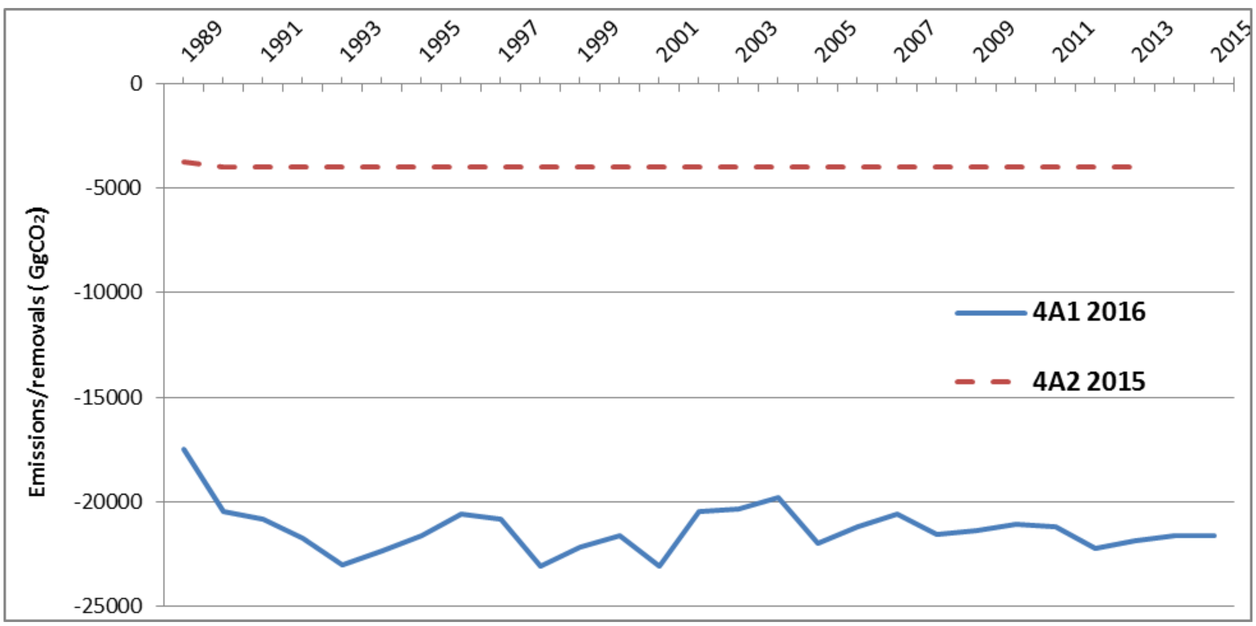
In the Coniferous forest, spruce is the most common species (21% of the forest land), followed by fir (4%) and other species (pine, larch, etc. – 4%). According to current data Romanian forests grow more than is harvested from them, with a growing / harvesting ratio of about 2.

According to current NFI1 data, the stand age class structure reflects an unbalanced distribution of age classes, with a surplus in in 2nd age class (23% of total forest land) above 3rd and 4th age classes (19% each) and a deficit in classes I (some 13%). According to the traditional forestry also re-stated in latest forest code all forest are managed following some basic principles:

rotation length ranging from 30 years (e.g. Robinia, poplar) to 120-140 years for oak, beech and spruce forests under high forest regime. Coppice area is small in Romania (< 7%).

Forest fires do not occur frequently and affect only small numerous scattered areas. Wildfires do not affect more than 1,000 ha annually. Litter fires, which affect only the forest floor (litter and deadwood), are the most common, while crown fires rarely occur. Major fall and breakings due to wind or snow occur at least once in a decade, especially in the coniferous forests, whose effect on the annual sink is estimated via harvest reported by the national statistics. Major windblown volume of about 6 mil. mc, i.e. 25-30% of regular annual cut, happen in the years 1997, 1998 and 2003. Under the current data availability there is a change of annual removals estimate only given by the annual harvest variation (i.e. total volume harvested, share on species).

Figure 6.1 Emissions for 4.A.1 - Forest Land remaining Forest Land and 4.A.2 - Land converted to Forest Land (kt CO_2)



6.4.2 Methodological issues

Methods currently implemented allow fully consistent reporting of activity data and Cstock change factors/C pools for Forest Land remaining Forest Land (CRF 4.A.1) and Land converted to Forest Land (CRF 4.A.2).

6.4.2.1 Forest Land remaining Forest Land (CRF 4A1)

Estimation of CO_2 removals have been following default, i.e. "gain-loss" method. The method involves estimating the C stock change for all C pools as multiplication of forest area (the activity data) and country specific parameters (used to derive the C stock change factors).

Actual and updated data was used as much as possible for the estimations of national GHG inventory, while improvements are underway as new data becomes available from the second NFI cycle. Generally, a Tier 2 applies.

6.4.2.1.1 Change of C stocks in living biomass

Estimation of C stock change uses equation 2.7 (IPCC, 2006).

Equation 6.1 Estimation of C stock change uses

$$\Delta CFF_{LB} = (\Delta CFF_G - \Delta CFF_L)$$

where:

- ΔCFF_{LB} = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land, tonnes C yr^{-1}
- ΔCFF_G = annual increase in carbon stocks due to biomass growth, tonnes C yr^{-1}. These estimates result from the multiplication of the activity data and country specific C stock change factors.
- ΔCFF_L = annual decrease in carbon stocks due to biomass loss, tonnes C yr^{-1}. These estimates are derived from statistics on removals of biomass from forest (i.e. wood harvest) and other losses (i.e. forest fires).

Activity data

Activity data is provided by the land-use change matrix (the area, see Annex 6.7.1).

The area and the structure of the forest land by species/groups of species are obtained from the NFI (for mid-year 2010). Same proportions are applied throughout the time series since 1990.

Table 6.6 Activity data on area of species/ groups of species used for calculation of the "increase" in carbon stocks due to living biomass growth (kha)

Year/ Parameter	**Total area**	**Distribution on species/groups of species**				
		Coniferous	**Beech**	**Oaks**	**Various Hardwood**	**Various Softwood**
1989	6672.2	2027.1	1992.3	1206.1	1018.2	333.2
1990	6658.4	2025.0	1990.3	1202.0	1013.9	331.8
1995	6706.1	2014.5	2037.8	1199.4	1024.1	335.1
2000	6753.9	1990.3	2078.0	1200.0	1047.5	342.8
2005	6801.6	1996.2	2151.4	1184.5	1040.1	334.1
2010	6849.4	2063.3	2172.1	1148.4	1024.7	345.5
2014	6035.7	2016.3	4073.2	1843.4	1504.2	545.6
2015	6035.7	2016.3	4073.2	1843.4	1504.2	545.6

Annual increase in C stocks in living biomass

Annual estimation of C stock increment uses country specific data, meeting the Tier 2 methodological level (with the exception of belowground biomass, where Tier 1, i.e. set to zero, applies). Thus, the average annual increment in biomass (G_{TOTAL}) is calculated with the equation 2.10 from 2006 Guidelines (IPCC, 2006), as follows:

Equation 6.2 The average annual increment in biomass (G_{TOTAL})

$$G_{TOTAL,\, i} = I_v * D * (1+R)$$

where:

- $G_{TOTAL,\, i}$ = average annual biomass increment above and belowground for strata *i*, tonnes d.m. $ha^{-1}yr^{-1}$. Currently, there are considered only six strata given on species/groups of species;
- I_V =average annual increment of the growing stock on species/group of species, $m^3ha^{-1}yr^{-1}$;
- *R* = ratio of below-ground biomass to above-ground biomass (set to zero under Tier 1);

- *D* = basic wood density, tonnes d.m. m^{-3}.

Details of the country specific data used for estimation are as following:

- ❖ **Average annual increment in volume** (I_V) by species and groups of species is obtained from the „Summary of the Forest Fund Inventory of Romanian Socialist Republic" (by ICAS, Ministry of Forests, 1984) for the entire period. This data is based on forest inventory drawn from the forest management plans for the national forest fund. Forest management plans are renewed every 10 (4) years and include specific estimates at the forest stands in terms of area, volume, species composition, current growth, etc. Growths values were calculated by summing the corresponding updated forest management plans data in force for the year 1984 (no other estimate was available meantime). New NFI increment data is available from first cycle, although it is not yet used being mostly because of apparently incomplete harvesting statistics (meantime a NFI based methodology is prepared to extract such data);

Table 6.7 Parameter values used to estimate annual increment of living biomass

Species / groups of species	I_V [m^3/ha/yr]	D [tone d.m./m^3]	R [dimensionless]
Coniferous	6.4	0.4	0
Beech	4.4	0.644	0
Oaks	4.7	0.644	0
Various hardwood	4.7	0.6	0
Various softwood	7.4	0.41	0

- ❖ Annual growth value is the increase in the aboveground stand volume, including trunk and branches, with bark but not the foliage. C stock in the foliage is assumed to be constant in time and not change from a year to another. For this reason no biomass expansion and conversion factor ($BCEF_I$) is applied. These data are the only data available at this time and are used in all national and international reporting (e.g. FAO);

- **Wood density** (D). Country specific values are available from "Studies and research for expansion of wood industry raw material base taking into account the structure, the physical-mechanical and technological characteristics of national forest tree species", ICPIL Manuscript, 1984. This data is provided by The National Institute of Wood (2008), which resulted from a national evaluation that took place as part of an assessment of the national forest resources, completed in 1984 (along with the Forest Fund Inventory). These values represent the best estimates for the breakdown used in forestry statistics and applied therefore in the national GHG inventory;
- **C fraction** (CF) is assumed to be 0.47 of the dry biomass is generally applied.

Annual loss of C stock from living biomass

As the annual losses of living biomass C stocks, includes the effects of:

i. wood harvesting, according with management plans allowable cuts;

ii. disturbances (wind storms, unauthorized logging, forest fires).

Collecting firewood from forests by people is not a significant practice in Romanian forests.

Unlawful cutting of trees is accounted for separately using field check data collected by forest administrators. This data is summarized regionally by forest authority offices and reported by the ministry. The volume of unauthorized harvested trees is finally estimated based on the official yield tables.

Wood resulted following disturbances is included in the national statistics as a normal harvest, in the year when the wood is harvested (not necessarily in the year of disturbance). Recent assessment showed that for large disturbances (> 2 mil. mc) a small volume of max 10% may remain untouched in the forest.

For forest fires CO_2, CH_4, N_2O emissions are calculated using country-specific activity data and default emission factors and are reported in CRF Table 4 (V) "Emissions from biomass burning". Currently available data allow the use of Tier 1, thus assuming that the belowground biomass C stock is entirely emitted in the same year. Also, under Tier 1 it is assumed that entire C stock in aboveground biomass is emitted in the event year, thus there is no debris or slash factor applied to assess changes in dead wood or litter pools.

Annual decrease of carbon stock due to biomass loss (ΔL_{FF})

Equation 6.3 Annual decrease of carbon stock due to biomass loss

$$\Delta L_{FF} = L_{fellings} + L_{other\ losses}$$

where:

- $L_{felings}$= annual carbon loss due to wood harvesting [tC/year];
- $L_{other\ losses}$= other annual carbon losses, due to illegal logging [tC/year].

Further on, the annual carbon loss due to timber harvest ($L_{harvest}$) is computed as following:

Equation 6.4 Annual carbon loss due to wood harvesting

$$L_{fellings} = H \times D \times (1+R) \times CF$$

where:

- H = annual volume of wood extracted [m^3/year];
- *R – is from national sources.*

Parameters D and CF have the same meaning as in the other equations. As well, for the estimation of the gain or loss, the values of these parameters are identical for same breakdown (i.e. on species/ group of species). Currently, the suppliers of data on wood harvesting are forest land administrators (i.e. forest districts).

The statistics include i) the normal harvest, respectively the allowable cut composed by main and secondary products resulting from the implementation of management plans, and ii) any wood volume removed as a result of forest disturbances. The national statistics report entire wood volume extracted from forest, with non-explicit contribution of wood sources (regular management, natural disturbances, deforestation) or wood faith on commercial wood (for industrialization) and firewood (Table 6.8). Harvest statistics refer to entire aboveground volume of the stands, over-bark and include all branches (Technical Norms for commercial wood volume assessment, MAPPM 2000), consistent with “gain” estimation. Under theoretically intensive forest management in Romania there is no standing dead wood in the forests. It is considered as part of the harvest and probably most of it used as firewood. This way, the forest growth, standing volume and harvested volume are fully consistent within Romanian forestry.

Table 6.8 Activity data for harvested wood volume during 1989-2015 (Thousands cubic meters / year)

Year	Distribution on species/groups of species					Unauthorized cut	Total harvest
	Coniferous	Beech	Oaks	Various Hardwood	Various Softwood		
1989	6516	6636	1842	2268	2004	83	19266
1990	5813	4958	2045	2071	1762	121	16649
1995	4973	4215	1551	1774	1300	122	13813
2000	5346	4509	1333	1731	1366	143	14285
2005	6061	4794	1586	1852	1378	86	15671
2010	6635	5489	1403	1845	1155	238	16527
2014	6635	5489	1403	1845	1433	331.4	16805
2015	6635	5489	1403	1845	1433	331.4	16805

Other annual carbon losses (unauthorized logging)

Equation 6.5 Other annual carbon losses

$$L_{other\ losses} = H_i \ x\ D\ x\ (1+R)\ x\ CF$$

where:

- H_i = volume extracted annually by illegal logging [m^3/year].

Other parameters have the same meaning as the previous equation.

Unauthorized logging statistics refer to entire aboveground volume of the stands/trees. Once the NFI data becomes available this will be implicitly included in the biomass loss estimate.

6.4.2.1.2 Change of C stocks in dead organic matter

It is assumed that the average transfer rates in and from the C pools in dead organic matter, are equal, and that annual net change is zero (Tier 1 according to the IPCC (2006)). This assumption is consistent as far as entire annual change of aboveground and belowground C stock in biomass is accounted as emission in the year of disturbance (i.e. for forestry operations), while there is also a rather constant annual rate of harvesting. As long as it is a key category, more information on how this assumption is supported with quantitative and qualitative information is shown under Ch. 11 on supplementary information on forest management activity (including a couple of measured data and modeling exercise).

6.4.2.1.3 Change of C stocks in forest soils

Forest land remaining forestland is a key category, for which reason assumption that SOC pool in ***mineral soils*** does not change is supported with additional quantitative and qualitative information in Ch. 11.

The area reported as ***drained organic soils*** on forest land in Romania is **95.33 kha.**Such areas are located in mountainous areas included under protected areas of the national forest fund and there are no involved in conversions. An ongoing analysis based on forest management plans has shown that this can be true for a small share of the total area of organic soils, while largest share might be actually represented by drained hydromorphic mineral soils (under excess of groundwater for at least part of the year), showing high clay and organic matter content. Drainage systems were actually settled before 1990. Nevertheless for a conservative approach, entire area of **95.33 kha** is assumed as subject of drainage (still subject of investigation).

IPCC 2006 default CO_2 emission factor for cool temperate forests of 0.68tC/year/ha (Table 4.6) and N_2O emission factor for mineral soils of 0.1 kg N_2O-N ha-1 (for temperate nutrient poor forest soils, Table 11.1) were applied to drained area under forest management. All emissions estimates have been reported under 4.A.1 Forest Land remaining Forest Land - in Table 4(III).

6.4.2.2 Land converted to Forest Land (CRF 4.A.2)

Activity data

In Romania conversions to forest land occur by:

i) artificial afforestation (which is later considered as afforestation/reforestation activity (A/R) under the Kyoto Protocol) where is classified as 4.A.2.1 Cropland converted to Forest Land and 4.A.2.2 Grassland converted to Forest Land;

ii) natural expansion of forest reported under mostly as conversion from Cropland, Grasslands and Wetlands. Such natural expansion of forest vegetation is included in the forest management plans, then also considered under forest management activity (FM) under the Kyoto Protocol (which explains why FM area is higher than area reported under 4.A.1 and AR is smaller than 4.A.2).

The activity data for conversions to forest land is detailed in the land area matrix (see Table 6.5). GHG inventory emission/removals estimates were prepared assuming an annual afforested area ratio of 20% by Populus 40% Robinia and 40% Oak and other broadleaved species. This share corresponds to the share of these species used in afforestation projects over the last 10 years.

Estimation of C stock change in living biomass

Annual change of C stock in living biomass in artificial plantations (as direct human induced)

The change of C stock in living biomass was determined based on the data and information from two research projects:

1) Reports on the implementation of the monitoring plan of the project "Afforestation of Degraded Agricultural Land Project in Romania" as a flexible mechanism of "Joint Implementation (JI)" under the Kyoto Protocol. The monitoring is carried out by the Forest Research Management and Planning Institute (Romania) according to “Monitoring Plan for Changes in Carbon Stocks in Forest Plantations”, agreed by partners in the project. *Project related documents are available with Forest Research Management and Planning Institute Bucharest.* This plan covers all issues related to sampling, measuring, processing, reporting

and archiving data and information. Data from second verification of carbon stock accumulated in the project was sampled in 2012. Second independent verification of the project was achieved in 2014, 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)" financed by the Ministry of Education and Research (Romania) during 2006-2009. The final report is available at ICAS Bucharest and some results were published in peer-review journals.

The data obtained in these two projects have allowed the development of biomass equations for the eight forest species most used in plantations on degraded lands in Romania. Both projects estimate changes of C stocks in the living biomass pools based on sampling in about 240 plots (all geo-referenced, with 176 subject to re-measurement in 2017 by the JI project). Relevant biometric data of trees in sampling plots were registered, as well as administrative information (parcel coding and location, age, etc). Available stand data was pooled together based on shares of main tree species (i.e. Robinia, oak and softwoods-poplar and willows) allowing derivation of plantations/young stands biomass equations for the 3 main types of plantations. Equations of the C stocks/biomass were obtained with non-linear processing following Richard-Chapman models functions. Data is shown in Table 6.9 below.

Table 6.9 Annual amount of C (t/ha) sequestered in biomass in forestry plantations

Plantation age (years)	Poplar & Willow	Robinia	Oak
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

Plantation age (years)	Poplar & Willow	Robinia	Oak
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
25	0,9	1,7	4,2

The data collected allows a Tier 3 estimation of C stock change in living biomass for AR land under 4.A.2 Land converted to Forest Land. Average net annual removals in all pools in JI project was 7.4 tCO_2/year since the project beginning. Based on detailed information from the JI project, while also confirmed by afforestation projects design and experts, the pre-afforestation land use was also determined as 80 % coming from marginal arable land and 20 % from degraded pasture and hayfields.

Annual change of C stock in living biomass in conversions to forestland by natural expansion of forest vegetation on non-forest land (as non-direct human induced)

As far as such areas occur by natural expansion and are sooner or later included in the forest fund they are assumed to behave as plantations. Structure of areas being under conversion to forestland by natural expansion of forest vegetation is not yet known although it can be derived from NFI, for which reason the same share of species is used as for artificial plantations. For estimation of annual C stock change the same approach as for direct human induced was used to report WL and OTL converted to FL (this approach is conservative as long as biomass in natural expansion is expected to be higher than in plantations, at least over the first age class).

Annual change of C stocks in the dead organic matter

Data available from the JI project is used to report estimates of C stock change in litter pool (which is an annually increasing sink) while dead wood pool is negligible (from same projects mentioned above an extremely small sink is estimated, but conservatively assumed as NO). The net values of annual increase of the C stock are computed as a time average according to the plantation age, but not differentiated ~0.1 tC $ha^{-1}yr^{-1}$ on plantations type. For estimation, the same share of planted area on main tree species was used as for calculation of changes in living biomass pool.

Table 6.10 Annual change in litter pool

Age (years)	Annual change in Litter pool (tC/ha/an)
1	0,04
2	0,04
3	0,08
4	0,13
5	0,18
6	0,21
7	0,22

Age (years)	Annual change in Litter pool (tC/ha/an)
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 change of C stocks in the soils

Conversion to forests occurs only on mineral soils. Currently, the estimation of C stock change in mineral soils is estimated based on national level reference C stocks (Table 6.11), which are computed from "Monitoring soil quality in the Romania" (ICPA, 2006). For Forest Land, the value was provided from the Forest management plans database.

Table 6.11 National reference C stocks in mineral soils on land use categories (tC/ha) and annual C stock change (tC ha^{-1}yr^{-1}) in conversions from to, assuming 20 years transition period

Land categories / C stock		from					
		FL	CL	GL	WL	SL	OTL
To	FL	84	+1.84	+1.74	+1.74	+2.64	+2.2

Land categories / C stock		from					
		FL	CL	GL	WL	SL	OTL
	CL	-1.84	**48**	-0.1	-0.1	+0.8	+0.34
	GL	-1.74	+0.1	**40**	0	+0.9	+0.44
	WL	-1.74	+0.1	0	**40**	+0.9	+0.44
	SL	-2.64	-0.8	-0.9	-0.9	**32**	-0.44
	OTL	-2.2	-0.34	-0.44	-0.44	+0.44	**41**

Based on Table 6.11 there is a built up of C stock in all types of conversion to Forest Land. Under country level averaged data several assumptions have been made, like:

i) because majority of wetlands in Romania occur on mineral soils similar C stock was assumed as for Grassland;

ii) C stock in settlements has been estimated as 32t/h assuming that top 10 cm of the mineral soils have been removed in a cropland soil;

iii) 41tC/ha in soils under other land, computed as weighted average of stony areas (5t C/ha), deposits of interior rivers (10tC) and Danube (60 tC, each with 33 % of the total area of other land).

Definition adopted for reporting emissions from organic soils in the National GHG inventory is in line with nationally available soil data: organic soils under any land use which are classified as histosols and are characterized by more than 40 cm peat layer having over 20 % organic content. Additionally, peat lands occur in Romania on very small areas (under natural reserves) at high altitudes where there are no artificial plantations.

6.4.3 Uncertainties and time-series consistency

Uncertainty assessment attached to the new approach for land assessment and NFI sampling errors for C pools is due to be provided with the new estimates. For 4.A.2, there is an estimation of uncertainty for the afforestation land for plantations on some 7,000 hectares included under the JI project. The sampled based uncertainty estimate for C stock was ± 10% (for 94% confidence interval of the mean).

6.4.4 Category-specific QA/QC verification, if applicable

There are three levels of QA/QC currently implemented within the LULUCF Sector of the national GHG inventory.

- The *first level* of QA/QC is conducted by the data providers. The data providers apply official procedures in order to ensure and control the quality of data provided to the GHG inventory compilers. Land classification and area estimation follows NFI procedures for data processing and quality control. In fact for LULUCF purpose specific QAQC components are developed for classification and control of non-forest land, including field assessments for the conversions (especially regarding the conversions from/to forests). A first version of the manual for land classification and associated QAQC manual for new land assessment system, including the schedule for implementation, was prepared in 2014 and it is subject for further development.
- *Secondly*, LULUCF GHG inventory compilers perform basic checks consisting of various procedures currently applied to avoid errors associated with different stages of data processing or calculation. Currently these QA/QC checks are:
    - Methods are established and followed step by step to avoid handling errors, especially by the implementation of complex excel spreadsheets.
    - Verification of land use classification by repeated assessment of sensitive cases (especially looking to forest conversions and forest/non forest wood areas) and comparison against other data sources. Expert consultation for specific issues (i.e. allocation of land under conversions among various categories; land definitions; forest data parameters and testing various proxies).
    - Cross-checks of IEFs values (C stock change factors) against values reported by other EU countries.
    - Graphic check of the smoothness of the time series for each land category and emissions of each individual C pool, check and fix any outlier and provide the explanation in the text for any extreme value.
    - Archiving of hard copies, or digital as appropriate, of the original data on the land categories (i.e. statistical reports, databases with digital maps and aerial photography).

  - The completion of the "List for Quality Control of the Greenhouse Gas National Inventory" in accordance with the provisions on quality assurance and quality control, approved by NEPA President Decision no. 24/2009. The list is completed and verified by different employees of Forest Research Management and Planning Institute Bucharest.
  - The project contractor on LULUCF sector, namely Forest Research Management and Planning Institute Bucharest, implements steps to ensure that the staff involved has gradually increasing understanding of the national GHG inventory reporting requirements. This included short training sessions on the 2006 Guidelines and 2013 Wetlands supplement and relevant UNFCCC decisions (e.g. 24/CP19).
- *Third* level of QA/QC is implemented by the Ministry of Environment – NGHGI, which consists of checks related to both CRF and NIR chapters. So far, there is no actual verification of the inventory estimate or the various parameters used in the inventory. Nevertheless, some scientific papers were issued recently on the sink in Romanian forests (e.g. Blujdea et. al, 2014).

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

Activity data from this category were not recalculated during this submission.

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

First, activity data is subject to major improvement starting year 2014. There is an ongoing improvement on land use assessment system for all land categories and C stock change in biomass. The shift consists in the use of all relevant land spatial databases available in the country, as mentioned under chapter 6.3. Development of the entire time series since 1970 for land matrix is expected to finish at the end of 2017, including quality assurance and quality control. The project is financed on annual basis by the Ministry of Environment and implemented by Forest Research Management and Planning Institute with various partners.

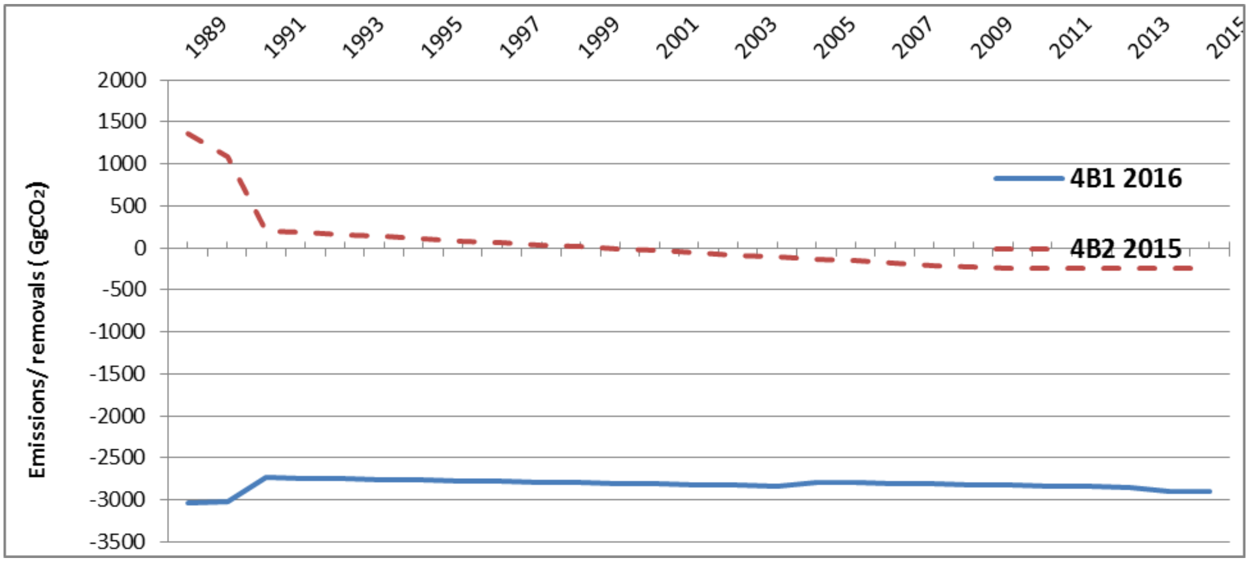
Second, C stock change data is also under improvement. With the availability of data from second NFI cycle it is endeavoured a shift to stock change method to estimate the change in living biomass. Although new annual increment data is available from NFI1, harvest data is still only available from the National Statistics (which seems much underestimated). For this reason current gain-loss method would be replaced by stock change entirely based on NFI data. New approach will also ensure implementation of all requirements from 2/CM7 (e.g. plantations replacing natural forests) and 2006 Guidelines (e.g. use of different biomass growth rates for forests naturally re-growing on abandoned lands and for forest plantations).

6.5 Cropland (CRF 4.B)

6.5.1 Category description

Cropland covers about 30% of the total country territory. Conversions to Cropland represent some 1105 kha/year for 25 years, with largest contribution of conversions from Grasslands. In 2015 about 95% is arable land, 3% is occupied by orchards and 2% is covered with vineyards. Cropland category also includes the lands subject to Revegetation activities eligible for reporting under the Kyoto Protocol. Such areas are reported in sectorial statistics as tree plantations (more information can be found at 11.1.3), but as a separate item than afforestation/reforestation. They are managed as part of the agricultural land – mainly arable, or transport infrastructure. These areas were recorded in statistics because of public funding and a long standing policy to improve the tree cover in plain areas of Romania. Revegetation occupies a very small area (less than 0.2% of total area of land included under 4.B.1 Cropland remaining Cropland category). While area of 4B1 was steadily decreasing since the base year, the annual CO_2 removals generally also decrease (Figure 6.2).

Figure 6.2 Removals and emissions for 4B1 - Cropland remaining Cropland (kt CO_2) and 4B2 - Land converted to Cropland (kt CO_2)



GHG removals and emissions trend in Cropland remaining Cropland is under the influence of two main components: area of permanent woody crops (orchards, vineyards) and land classified as “revegetation” (corresponding to activity under the Kyoto Protocol). Tree plantations classified as revegetated areas “behave” as forest plantations with regard to change in each C pools, and same data and approach is used as for Land converted to Forest Land (4.A.2) and AR. 4.B.1 - Cropland remaining Cropland is a key category based on level & trend assessment.

6.5.1.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The definition of this land category and the types of lands included in here are reported in section 6.1.1.

6.5.2 Methodological issues

Activity data (i.e. area) for the lands divisions included in this category is provided by the land use change matrix, for both 4.B.1 Cropland remaining Cropland and 4.B.2 Land converted to

Cropland subcategories. Estimation of carbon stock changes corresponds to Tier 1, estimating annual rates of growth and loss for national level data on the major type of crops.

6.5.2.1 Change of C stock in living biomass

Estimation of C stocks changes was made individually on each of the three different types of land included in the Cropland category and their subcategories: perennial crops (orchards and vineyards); revegetation and non-woody agricultural land (arable).

A. Woody perennial crops (vineyards and orchards)

Woody perennial species occupy about 5% of the Cropland area. For the estimation of *annual* removals and emissions "gain-loss method" following Equation 2.7 of IPCC's 2006 Guidelines on lands with woody perennial crops (vineyards and orchards) was applied:

Equation 6.6 Annual C stock change on lands with woody perennial crops

$$C_{stock\ change} = C_{stock\ annual\ increase} - C_{stock\ annual\ decrease}$$

Equation 6.7 Annual C stock increase on lands with woody perennial crops

$$C_{stock\ increase} = A_{CLp} * C_{biomass\ stock\ increment}$$

where:

- A_{CLp} – total national area of permanent cropland in a year [ha], which includes the old woody perennial crops (established in the previous years) and newest perennial crops established in the respective year (assumed in case of area increase).
  - $C_{biomass\ stock\ increment}$ – annual growth of carbon stock in the living biomass [=0.3 tC ha^{-1} $year^{-1}$], for <14 years plantations (Perennial Woody – Hungary's national GHG inventory 2014).

When there is a decrease of area of permanent woody crops between successive years that is considered as a conversion to other land use (category or within the cropland), in which case a C stock decrease is calculated in *Equation 6.7* above, as following:

Equation 6.8 Annual C stock decrease on lands with woody perennial crops

$$C_{stock\ decrease} = (A_{CLp\ previous\ year} - A_{CLp\ current\ year})) * C_{standing\ C\ stock}$$

where:

- $A_{CLp\ current\ year}$ – area of permanent cropland in the current year [ha];
- $A_{CLp\ previous\ year}$ – area of permanent cropland in the previous year [ha];
- $C_{standing\ C\ stock}$ – default value for standing carbon stock of woody biomass in permanent croplands [=4.43 tC ha^{-1}], (Perennial Woody – according to Hungary's national Inventory Report 2014).

Estimates also include conversions between arable and woody perennial crops, assuming a C stock for annual crops of 4.7 tC/ha.

B. ***Lands which are subject to revegetation***

These lands are included in the category 4.B.1 - Cropland remaining Cropland, but not highlighted as a specific land use in the land use change matrix (under scattered and non-identifiable locations). Such lands once covered by trees remain this way indefinitely in time and practically never convert back to arable lands.

Calculation of C stocks changes in all C pools is identical to that for artificial afforestation reported in the subcategory 4.A.2 – Land converted to Forestland, but averaged with equal weight across the 3 main types of plantations. Average C stock change in biomass in such planted tree patches are ~3 tC/ha/yr for 25 years (one cycle of tree plantations), which is quite realistic under fertilization and irrigation benefit from neighbor agricultural crops.

C. Land in conversion to agricultural land

Agricultural land here is represented mainly by arable land or management cycles which include arable land. Current data shows there are conversions from all land use categories to cropland, largest area being the conversions from grasslands. Conversion also occur from Settlements and Other land (i.e. industrial dumps and ecologization, reclamation of river deposits and islands along Danube and other rivers).

Estimates are calculated using equation 2.15 from 2006 Guidelines. Initial C stock changes in biomass are calculated under Tier 1 ($\Delta C_{conversions}$), assuming a biomass C stock of 91.34tC/ha for forests, 6.1 t dm/ha for grasslands the default value for the warm temperate dry eco-region (Table 6.4 of 2006 Guidelines) and 4.7t C/ha for annual crops (Table 5.9 of 2006 Guidelines). Entire amount of C stock in biomass in land use category before conversion is assumed to be lost in the moment of conversion to cropland (e.g. usually the technology implies deep soil preparation and removals of any pre-existing vegetation).

6.5.2.2 Change of C stock in dead organic matter pool

Carbon stock change in ***mineral soils*** on land category 4.B.1 – Cropland remaining Cropland is currently estimated only for areas under revegetation which cumulates some 103 kha in 2015 (when counted since 1990). The assumption is that under cropland management by tree plantations there is an increase of soil C stock from value specific to arable land to that specific to forest (namely an increase of 1.84 tC/ha/year is assumed for 20 years).

Normally for such tree patches there is a management cycle of ~ 25 years when such plantations are cut and rejuvenated without the change of location and followed by regeneration of same spot (generally ensured by assisted natural regeneration). For this reason starting age of 25 years of plantations since the establishment it is assumed there is no change in the soils (i.e. C stock is constant in time). Same approach is applied for DOM which increases for the first 24 years since tree plantation as for forest plantations, then it is assumed no change in DOM.

6.5.2.3 Change of C stock in soil organic matter pool

Following Tier 1 approach, there is no change estimated in soils organic matter pools for lands under annual crops (4B1), as soil management technologies did not change significantly (this issues is under current investigation).

Current approach is that there no change in soil organic matter C pool since there is no management change (reference soil C stock and values of C stock change factors did not changed in time practically).

For the category 4B2 – Land converted to Cropland, there are available the average values of C stocks in soils under (Table 6.11), as reference values nationwide on major land use categories. Under conversion of land use, the change in the soil C stocks is considered occurring linearly over a transition period of 20 years. As such conversions do not occur, informatively and for comparison purpose to other national values in Europe or region, for land conversion from Forest Land to Grassland, there is expected an annual decrease in C stock of 1.74 tC $yr^{-1}ha^{-1}$. In conversions from grassland and wetlands, there is a decrease of 0.1 tC $yr^{-1}ha^{-1}$, while increase is expected in conversions from settlements (+0.8 tC) and other lands (+0.34tC).

N_2O emissions from organic soils under cropland remaining cropland (area of 6.39 kha) are reported under Cultivation of Histosols. For organic soils area, CO_2 emissions under LULUCF are estimated for the entire time series using 2006 Guideline default emission factor for Cropland under ‘warm temperate dry’ zone of 10 tC/ha/yr. This adds annually an amount of 16 $GgCO_2$ emissions.

Definition of organic soils. Analysis includes histic soil types, like „gleiosoils” and „distric and eutric histosoils”. Definition used is consistent with FAO/IPCC definition.

Methodology to estimate organic soils area relies on Romanian soil database (SIGSTAR-200) and land use and cover information (LCCS-09) managed by Institutul Naţional de Cercetare-Dezvoltare pentru Pedologie, Agrochimie şi Protecţia Mediului (National Institute for Research and Development for Soil Scince, Agrochemistry and Environment, ICPA Bucureşti) (http://www.icpa.ro/). Core of database is the Soil Map of Romania (1:200000), whose original version was achieved between 1963-1994 and updated with newest available information, whenever that was available ever since. It is organized as a GIS database called SIGSTAR-200 (Geographic Information System of Soil Resources, as described by Vintilă şi colab., 2004, at http://www.icpa.ro/proiecte/SIGSTAR-200.pdf). For land use information for non-forest land use categories (Cropland, Grassland, Wetlands) another database owned by ICPA as well, called LCCS 09 (1:50000) provides information from photo-interpretation of recent aerial photography. Area is extracted by GIS analysis.

Results. Area of cultivation of organic soils under cropland as 6.387 kha of arable soils and 5.036 kha of grassland (grass covered considered as undisturbed soils). Cultivation refers to soil processing by technological means. Experts of MADR confirmed that in Romania grasslands are not subject of soil disturbance by machineries processing.

6.5.3 Uncertainties and time-series consistency

With ongoing project to derive new activity data for all land categories the uncertainty is not yet estimated. Estimates for the uncertainty of the activity data would be derived as soon as data processing will be finalized. The advantage of the new land classification and area estimation method is that it provides sampling error for the area estimates for each land category and subcategory.

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

General QA/QC rules mentioned for Forest Land (4.A) apply also for this category.

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

Activity data from this category were not recalculated during this submission.

Revegetation removals and emissions related estimates were maintained, considering total area managed as revegetated land in each of the base year and commitment period years.

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

For the estimation of C stock changes in soils of land "remaining croplands" there is an improvement plan available, related to the development of national system to respond accounting requirements set in decision 529/2013UE. According to this decision a reporting to European Commission on the national estimating system for cropland management and grazing land management is due annually for 2016-2018 while provide preliminary estimates before 2022 and final estimates in the final deadline in 2022.

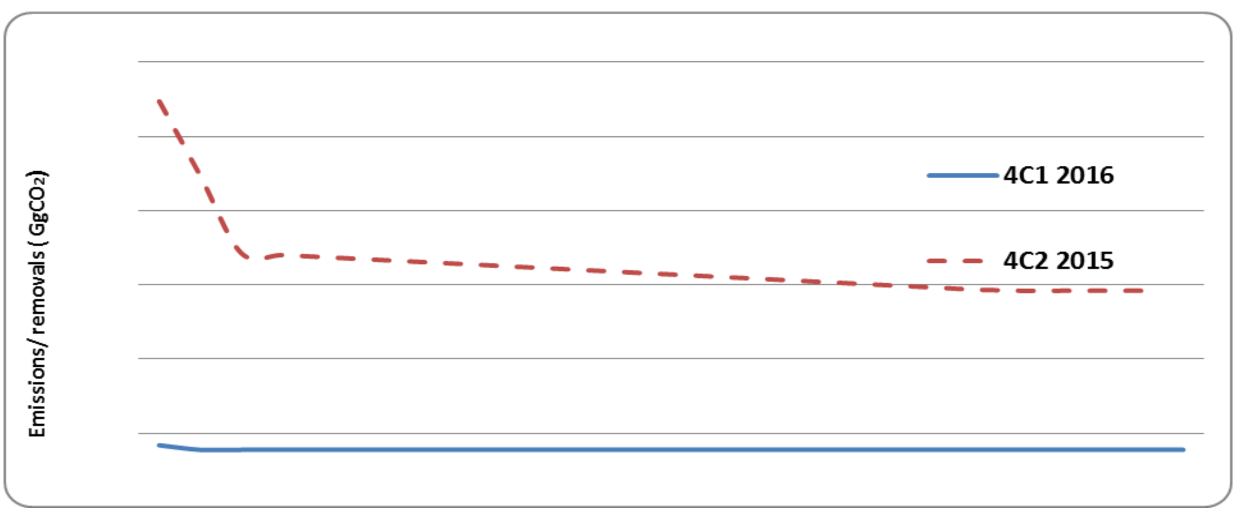
6.6 Grassland (CRF 4.C)

6.6.1 Category description

Grassland remaining Grassland area occupies 25% of the total country area, of which 1 % is represented by conversions among them.

Lands in conversion to grassland is around 1504 kha/year over 20 years. Main transition is from Cropland and Wetlands.

Figure 6.3 Emissions/removals for 4.C.1 – Grassland remaining grassland and 4.C.2 - Land converted to Grassland (kt CO_2)



6.6.1.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The definition of this land category and the types of lands included here are reported in section 6.2. From GHG inventory perspective, it is assumed there is no difference between hayfield and pasture.

6.6.2 Methodological issues

Activity data used to calculate GHG emissions for the land included in the Grassland category is provided by the land use change matrix, both for the 4.C.1 – Grassland remaining Grassland and 4.C.2 Land converted to Grassland category. Estimation of carbon stock change in the Grassland category corresponds to Tier 1, with country specific data on reference C stock in soils.

6.6.2.1 Change of C stock in living biomass

Estimate of the change of C stocks vary by type of land included in this land category:

- *Land remaining under the same use.* In the case of grasslands where there are no changes in usage it was considered that there are no changes in the C stocks of any pool (aboveground, belowground);
- *Land in conversion to grassland*. A default biomass value for the warm temperate dry eco-region (Table 6.4 of 2006 Guidelines) of 6.1tC/ha was used in calculations. Estimates are calculated using equation 2.15 from 2006 Guidelines. Initial C stock changes in biomass are calculated under Tier 1 ($\Delta C_{conversions}$), assuming a biomass C stock of 91.34tC/ha for forests and 4.7t C/ha for annual crops (Table 5.9 of 2006 Guidelines).

6.6.2.2 Change of C stock in dead organic matter and soil

For the estimation of C stock changes in soils of land “remaining grasslands” there is an improvement plan available, related to the development of national system to respond accounting requirements set in decision 529/2013UE. Current approach is that there no change in soil organic matter C pool since there is no management change (reference soil C stock and values of C stock change factors would practically no change in time).

For land in conversion to Grassland and reference C stocks from Table 6.11 are used for the calculation of emissions and removals under various conversions to grassland (assuming 20 years transition period).

6.6.3 Uncertainties and time-series consistency

With ongoing project to derive new activity data for all land categories the uncertainty is not yet estimated. Estimates for the uncertainty of the activity data would be derived as soon as data processing will be finalized. The advantage of the new method is that it provides sampling error for the area estimates.

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

General QA/QC rules are mentioned in the under Forest Land (4.A). Area of organic soils and drained areas was subject of repeated checks and identification of most reliable data sources with the Ministry of Agriculture.

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

Activity data from this category were not recalculated during this submission.

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

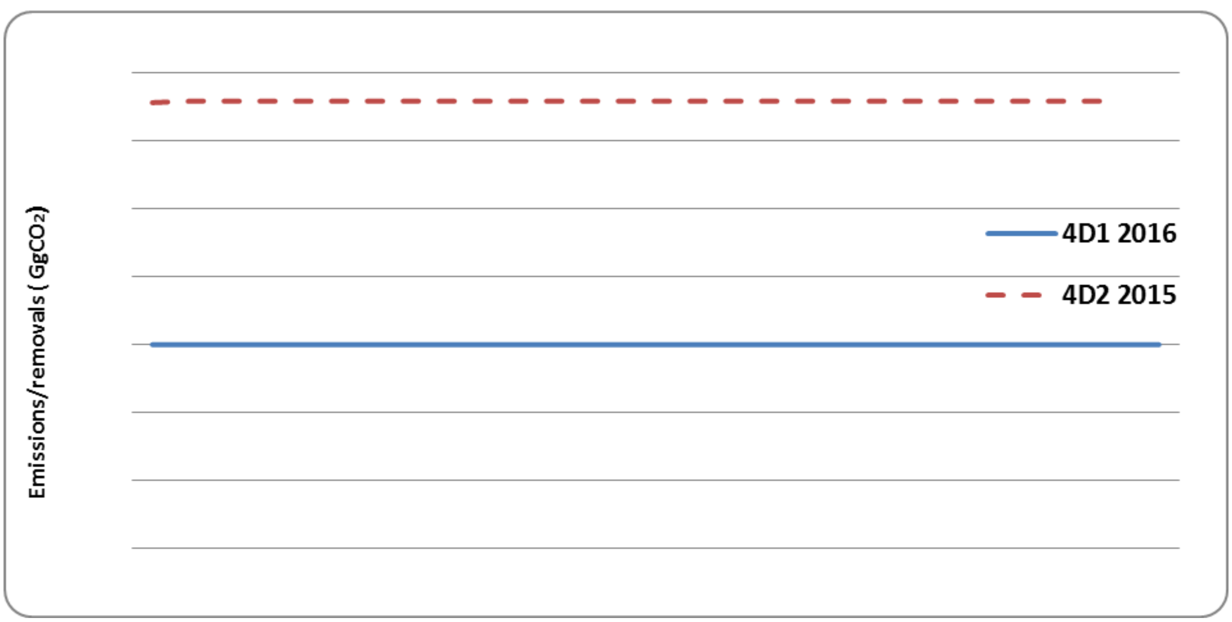
For the estimation of C stock changes in soils of land “remaining grasslands” there is an improvement plan available, related to the development of national system to respond accounting requirements set in decision 529/2013UE. According to this decision a reporting to European Commission on the national estimating system for cropland management and grazingland management is due annually for 2016-2018 while provide preliminary estimates before 2022 and final estimates in the final deadline in 2022.

6.7 Wetlands (CRF 4.D)

6.7.1 Category description

Wetlands area is about 3.4% of total land area. Absolute area is about 1062 kha, out of which 21% represents lands under conversion to wetlands cumulated during past 20 years. In Romania, peat bogs occupy very small area (as well as peat extraction activities) and do not associate with industrial activities. Also, in the last 20 years the area of drainage or flooding activities were rather small, compared to previous period 1970-1990 (under high intensification of agriculture and hydropower dam constructions), with such areas reported under CL or GL. Emissions related to these sources are discussed under Tables 4(II).

Figure 6.4 Emissions for 4D2 - Land converted to Wetlands (kt CO_2)



6.7.1.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The definition of this land category and the types of lands included in here are reported under this section 6.2.

6.7.2 Methodological issues

6.7.2.1 Changes of C stock change in living biomass

According to the land use change matrix, there were conversions from, “Grassland" and "Other Lands", on some 400 kha over the 20 years transition period. This conversion is associated with total emission from C stock in biomass. Same national average values of C stocks in all pools used in the “conversions from Forest Land” are used also here for estimation of related emissions (later described under section “Forest converted to Settlements”).

6.7.2.2 Changes of C stock change in dead organic matter and soils

In case of forest land conversion, the emissions associated with dead organic matter pool is computed by same approach as in 4.E.2 Land converted to Settlements. Soils emissions under various conversions to wetlands are computed based on reference C stocks provided in Table 6.11 (assuming a 20 years transition).

6.7.3 Uncertainties and time-series consistency

An investigation was done by a consortium consisting of Umweltbundesamt, Vienna, and University of Graz in a twinning project “Assessing the uncertainty of the Romanian Greenhouse Gas Inventory” which resulted in an relative uncertainty of 30%.

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

General QA/QC rules are mentioned in the 6.4.4 subcategory, under Forest Land (4.A).

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

Activity data from this category were not recalculated during this submission.
Recalculations are expected for the ~~following two~~ next year until the time series will be finalized

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

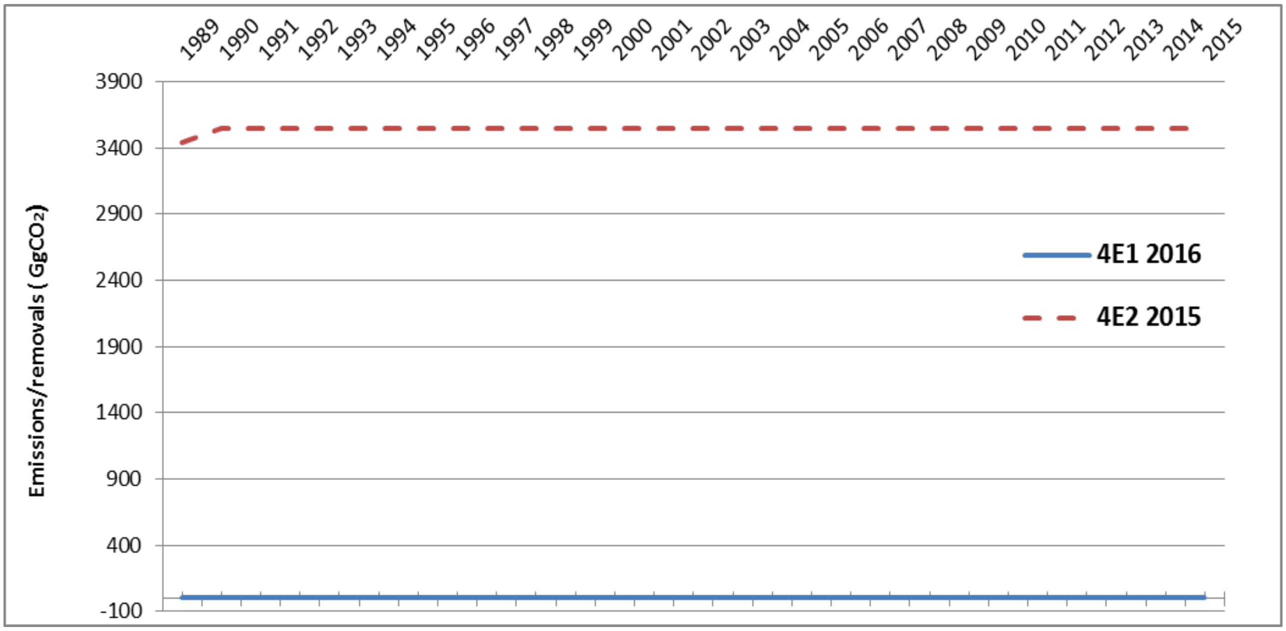
Improvements cover preparation to shift to post-2014 reporting requirements spelled out in GL 2006 and previsions of Wetland supplement 2014.

6.8 Settlements (CRF 4.E)

6.8.1 Category description

Area of settlements is about 4% of the total land area, respectively 1660 kha.
Conversions to "Settlements" during the last 20 years are about 30% of the total area of this category.
From 1990 to 2015 there are reported conversions to "Settlements" from almost all land categories. For conversions to settlements, a small contribution occurs in the case of conversions from “Forest Land” (66 kha kha cumulated over 20 years).
Land conversion to Settlements is a key category based on trend assessment.

Figure 6.5 Emissions for 4.E.2 - Land converted to Settlements (kt CO_2)



6.8.1.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The definition of this land category and the types of lands included here are reported under the section 6.2. Area of forest leaving national forest fund to settlements is subject to national legislation on licensing land for constructions which generally requires the removals of trees and/or soils upper layers in few months since permit is issued. C stock for all pools is assumed emitted in the year of conversions (license issuance).

6.8.2 Methodological issues

6.8.2.1 Changes of C stock in living biomass and dead organic matter and in soils

GHG emissions associated with the 4E1 are not estimated in the absence of an appropriate methodology in IPCC GPG LULUCF 2003.

In the case of conversions from forest land it was considered that the emissions from biomass and dead organic matter (DW, LT) occur in the year of conversion.

To estimate LB carbon stock change in Forest Land converted to Settlements, we have considered instant oxidation of carbon stock in living biomass and litter & dead wood and 20 years transition for soil pools. Starting with 2009, in the 21^{st} year, the area from 1989 is moved under 4.A.1 – Forest Land remaining Forest Land. Bellow it is an excerpt from the spread sheet. It should be noted the dominance of the very large conversion area in 1989 over entire time series in post-1990.

C stock change in biomass was estimated based on national average standing stock wood volume per hectare. According to the 1984 Forest Fund Inventory, this value is 218 m^3ha^{-1} (applied for 1990-2007) and 314 m^3ha^{-1} according to latest NFI (applied for 2008-on). Estimation also considered a weighted average of the wood density of 420 kg/m^3, as nationwide value and the default C fraction in dry matter. 1+R, root-to-shoot value was 1.18, also obtained as a weighted average among all species (a country specific value). No BEF was applied as the reported volume refers to aboveground wood standing stock. Consequently, country specific values of the wood standing stock in living biomass resulted of 66.88 $tCha^{-1}$ for 1990-2007 and 96.34 $tCha^{-1}$ for 2008-2015 are used.

Emissions from DOM were also estimated from two different databases: i) lying dead wood C pool from NFI as a national average of 0.74 tC/ha and ii) national average litter pool C stock of 7.42 tC/ha from ICP Forest database (author Surdu A., 2006).

Dead wood density was considered 400kg/m^3. An average standing dead wood stock is also estimated from NFI, but the standing dead wood is not included in this pool because it is assumed as subject to immediate harvesting, and it is already included in the regular harvest statistics, under very intensive forest management in Romania.

For conversions of non-forest lands to settlements, the CO_2 emissions from biomass and dead organic matter were considered negligible, with the exception of conversion from grassland where default value of the C stock in biomass was used (Tier 1), assuming an initial biomass C stock of 1.6 t dm/ha, respectively 0.8t C/ha, according Table 3.4.2 of IPCC GPG (2003), the default value for the warm temperate dry eco-region. Entire amount of C stock in the biomass in grasslands is assumed to be lost in the moment of conversion, so for years when such conversions do not occur NO is reported in the CRF. CO_2 emissions from soils under conversion to settlements were computed based on C stock data in Table 6.11 and it associated with emissions no matter of origin land category.

6.8.3 Uncertainties and time-series consistency

An investigation was done by a consortium consisting of Umweltbundesamt, Vienna, and University of Graz in a twinning project “Assessing the uncertainty of the Romanian Greenhouse Gas Inventory” which resulted in an relative uncertainty of 30%.

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

General QA/QC rules are mentioned in the 6.4.4 subcategory, under Forest Land (4.A).

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

In current submission there were no recalculations associated to this category. Romania currently making every effort to present improved values for the next submission.

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

Improvements under this land category are related to the targets assumed for the other land categories and expected under the next submission. Reference C stock in the soils under settlements could be reanalyzed as well as the transition period to this category.

6.9 Other land (CRF 4.F)

6.9.1 Category description

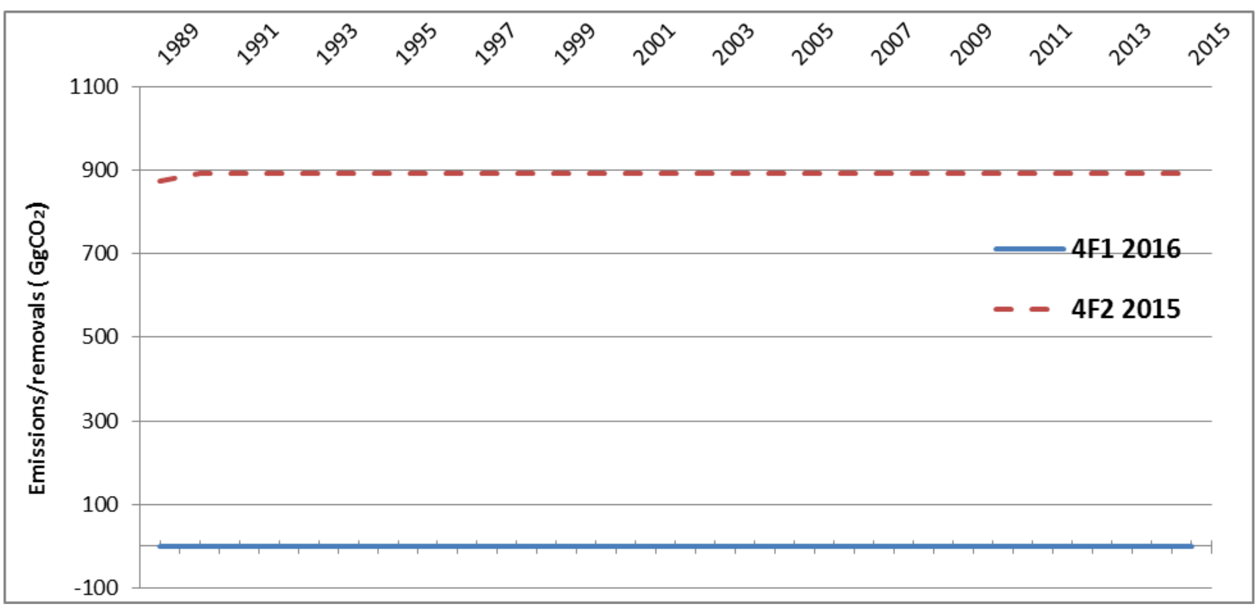
Area occupied by "Other Lands" is about 2% of the total land area, 399 kha respectively. Out of this, 73% are areas under conversion to Other Land.

This category was used as a "buffer" in the matrix of land use change (for relocation of areas among categories, so total area of land remaining in the same category and under conversion always equals to the net values reported by the national statistics at the end of each calendar year). It was also assumed that the country area is constant to 23839.1 kha, while sometimes the statistics varied in the narrow range of ±0.01%.

Thus, one of the features is the conversion to "Other Lands" of some 14 kha of forest land (for a period of 20 years). This cannot be considered "definitive leave from the forest fund" respectively legal forest "leaving" (associated with "deforestation" under the Kyoto Protocol), as not being resulted from legal proceedings (which are strictly regulated). This is nevertheless considered as "deforestation" under reduced area of "managed forestland". Explaining the transition of the area concerned to "Other Lands" is, first, by the continuous erosion of the Danube banks on the Romanian side (the forest fund stretches along the Danube on a length of some 1000 km) and inland rivers, but most of this decrease is likely related to management planning cycle because of changing (improvements) the cartographical base used in the determination of the area of forest parcels in subsequent planning.

Land conversion to Other Land is a key category based on trend assessment.

Figure 6.6 Emissions for 5.F.2 - Land converted to Other land (kt CO_2)



6.9.1.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The definition of this land category and the types of lands included in here are reported under section 6.2.

6.9.2 Methodological issues

6.9.2.1 Changes of C stock in living biomass and dead organic matter and in soils

For category 4.F.1 – Other Land remaining Other Land, GPG LULUCF IPCC does not recommend a method for calculating GHG emissions.

There were not calculated emissions from C stock change in biomass in conversions of non-forest lands.

In the case of Forest Land conversion to Other Land (4.F.2.1), CO_2 emissions from living biomass removals were estimated according to the national average standing wood volume per hectare, considering that the emission occurs in the year of conversion. The estimations of LB emissions of Forest Land converted to Other Land follows exactly the same data and estimation procedure as that used in Forest Land converted to Settlements at 6.8.2.1.

C stock changes in DOM pool were also reported as full emission in the event year. The parameters used and computation assumptions are reported in the section covering the category 4.E.2 – Land converted to Settlements.

Soils C stock changes are estimated based on C stock data in Table 6.11 and it is associated with emissions no matter of origin of the land category.

6.9.3 Uncertainties and time series consistency

An investigation was done by a consortium consisting of Umweltbundesamt, Vienna, and University of Graz in a twinning project "Assessing the uncertainty of the Romanian Greenhouse Gas Inventory" which resulted in a relative uncertainty of 30%.

6.9.4 Category specific QA/QC and verification, if applicable

General QA/QC rules are mentioned in the 6.4.4 subcategory, under Forest Land (4.A).

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

Activity data from this category were not recalculated during this submission.
Recalculations are expected for the next year until the time series will be finalized.

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

No specific improvements are envisaged.

6.10 Harvested wood products (CRF 4G)

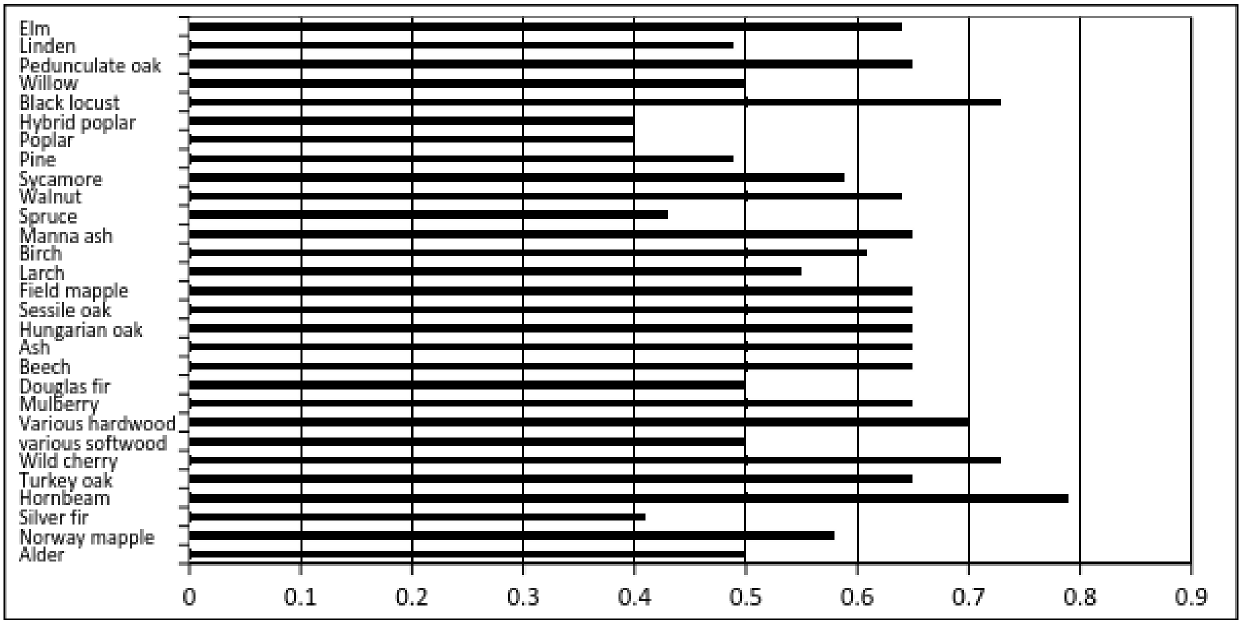
6.10.1 Category description

In Romania, HWP reservoir size is estimated to about 10.mil. tC in 2015.

6.10.2 Methodological issues

Establishing the carbon conversion coefficients specific to Romania. When establishing parameters needed for estimation of emissions/removals associated to HWP, it was necessary to consult the literature regarding wood density and carbon content of Romanian tree species (Rîșcuță, 1979; Petrovici and Popa, 1997). When aggregated on species and groups of species we took into account the share of tree species in wood harvest (Figure 6.7).

Figure 6.7 Oven dry density of wood (g·cm-3) species harvested in Romania



Further on, the coefficients from Table 12.4 of 2006 Guidelines (Default factors to convert from product units to carbon) were adapted to the conditions of our country, resulting the following factors for conversion to carbon:

Table 6.12 Factors for conversion to carbon

Item	Value
1. Solid wood	0,285
1.1 Sawnwood	0,268
1.2 Wood panels	0,294
2. Paper and paperboard	0,45
3. Wood charcoal	0,765
4. Bark	1,120

1.1 *The Half-live time parameter*. According to the *2006 Guidelines*, the half-live time parameters are: 30 years - solid wood (decay rate k=0,023) and 2 years- paper products (decay rate k=0,347).

1.2 *Consulting international databases (FAO).* When determining CO_2 emissions, we resorted to consulting the FAO database (available at the following address: http://faostat.fao.org).

Based on FAO classification, we retrieved data regarding the production, import and export of the following wood products: roundwood, sawnwood, wood-based panels, paper and paperboard, wood pulp and recovered paper, industrial roundwood, chips and particles, wood charcoal and wood residues. In case of chips and particles boards, data were transformed from the fiberboard and particleboard category (import-export), using conversion factors inferred from literature (Bularca,1996).

1.3 *Estimating data for the period between 1900 and 1960*. Due to the fact that FAO only supplies data beginning with 1961, we resorted to estimate production, import and export of wood products between 1900 and 1960 by equation 12.6, which takes into account the production, imports and exports values for 1961 and *U* (the exchange rate in Europe, which amounts to 0.0151).

The variables (1A, 1B, 2A, 2B, 3, 4, 5) were determined in conformity with the provisions of the *IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use, chapter 12 Harvested Wood Products 2006*. Calculation runs through all of the mentioned stages, and also by using the I*nventory Software ver 2.12*, available at http://www.ipcc-nggip.iges.or.jp/software/index.html.

1.4 *Calculating variable 1A* (i.e. Annual change in carbon stock in “products in use”). It was calculated using formulas 12.1 and 12.2, for each product category (solid wood or paper products), inflow, k (decay rate), and the carbon stock at the beginning of the year ($C_{(i)}$).

1.5 *Calculating variable 2A* (Annual change in carbon stock in "products in use" where wood came from harvest in the reporting country (includes exports)). It was calculated using formulas 12.1 and 12.3, accounting for the product category (solid wood or paper products), inflow, k (decay rate) and the stock of carbon at the beginning of the year ($C_{(i)}$).

1.6 *Calculating variable 1B* (Annual Change in stock of HWP in SWDS from consumption) and 2B (annual Change in stock of HWP in SWDS produced from domestic harvest).

When calculating the 1B and 2B variables, we took into account the Waste Sector Tier 1 estimates, as laid out in the IPCC Guidelines (2006).

6.10.3 Uncertainties and time series consistency

Estimation of C stock change in HWP is under further refining. Estimate of uncertainty is going to be done with future submissions.

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

Comparable order of magnitude of currently submitted estimates with those submitted by Romania in the past (TAR for forest management reference level).

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

Romania submits estimates for HWP starting with 2014 submission. In the current submission, were no made recalculations associated to this category.

6.10.6 Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors, etc.), including those in response to the review process

Current approach is to build capacity to cover HWP, to better understand the estimation methodologies and requirements, as well as available data.

6.11 Nitrous oxide emissions from runoff associated to land conversions

6.11.1 Description of sources of indirect emissions in GHG inventory

Under land use change, N_2O 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.

6.11.2 Methodological issues

Default factors from Tier 1 and Equation 11.10 is tested. Amount of N_2O emissions from runoff / leaching is negligible.

6.11.3 Uncertainties and time-series consistency

Not applicable.

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

Not applicable.

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

Not applicable.

6.11.6 Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors, etc.), including tracking of those identified in the review process

Further research have to be implemented in order to estimate such sources and emissions. Potential GHG source may be erosion of agricultural soils.

6.12 GHG emission from LULUCF sources

6.12.1 Direct N_2O emissions from N fertilization of Forest Land and Other (CRF Table 4(I))

Fertilization of forest land is extremely limited (i.e. rarely occurs in forest nurseries) under very extensive forest management practices in the country. In any case, although it may occasionally occur, the statistics on fertilizer amount applied is not breakdown on land uses.

Thus related emissions are assumed as reported under Chapter 4 Agriculture of the national GHG inventory. Thus, these emissions are reported as "IE" in CRF Table 4(I).

6.12.2 Non-CO_2 emissions from drainage of soils and wetlands (CRF Table 4(II))

An area of 95.3 kha is reported as drained organic soils under forestland with CO_2 emissions reported under 4A1/FM and N_2O emissions in Table 4(II). Since 1989 there is not reported any activity of drainage of forest lands in Romania. Peatland area and related activities are insignificant. Floodings are also considered negligible.

6.12.3 N_2O emissions from disturbance associated with land-use conversion to cropland (CRF Table 4(III))

Land use change from forestland to cropland is not legally allowed, and does not occur in Romania. Nevertheless, there are such conversions from grassland and wetlands, which summed up to some 933 kha since 1989.

To this adds the drainage of non-forestlands, a total of some 95.3 kha in 1990 with some 64 % of total area as drainage of organic soils. In 2015 there are no new drained areas, but only areas under 20 years transition period (since drainage occurred).

Drainage leads to soil perturbation which associates with N_2O emissions by humus decomposition. According the land use matrix, from total cumulated area under conversion to arable land, in 2015, 43% were conversions from grasslands, 38 % from wetlands and 10 % from other land (they are all reported under 4.B.2 Land converted to Cropland). N_2O emissions are estimated assuming 20 years transition period.

N_2O emissions from areas GL, WL under conversions to CL was recalculated for the entire time series, because of an error (which drove IEF to be continually growing). Amount of soil C mineralized (kgC/yr) was 840KgC/ha/yr. IPCC default values were used: C/N ratio (~14) and emission factor for N (~0.0124 kg N_2O-N/kg N). Thus IEF is constant around 0.01 kg N_2O-N/ha. There are no conversions on organic soils, and if there is any it is reported as IE in drained cropland. Also, conversions from WL to CL are assumed to only occur on mineral soils (as being lands under temporary flooding and classified as wetlands but not associated with mineral soils).

6.12.4 N_2O emissions from disturbance associated with land-use conversion to cropland (CRF Table 4(III))

Land use change from forestland to cropland is not legally allowed, and does not occur in Romania. Nevertheless, there are such conversions from grassland and wetlands, which summed some 146 kha since 1989. N_2O emissions from areas GL, WL under conversions to CL was recalculated for the entire time series, because of an error (which drove IEF to be continually growing). Amount of soil C mineralized (kgC/yr) was 840KgC/ha/yr. IPCC default values were used: C/N ratio (~14) and emission factor for N (~0.0124 kg N_2O-N/kg N). Thus IEF is constant around 0.01 kg N_2O-N/ha.

There are no conversions on organic soils, and if there is any it is reported as IE in drained cropland. Also, conversions from WL to CL are assumed to only occur on mineral soils (as being lands under temporary flooding and classified as wetlands but not associated with mineral soils).

6.12.5 Biomass Burning (CRF Table 4(V)

Controlled biomass burning is not allowed in Romania, while the wildfire frequency is very limited. Nevertheless, occasionally it is practiced unlawfully on arable or grass lands (on which data is not yet available for reporting in the national GHG inventory).

For forestland, the area annually affected by wildfires is reported in sectoral forest statistics. Characteristically, the forest fires consist in ground floor dead mass burning (litter and lying dead wood), and in extremely few cases of the stand crown fires (in average 2 % of annually affected area).

As far as the wood is not qualitatively affected, it is harvested and reported in the annual wood harvest statistics (while the land remains forest land). From all these reasons, CO_2, N_2O and CH_4 are all reported in CRF Table 4(V). Annually affected area on land categories is reported by the General Inspectorate of Emergency Situations.

In 2015 submission, separate estimates for forest remaining forests (4.A.1 – Forest Land remaining Forest Land) and lands under conversion to forests (4.A.2 – Land converted to Forest Land) are estimated. Although there are no reported fires on such lands, a conservative approach was taken by calculating GHG emissions assuming that officially reported wildfire burnt area is shared between AR areas and FM areas, in a ratio equal to AR share in total FM area. AR share is 4,2% from total wildfire area, while avoiding double accounting of area between FM and AR.

For 4.A.2 and AR estimation assumes that both DOM and standing living biomass pool are entirely burned. DOM estimate is 0.74 tC/ha and living biomass is 12.96 tC/ha at 10 years old plantations as resulted from a running JI afforestation project. This resulted in an increase of non-CO_2 emissions by some +4% in Table 4(V) and (KP-II)4, because of larger C stock in DOM+LB in AR than in DOM in FM (since only litter fires was previously assumed).

Table 6.13 Forest fires area

Year	Total affected area (ha)
1989	93
1990	444
1991	277
1992	729
1993	418
1994	312
1994	208
1996	227
1997	68
1998	137
1999	379
2000	3607
2001	1020
2002	3490
2003	762
2004	124
2004	212
2006	946
2007	2924

Year	Total affected area (ha)
2008	844
2009	974
2010	206
2011	3047
2012	1228
2013	1295
2014	1130
2015	1130
Average area	972

GHG emissions from forest fires are computed based on Eq. 3.2.19 of the IPCC GPG 2003.

Equation 6.9 GHG emissions from forest fires

$$L_{forest\ fires} = S_{forest\ fires} \times M_f$$

where:

- $L_{forest\ fires}$ = total amount of C annually emitted (tC yr^{-1});
- $S_{forest\ fires}$ = annually affected area (ha yr^{-1});
- M_f = amount of C in „dead wood lying on the soil surface" [MgC ha^{-1}].

For 4.A.1 and FM it is assumed that entire litter and dead wood is burning (both lying and standing dead wood). Emissions is computed from the nationally average C stock in litter (=7.42tC/ha) and dead wood volume preliminarily available from the NFI (0.74 tC/ha computed from 3.13 mc/ha of standing dead wood and 0.62 mc/ha lying dead wood). Conversion from dead wood volume to dead mass was done assuming 400 kg/m^3 (same input data as for the estimation of DOM related emissions in land converted to settlements 4E2). Carbon content was 0.4 according to the GPG LULUCF 2003. Finally, C stock in dead organic matter used was 8.18 tC/ha.

It was also assumed that there are no understory emissions.

For the calculation of absolute CO_2 and non-CO_2 emissions from forest fires, IPCC default factors are used in the formulas 3.2.19 of IPCC GPG 2003.

Equation 6.10 Calculation of absolute CO_2 and non-CO_2 emissions from forest fires

$$\text{Emission of } CO_2\ [Gg\ yr^{-1}] = (C\ emitted)\ [tC\ yr^{-1}] \times (44/12)/1000,$$
$$\text{Emission of } CH_4\ [Gg\ yr^{-1}] = (C\ emitted)\ [tC\ yr^{-1}] \times (emission\ ratio) \times (16/12)/1000,$$
$$\text{Emission of } CO\ [Gg\ yr^{-1}] = (C\ emitted)\ [tC\ yr^{-1}] \times (emission\ ratio) \times (28/12)/1000,$$
$$\text{Emission of } N_2O\ [Gg\ yr^{-1}] = (C\ emitted)\ [tC\ yr^{-1}] \times (N/C\ ratio) \times (emission\ ratio) \times (44/28)/1000,$$
$$\text{Emission of } NOx\ [Gg\ yr^{-1}] = (C\ emitted) \times [N/C\ ratio] \times (emission\ ratio) \times (46/14)/1000,$$

where:

- *(C emitted)* = $L_{forest\ fires}$, respectively total amount of C annually emitted (tC/year),
- *N/C ratio* = ratio of nitrogen/carbon in the burnt dead mass, N/C ratio was 1/24,
- *(emission ratio)* = default values of direct and indirect GHG emission factors from forest fires. According Table 3A.1.14 of IPCC GPG 2003 these values are: CH_4 – 0.012; CO – 0.06; N_2O – 0.007 and NOx – 0.121.

Emissions for Biomass Burning in the Cropland category are included under Agriculture Sector - 4.F Field Burning of Agricultural Residues. No activity data on woody perennial burning has been reported.

6.12.6 Category-specific planned improvements, including those in response to the review process

Despite small importance in the national GHG inventory accurate estimates are provided in 2016 submission following data provided by the Ministry of Agriculture, also because highlighted by the ERT’s reports.

6.12.7 Recalculations of non CO_2 emissions from sources

Like previous reporting, in 2008 and 2015, some amount of lime was disaggregated to dolomite because of improved data.

Both for AR and FM activities, an error in calculation formula for CH_4 and N_2O was corrected in 2014 submission. Error consisted in wrong entering of CO_2 amount instead of C amount in equation; corrected estimates are 3.666 less now like in previous submission.

Split of forest fires emissions between 4.A.1 and 4.A.2 resulted in slight change in emissions of about 4% for the respective year for all the greenhouse gases.

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 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 ware estimated.

Table 7.1 Status of the direct GHG emissions estimation in the Waste Sector

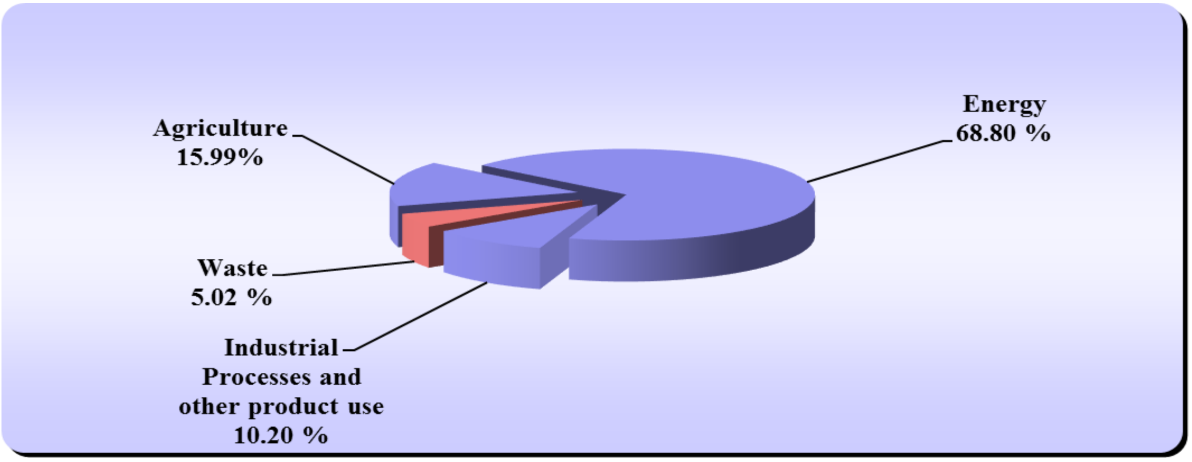
IPCC category	**Emissions estimation status**		
	CO_2	**CH_4**	**N_2O**
5.A Solid Waste Disposal			
5.A.1 Managed Waste Disposal	✓	✓	NA
5.A.2 Unmanaged Waste Disposal	✓	✓	NA
5.A.2.1 deep (>5m)	✓	✓	NA
5.A.2.2 shallow (<5 m)	✓	✓	NA
5.A.3 Other	NA	NA	NA
5.B Biological Treatment of Solid Waste			
5.B.1 Composting	NA	✓	✓
5.B.1 Anaerobic Digestion at Biogas Facilities	NA	NA	NA
5.C Incineration and open burning of waste			

IPCC category	**Emissions estimation status**		
	CO_2	**CH_4**	**N_2O**
5.C. 1 Waste incineration	✓	✓	✓
5.C.1.1 Biogenic	NE	NE	✓
5.C.1.1.a Municipal Solid Waste	NA	NA	NA
5.C.1.1.b Other-Biogenic Waste other than Municipal Solid Waste	NE	NE	✓
5.C.1.2 Non-biogenic	✓	NE	✓
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 2015 GHG emissions from the Waste Sector accounted for 5843.31 kt CO_2 equivalent, which represent 5.02 % 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, 2015



In the base year (1989), the total GHG emissions from the waste sector amounted to 5135.66 kt CO_2 equivalent, which accounted for 1.70 % 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 13.78 %, due to increasing of incineration activities and waste generation rate in parallel with increasing of living standards (Table 7.2, Figure 7.2).

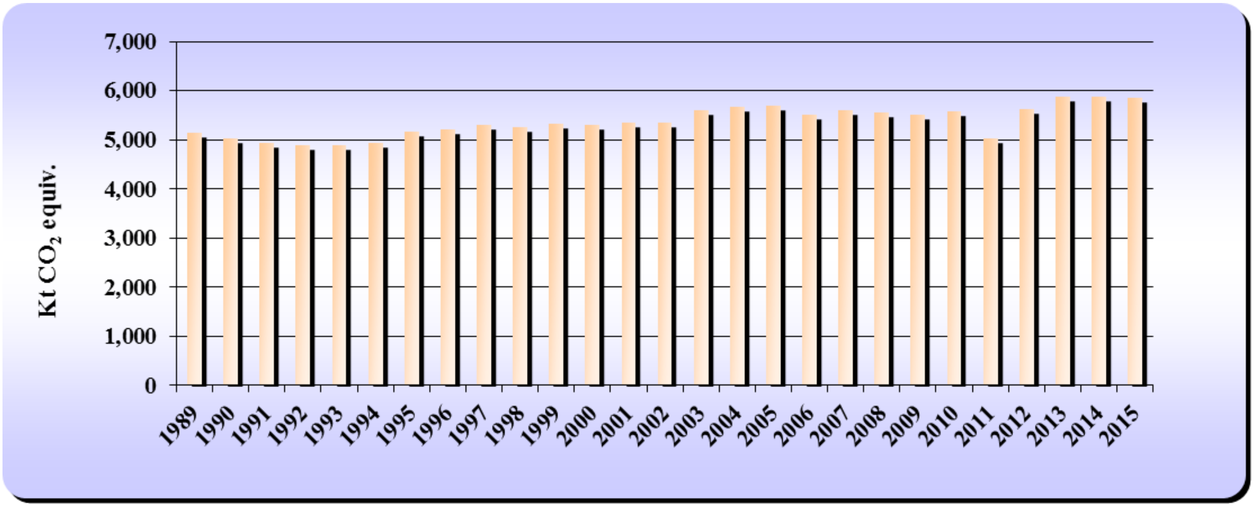
Table 7.2 The contribution of Waste Sector to the total GHG emissions in Romania, for 1989–2015 period

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	285,032.12	5,135.66	1.80
1990	226,889.41	5,023.36	2.21
1991	181,998.67	4,941.02	2.71
1992	165,567.99	4,878.82	2.95
1993	154,997.56	4,895.36	3.16
1994	150,189.31	4,929.49	3.28
1995	157,613.10	5,157.27	3.27
1996	161,389.92	5,218.69	3.23

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 [%]
1997	148,845.18	5,289.82	3.55
1998	127,222.44	5,253.80	4.13
1999	110,829.74	5,326.08	4.81
2000	117,344.75	5,303.93	4.52
2001	123,581.61	5,342.53	4.32
2002	125,370.56	5,343.43	4.26
2003	130,665.15	5,588.54	4.28
2004	130,171.18	5,656.04	4.35
2005	126,331.70	5,688.19	4.50
2006	127,335.59	5,511.72	4.33
2007	132,581.10	5,604.08	4.23
2008	127,631.72	5,546.58	4.35
2009	108,192.02	5,515.86	5.10
2010	102,402.84	5,584.39	5.45
2011	108,187.64	5,032.37	4.65
2012	106,481.05	5,620.45	5.28
2013	97,156.71	5,881.45	6.05
2014	97,155.02	5,865.10	6.04
2015*	98,168.54	5,843.31	5.95

* Preliminary data

Figure 7.2 Total GHG emissions trend from Waste Sector for 1989–2015 period



The most important contribution to GHG emissions from Waste Sector, in 2015 year, has Solid Waste Disposal Subsector, contributing with 60.24% in the total (Figure 7.3), Biological treatment - Composting accounts for 0.99 %; Incineration and Open Burning of Waste Subsector accounts for only 0.12 % and Wastewater Treatment and Discharge Subsector contribute with 38.65 %. 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 2015

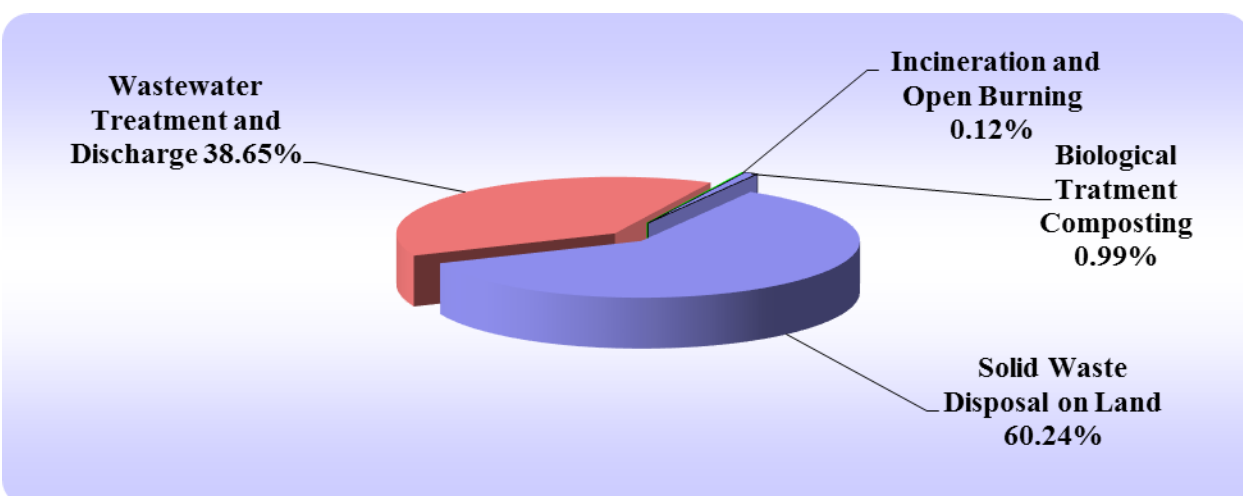
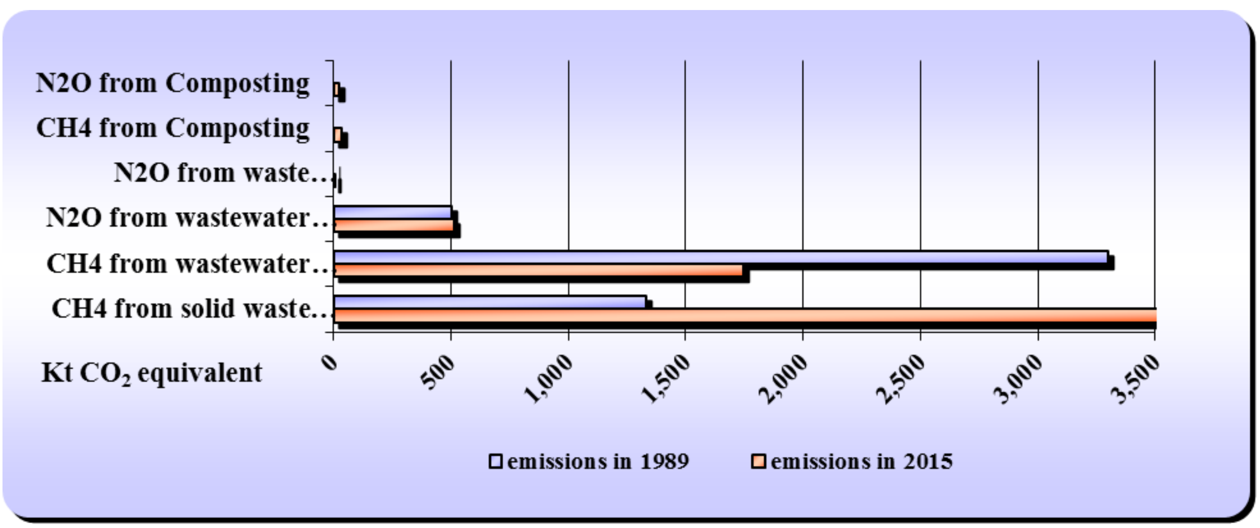


Table 7.3 Key categories in Waste Sector based on the level and trend assessment in 2015

Key category	Direct GHG	Criteria for identification	Contribution of key category in total GHG emissions [%] - (excluding LULUCF)
5.A Solid waste disposal	CH_4	L,T	3.02
5.D Wastewater Treatment and Discharge	CH_4	L,T	1.50
	N_2O	T	0.46

Figure 7.4 Key categories in Waste Sector both by level and trend criteria, in 2015



Methane represents the major greenhouse gas from Waste sector with a contribution of 17.40 % to the total methane emissions in Romania, in 2015. In the same year, nitrous protoxide has a contribution of 7.58 % 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 three 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 2015 year comparing with the level in the base year, with a percentage of 164.16% (Figure 7.5).

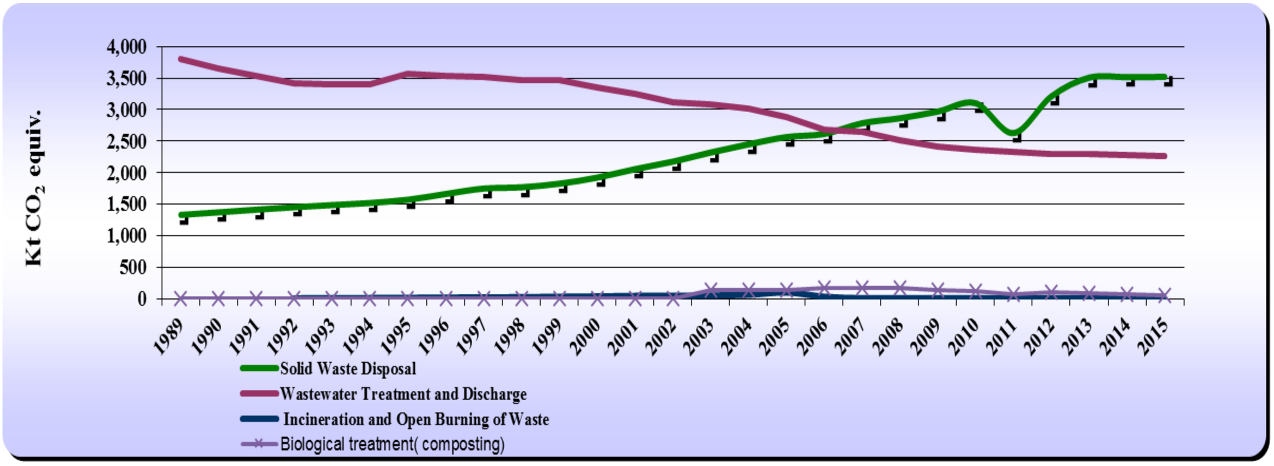
This increase is due to the increasing trend of waste generation rate following the relatively increased trend of population consumption. Emissions from wastewater treatment and discharge decreased with 40.64 % in 2015 compared to 1989. This decrease is due on the one hand to the decreasing number of population and the increase number of inhabitants connected to sewerage, and on the other hand to the decreasing level of industrial production.

GHG emissions trend from Biological treatment (composting) decreased in 2015 year comparing with the level in the base year, with a percentage of 57.11 %.

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 decrease in 2015 year comparing with the level in 1992 year, with a percentage of 23.61% (Figure 7.5).

In Waste Incineration Subsector the emissions trend has remained almost constant in 2015 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 1989–2015 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, the amount of waste collected through specialized services to the municipalities or through sanitation companies was 4.981 million tone.

In the year 2014 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.

For 2015, the data regarding recovered/deposited MSW categories will finalized later this year after statistical survey.

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 Table 7.4 are presented the amount of municipal solid waste categories which have been colected in 2014.

Table 7.4 Total amount of collected waste MSW, in 2015 (Source www.anpm.ro)

Municipal Solid Waste categories	**Recovered from total collected MSW (%)**	**Deposited from total collected MSW (%)**
Household and similar waste	3921	78.72

Municipal Solid Waste categories	Recovered from total collected MSW (%)	Deposited from total collected MSW (%)
Waste from municipal services	638	12.81
Waste from construction and demolition activities	422	8.47

Waste collection system, complies with European standards and the method is the most common, accounting for a share of about 75.69%. Newer methods of waste management such as selective collection and separate collection of bulky waste were implemented in very small shares, according to available data.

In Romania municipal solid waste are deposited both in managed and unmanaged SWDS. In the last years, in accordance with European regulations, the number of unmanaged SWDS decreased reaching a number of 35 sites in 2015 year (Table 7.5). In accordance with European regulations, the unmanaged SWDS are subject to a transition period, storage activity being stopped gradually until 2017.

Table 7.5 Number of Solid waste Disposal Sites (Source Waste Directorate of NEPA)

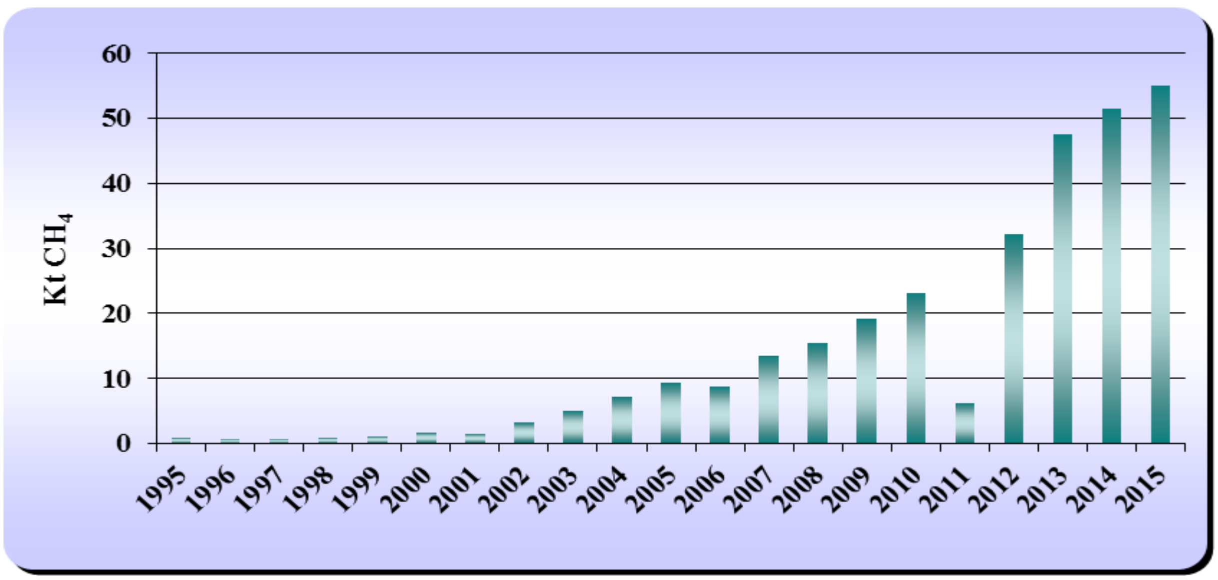
<table>
<tr><th>Type of SWDS/Year</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th></tr>
<tr><td>Managed</td><td>20</td><td>20</td><td>20</td><td>26</td><td>27</td><td>31</td><td>33</td><td>34</td><td>34</td><td>34</td></tr>
<tr><td>Unmanaged deep</td><td>90</td><td>92</td><td>87</td><td>87</td><td>40</td><td rowspan="2">70</td><td rowspan="2">49</td><td rowspan="2">48</td><td rowspan="2">33</td><td rowspan="2">33</td></tr>
<tr><td>Unmanaged shallow</td><td>130</td><td>109</td><td>96</td><td>14</td><td>35</td></tr>
</table>

CH_4 emissions from SWDS

The methane emissions from Solid Waste Disposal Sites to managed landfills were estimated for the period 1995-2015, because in 1995 year was opened the first managed SWDS.

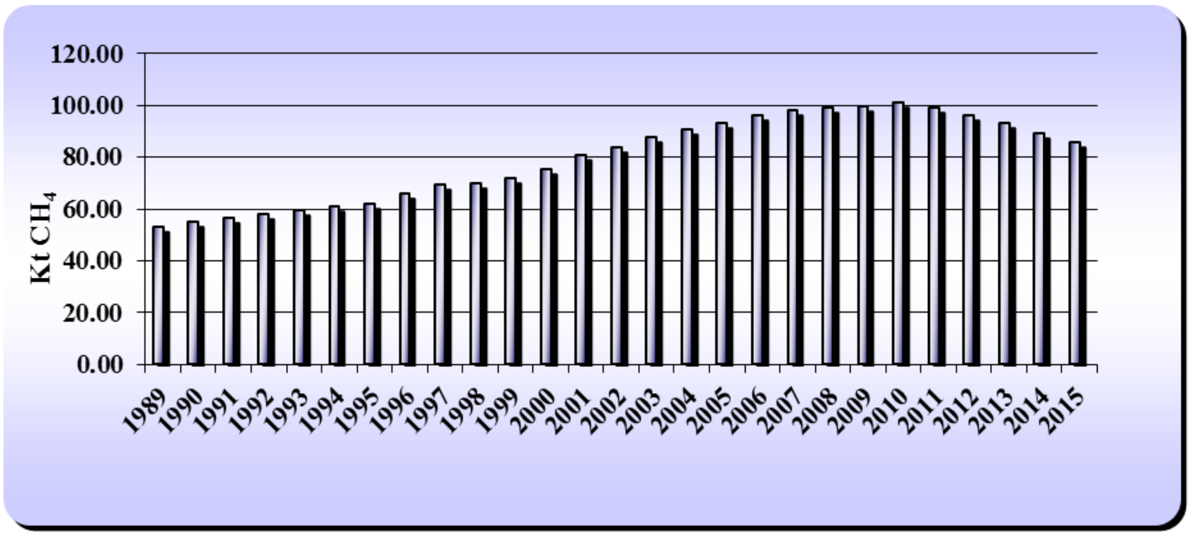
The methane emissions from managed SWDS have an increasing trend between 1995 – 2010 period. The significant difference between the level in 2010 and 2011 years is associated to the amount of CH_4 recovered in 2011 which register a value of 40.80 kt and determine in 2011 a lower level of CH_4 emissions from managed solid waste disposal sites of about 1.78 kt. In 2015 year, the amount of CH_4 recovery register a increase coparing with 2014 year (7.91 kt in 2014 to 9.02 kt in 2014 year). The decrease associated to the amount of CH_4 recovery is due to the rearrangement of certain waste disposal sites that have stopped the recovery of methane created during the development works (Figure 7.6).

Figure 7.6 CH_4 emissions trend from waste disposed to managed sites for 1995–2015 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.

Figure 7.7 CH_4 emissions trend from waste disposed to unmanaged sites for 1989–2015 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 1950-2015 period, according to the IPCC 2006 provisions, to achieve an acceptably accurate result.

In order to estimate CH4 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 2003-2014 (see the Table 7.6).

Given the statistical survey on waste for 2015 has not yet finalised, for this year it was considered the same value as in 2014.

Table 7.6 The percentage composition of municipal solid waste

Year	Paper and textiles [%]	Garden & park waste/ other non-food organic Putrescible [%]	Food waste [%]	Wood/straw [%]	DOC	Source
1950	4.82	5.77	14.79	0.37	0.05	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"*
1951	4.88	5.83	14.95	0.37	0.05	
1952	5.00	5.97	15.33	0.38	0.05	
1953	5.12	6.11	15.69	0.39	0.06	
1954	5.22	6.24	16.02	0.40	0.06	
1955	5.33	6.37	16.34	0.41	0.06	
1956	5.30	6.34	16.27	0.40	0.06	
1957	5.53	6.61	16.96	0.42	0.06	
1958	5.61	6.70	17.20	0.43	0.06	
1959	5.67	6.78	17.40	0.43	0.06	
1960	5.79	6.92	17.74	0.44	0.06	
1961	5.86	7.00	17.95	0.45	0.06	
1962	5.90	7.06	18.10	0.45	0.06	
1963	5.97	7.13	18.30	0.46	0.06	
1964	6.02	7.19	18.45	0.46	0.07	
1965	6.07	7.25	18.60	0.46	0.07	

Year	Paper and textiles [%]	Garden & park waste/ other non-food organic Putrescible [%]	Food waste [%]	Wood/straw [%]	DOC	Source
1966	6.35	7.59	19.48	0.48	0.07	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" calculation methods implementation"*
1967	6.42	7.67	19.68	0.49	0.07	
1968	6.43	7.68	19.71	0.49	0.07	
1969	6.54	7.82	20.05	0.50	0.07	
1970	6.64	7.93	20.35	0.51	0.07	
1971	6.73	8.04	20.63	0.51	0.07	
1972	6.82	8.15	20.90	0.52	0.07	
1973	6.90	8.24	21.15	0.53	0.07	
1974	7.00	8.37	21.46	0.53	0.08	
1975	7.10	8.49	21.78	0.54	0.08	
1976	7.21	8.62	22.11	0.55	0.08	
1974	7.53	9.00	23.08	0.57	0.08	
1977	7.64	9.14	23.44	0.58	0.08	
1978	7.72	9.22	23.66	0.59	0.08	
1979	7.83	9.36	24.01	0.60	0.09	
1980	7.95	9.51	24.39	0.61	0.09	
1981	8.09	9.67	24.81	0.62	0.09	
1982	6.35	7.59	19.48	0.48	0.07	

Year	Paper and textiles [%]	Garden & park waste/ other non-food organic Putrescible [%]	Food waste [%]	Wood/straw [%]	DOC	Source
1983	8.16	9.75	25.02	0.62	0.09	Study *"Elaboration/documentation of national emission factors/other parameters relevant to N GHGI Sectors Energy, Industrial Processes, Agriculture and Waste, values to allow for the higher Tier calculation methods implementation"*
1984	8.20	9.80	25.14	0.63	0.09	
1985	8.29	9.90	25.41	0.63	0.09	
1986	8.35	9.99	25.62	0.64	0.09	
1987	8.45	10.10	25.90	0.64	0.09	
1988	8.52	10.19	26.14	0.65	0.09	
1989	8.64	10.33	26.51	0.66	0.09	
1990	8.74	10.45	26.80	0.67	0.09	
1991	8.72	10.42	26.74	0.67	0.09	
1992	8.58	10.25	26.31	0.65	0.09	
1993	8.58	10.26	26.32	0.65	0.09	
1994	8.58	10.26	26.32	0.65	0.09	
1995	11.92	14.25	36.55	0.91	0.13	
1996	10.77	12.87	33.02	0.82	0.12	
1997	7.06	8.44	21.64	0.54	0.08	
1998	9.62	11.49	29.48	0.73	0.10	
1999	11.85	14.17	36.35	0.90	0.13	
2000	13.68	16.36	41.96	1.04	0.15	

Year	Paper and textiles [%]	Garden & park waste/ other non-food organic Putrescible [%]	Food waste [%]	Wood/straw [%]	DOC	Source
2001	12.58	15.04	38.58	0.96	0.14	
2002	14.21	16.98	43.57	1.08	0.15	
2003	13.11	15.67	40.20	1.00	0.14	NEPA
2004	11.67	12.53	38.12	1.00	0.13	
2005	12.76	14.50	38.60	1.00	0.14	
2006	12.68	14.36	36.45	1.00	0.13	
2007	11.48	13.77	34.45	1.00	0.12	
2008	8.32	6.03	45.29	1.58	0.12	
2009	10.18	5.54	44.40	1.97	0.12	
2010	9.88	7.02	45.48	2.11	0.13	
2011	8.81	6.69	45.39	1.64	0.12	
2012	11.06	8.49	48.76	1.77	0.14	
2013	10.42	8.09	45.61	1.71	0.13	
2014	9.23	5.76	46.47	0.73	0.12	
2015*	9.83	6.13	49.45	1.53	0.13	

* 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 7.7and 7.8).

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	0.55	0.50	0.05	0.1
MSW disposed to unmanaged-deep	0.80	0.55	0.50	0.05	0.00
MSW disposed to unmanaged-shallow	0.40	0.55	0.50	0.05	0.00
Source	**IPCC 2006**				

Table 7.8 Parameters used to calculate the emission factors (SWDS) for sewage sludge disposed to SWDS

Type of site	MCF	DOC	DOC_F	F	k	OX
Sewage sludge disposed to managed SWDS	1.00	0.05	0.50	0.5	0.06	0.1
Sewage sludge disposed to unmanaged-deep	0.80	0.05	0.50	0.05	0.06	0.00
Sewage sludge disposed to	0.40	0.05	0.50	0.05	0.06	0.00

Type of site	MCF	DOC	DOC_F	F	k	OX
unmanaged-shallow						
Source	IPCC 2006					

Activity data

Municipal solid waste

For 2003-2015 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 by NEPA and National Institute for Statistics (NIS). For 2015 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	Amount of waste in Gg disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
1950	NO	1,420.71	910.06	Study *"Elaboration/documentation of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Processes,*
1951	NO	1,435.61	919.61	
1952	NO	1,472.02	942.93	
1953	NO	1,506.35	964.92	
1954	NO	1,538.18	985.31	
1955	NO	1,569.46	1,005.35	
1956	NO	1,562.08	1,000.62	
1957	NO	1,629.21	1,043.62	
1958	NO	1,651.55	1,057.93	

Year	Amount of waste in Gg disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
1959	NO	1,670.59	1,070.13	*Agriculture and Waste, values to allow for the higher Tier calculation methods implementation"*
1960	NO	1,703.69	1,091.33	
1961	NO	1,724.23	1,104.49	
1962	NO	1,738.34	1,113.53	
1963	NO	1,757.34	1,125.70	
1964	NO	1,771.71	1,134.91	
1965	NO	1,786.60	1,144.44	
1966	NO	1,870.61	1,198.26	
1967	NO	1,890.37	1,210.91	
1968	NO	1,892.51	1,212.28	
1969	NO	1,925.74	1,233.57	
1970	NO	1,954.03	1,251.69	
1971	NO	1,981.17	1,269.08	
1972	NO	2,006.88	1,285.55	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"*
1973	NO	2,031.14	1,301.09	
1974	NO	2,061.29	1,320.40	
1975	NO	2,091.78	1,339.93	
1976	NO	2,122.92	1,359.88	
1977	NO	2,216.33	1,419.72	
1978	NO	2,250.90	1,441.86	
1979	NO	2,272.55	1,455.73	
1980	NO	2,306.24	1,477.30	
1981	NO	2,342.09	1,500.27	
1982	NO	2,382.34	1,526.05	
1983	NO	2,402.33	1,538.86	
1984	NO	2,414.28	1,546.52	
1985	NO	2,439.76	1,562.84	
1986	NO	2,460.34	1,576.02	
1987	NO	2,487.09	1,593.16	
1988	NO	2,510.33	1,608.04	
1989	NO	2,545.70	1,630.70	
1990	NO	2,573.86	1,648.74	
1991	NO	2,567.78	1,644.84	
1992	NO	2,526.33	1,618.29	

Year	Amount of waste in Gg disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
1993	NO	2,527.31	1,618.92	
1994	NO	2,527.45	1,619.01	
1995	150.00	3,418.33	2,189.67	
1996	235.00	3,027.61	1,939.39	
1997	320.00	1,883.49	1,206.51	
1998	405.00	2,584.57	1,655.60	
1999	490.00	3,192.01	2,044.70	
2000	565.66	3,684.89	2,360.43	
2001	1,500.00	2,791.10	1,787.89	
2002	1,705.00	3,145.04	2,014.62	
2003	1,723.55	2,810.00	1,800.00	NEPA
2004	1,933.00	2,850.00	1,850.00	
2005	2,079.84	3,020.00	1,780.00	
2006	2,558.26	2,817.22	1,392.41	
2007	2,841.68	2,874.98	1,132.44	
2008	3,024.99	3,506.79	754.62	
2009	3,158.06	3,022.59	574.24	
2010	3,522	1,556.33	372.64	
2011	3,698	1,156.85	213.96	
2012	3,803	667.38	164.69	
2013	3,789	449.03	108.98	
2014	3,900	300.85	73.02	
2015*	4,013	300.85	73.02	

*Preliminary data (final data for 2015 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.

By expert judgement, the NIS data on the total quantities of sewage sludge landfilled in the period 2006-2012 were considered in the emission estimation.

Taking into account that the statistical survey on waste has not yet finalized for 2015 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 1950-2015.

Table 7.10 Total annual sewage sludge disposed to Solid Waste Disposal Sites (1950–2015 period)

Year	**Total amount of sewage sludge in Kt disposed to**			**Source**
	managed sites	**unmanaged deep sites**	**unmanaged shallow sites**	
1950	NO	9.32	21.74	Study *"Determining the quantities of industrial waste with biodegradable contents and the*
1951	NO	9.45	22.04	
1952	NO	9.58	22.34	
1953	NO	9.71	22.65	
1954	NO	9.84	22.96	
1955	NO	9.97	23.27	

Year	Total amount of sewage sludge in Kt disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
1956	NO	10.11	23.59	*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"*
1957	NO	10.25	23.92	
1958	NO	10.39	24.24	
1959	NO	10.53	24.58	
1960	NO	10.53	24.58	
1961	NO	11.56	26.98	
1962	NO	11.56	26.98	
1963	NO	11.56	26.98	
1964	NO	11.57	26.99	
1965	NO	11.57	26.99	
1966	NO	11.57	26.99	
1967	NO	10.54	24.60	
1968	NO	10.55	24.61	
1969	NO	11.58	27.01	
1970	NO	11.58	27.02	
1971	NO	11.58	27.02	
1972	NO	11.58	27.03	
1973	NO	11.59	27.04	
1974	NO	11.59	27.05	
1975	NO	11.60	27.06	
1976	NO	11.60	27.07	
1977	NO	11.61	27.09	
1978	NO	11.62	27.10	Study *"Determining the quantities of industrial waste with biodegradable contents and the quantities of sludge resulting*
1979	NO	11.88	27.73	
1980	NO	15.05	35.12	
1981	NO	15.05	35.12	
1982	NO	15.25	35.59	

Year	Total amount of sewage sludge in Kt disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
1983	NO	15.29	35.68	*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"*
1984	NO	15.29	35.69	
1985	NO	15.35	35.81	
1986	NO	15.35	35.83	
1987	NO	15.38	35.88	
1988	NO	21.80	50.87	
1989	NO	21.78	50.82	
1990	NO	21.73	50.70	
1991	NO	23.24	54.22	
1992	NO	23.21	54.15	
1993	NO	23.18	54.10	
1994	NO	23.13	53.96	
1995	72.23	33.97	49.07	
1996	12.57	33.96	49.05	
1997	11.38	33.95	49.04	
1998	11.15	38.49	55.60	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*
1999	13.27	38.51	55.62	
2000	123.39	38.65	55.82	
2001	26.48	38.40	55.46	
2002	184.71	38.51	55.63	
2003	169.26	37.52	54.19	
2004	306.89	32.53	46.98	
2005	443.50	31.13	44.96	
2006	438.66	36.35	52.51	
2007	572.07	4.99	5.91	
2008	1186.75	6.17	6.81	
2009	308.48	4.20	0.68	

Year	Total amount of sewage sludge in Kt disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
2010	271.61	2.05	1.80	*incineration thereof, for 1989-2012. Assesing the N_2O emissions resulting from waste incineration"*
2011	692.50	2.06	1.54	NIS
2012	93.11	1.08	0.81	
2013*	130.49	144.82	92.26	
2014*	133.56	205.94	130.37	
2015*	133.56	205.94	130.37	

* Preliminary data (final data for 2015 will be provided after statistical survey of the end of this year).

CH_4 recovery

Since 1996 to 2001, only a single landfill began to recover the methane 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 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 (see Table 7.11).

Considering information from this time, the methane is recovered from 8 managed SWDS.

According to the data sources used there is no methane recovery from the unmanaged sites and the emissions are reported as NO.

Table 7.11 The amounts of CH_4 recovered from managed SWDS (Source: operators of landfills)

Year	Amount of CH_4 recovered (kt)	Year	Amount of CH_4 recovered (kt)
1989	NA	**2002**	4.72
1990	NA	**2003**	6.40
1991	NA	**2004**	7.76
1992	NA	**2005**	8.91
1993	NA	**2006**	13.61
1994	NA	**2007**	13.09
1995	NA	**2008**	15.91
1996	0.43	**2009**	15.99
1997	0.83	**2010**	16.37
1998	1.23	**2011**	40.80
1999	1.60	**2012**	17.56
2000	1.97	**2013**	6.79
2001	3.27	**2014**	7.91
2015	9.02		

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
1991	56.51	50	45.21	40
1992	58.09	50	46.47	40
1993	59.48	50	47.58	40
1994	60.77	50	48.61	40
1995	62.83	50	50.26	40
1996	66.48	50	53.18	40
1997	69.93	50	55.94	40
1998	70.72	50	56.58	40
1999	73.03	50	58.42	40
2000	76.87	50	61.50	40
2001	82.24	50	65.79	40
2002	87.01	50	69.61	40
2003	92.81	50	74.25	40
2004	98.01	50	78.41	40
2005	102.60	50	82.08	40
2006	104.65	50	83.72	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	105.12	50	84.10	40
2012	128.41	50	102.73	40

Year	Greenhouse Gas			
	CH_4		CO_2	
	kt	%	kt	%
2013	140.32	50	112.26	40
2014	140.63	50	112.50	40
2015*	140.79	50	112.63	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	20.00	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 1989-2015 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 Fugitive emissions from fuels and transport category except road transportation category, 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 2003-2015 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

The amount of MSW deposited in managed and unmamaged SWDS in 2010-2014 period was updated based on recalculations made by Waste directorate of NEPA.

The amounts of CH_4 recovery were updated for 2011-2014 period due to an error of reporting data.

The NMVOC emissions were updated based on revised methane emissions for 2010-2015 year.

Table 7.14 Changes made parameters and their effects on emission estimates

The effects of recalculations in Solid waste disposal sub - sector			
Years	NGHGI 2016 v. 4	NGHGI 2017 v. 1	Differences [%]
	CH_4 emissions [kt]		
1989	53.24	53.24	0.00
1990	54.86	54.86	0.00
1991	56.51	56.51	0.00
1992	58.09	58.09	0.00
1993	59.48	59.48	0.00
1994	60.77	60.77	0.00
1995	62.83	62.83	0.00
1996	66.48	66.48	0.00
1997	69.93	69.93	0.00
1998	70.72	70.72	0.00
1999	73.03	73.03	0.00
2000	76.87	76.87	0.00
2001	82.24	82.24	0.00
2002	87.01	87.01	0.00
2003	92.81	92.81	0.00
2004	98.01	98.01	0.00

The effects of recalculations in Solid waste disposal sub - sector			
Years	**NGHGI 2016 v. 4**	**NGHGI 2017 v. 1**	**Differences [%]**
	CH_4 emissions [kt]		
2005	102.60	102.60	0.00
2006	104.65	104.65	0.00
2007	111.38	111.38	0.00
2008	114.53	114.53	0.00
2009	118.82	118.82	0.00
2010	123.43	124.09	0.54
2011	103.95	105.12	1.13
2012	123.93	128.41	3.61
2013	136.49	140.32	2.81
2014	135.47	140.63	3.81

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

In order to improve the next submission, we will try to obtain more detailed data in respect to IPCC 2006.

7.3 Biological Treatment of Solid Waste (CRF 5.B)

7.3.1 Category description

The category includes calculation of CH_4 and N_2O emissions in the atmosphere from biological treatment of solid waste (composting). At the end of 2015, acording to the Annual report on the state of the environmentat, at the national level, about 85 plants and platforms were authorized for composting biodegradable municipal waste.

Figure 7.8 CH_4 emissions trend from composting , for 2003–2015 period

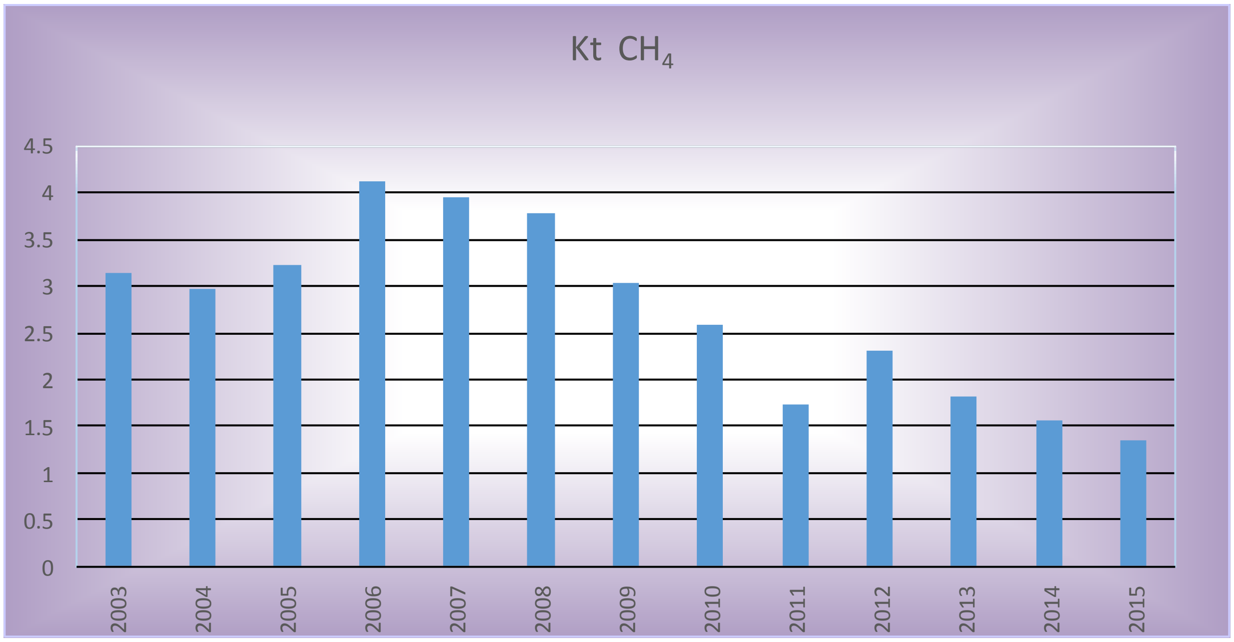
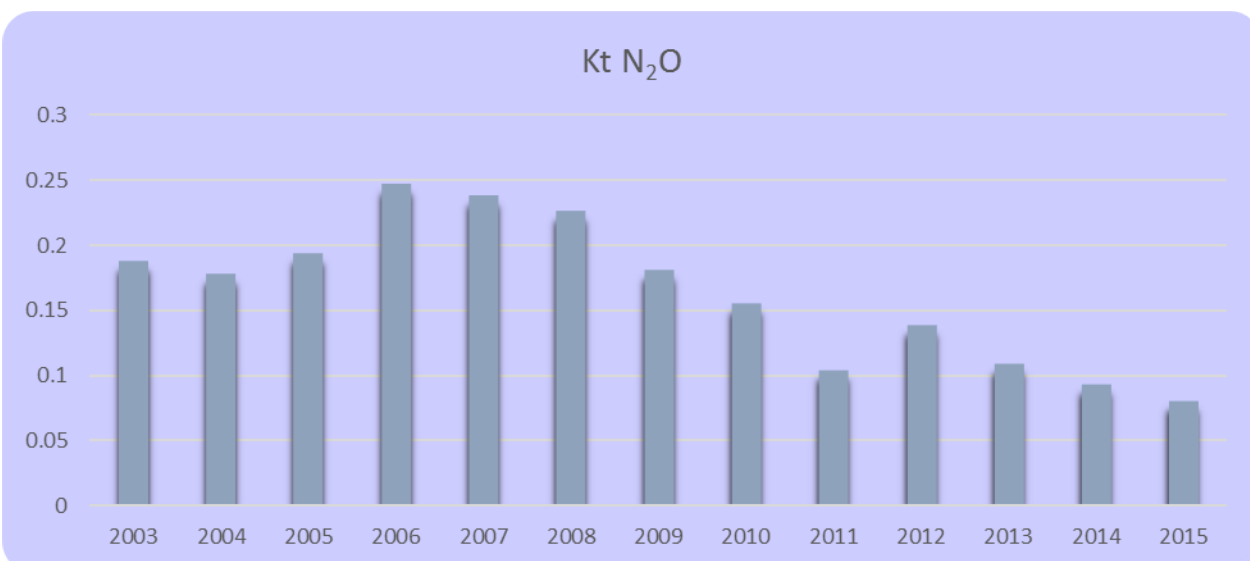


Figure 7.9 N_2O emissions trend from composting , for 2003–2015 period



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 wet weight were used for emission estimations from composting:

- Emission factor 4 g CH_4/kg of waste treated;
- Emission factor 0.24 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 2003-2015 period, the data on the amounts of MSW composted were provided by Waste Directorate from National Environmental Protection Agency. For 2015 the statistical survey has not yet finalised and estimated data are used.

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 7.15 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	20.00	4 (0.03-8)
Amount of composted municipal waste	N_2O	20.00	0.24 (0.06-6)

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 Fugitive emissions from fuels and transport category except road transportation category, 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

For this category no recalculations have been performed.

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)

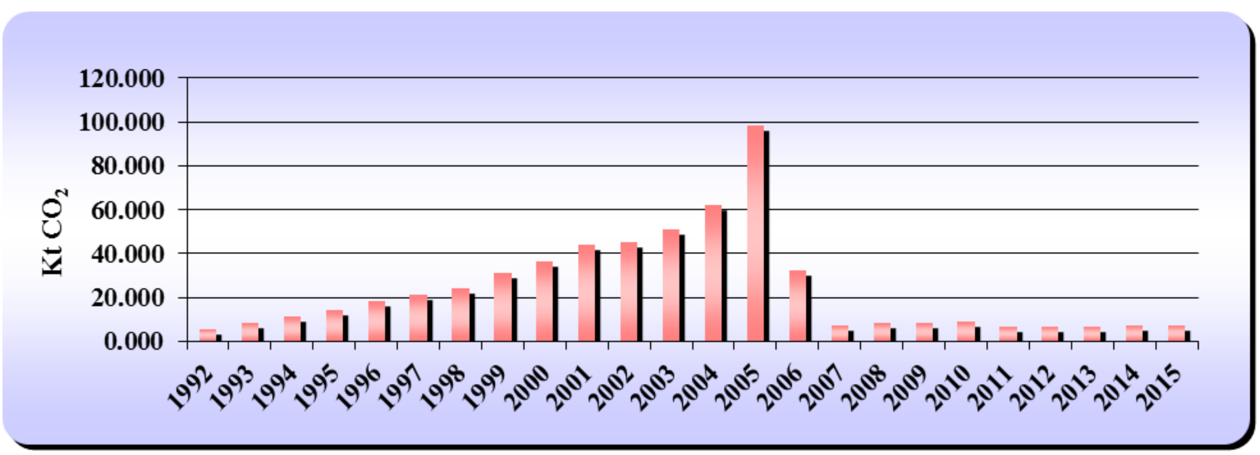
7.4.1 Category description

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.

The CO_2 emissions from incinerated waste were calculated starting with 1992, because since this year we have activity data. There is no data regarding open burning of waste.

Figure 7.10 CO_2 emissions trend from waste incineration, for 1992–2015 period



The CO_2 emissions from waste incineration were calculated for hazardous and clinical 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 1996–2015 period

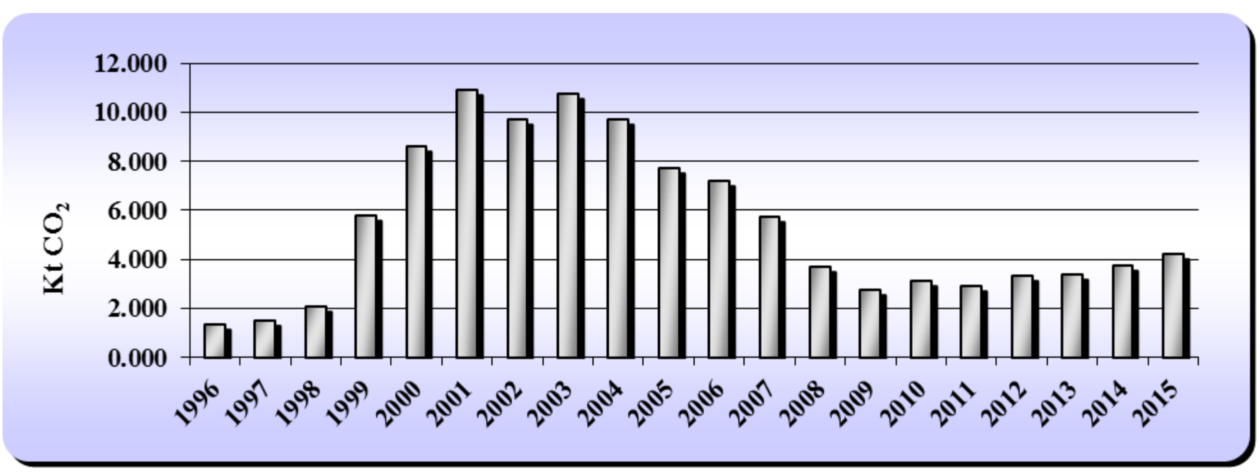


Figure 7.12 CO_2 emissions trend from hazardous waste incineration, for 1992–2015 period

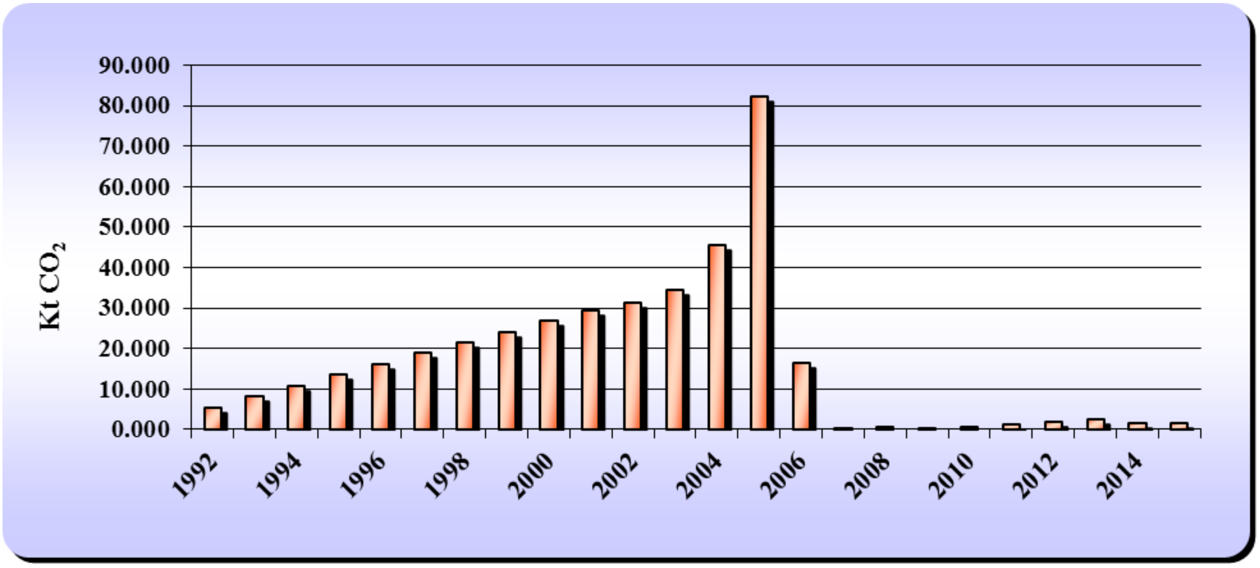


Figure 7.13 N_2O emissions trend from waste incineration, for 1992–2015 period

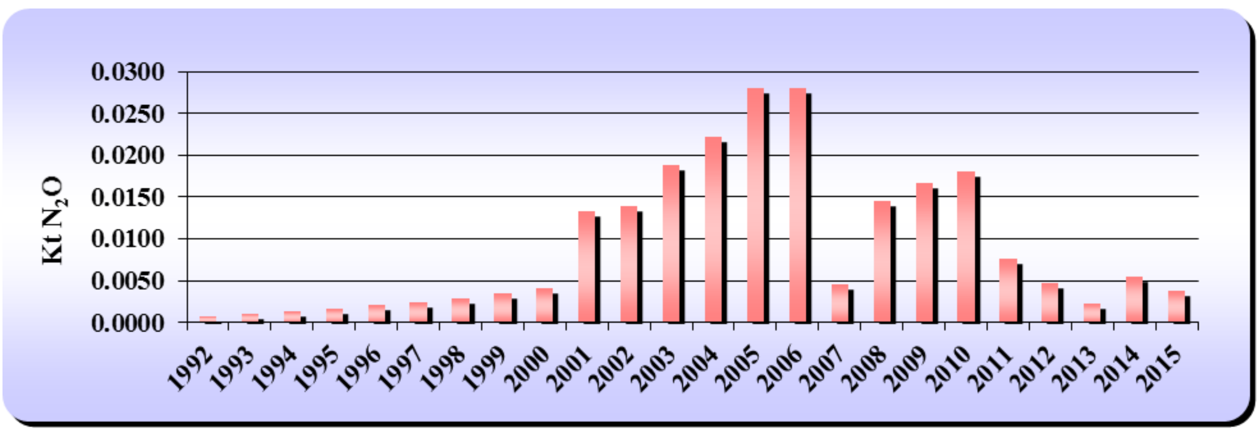
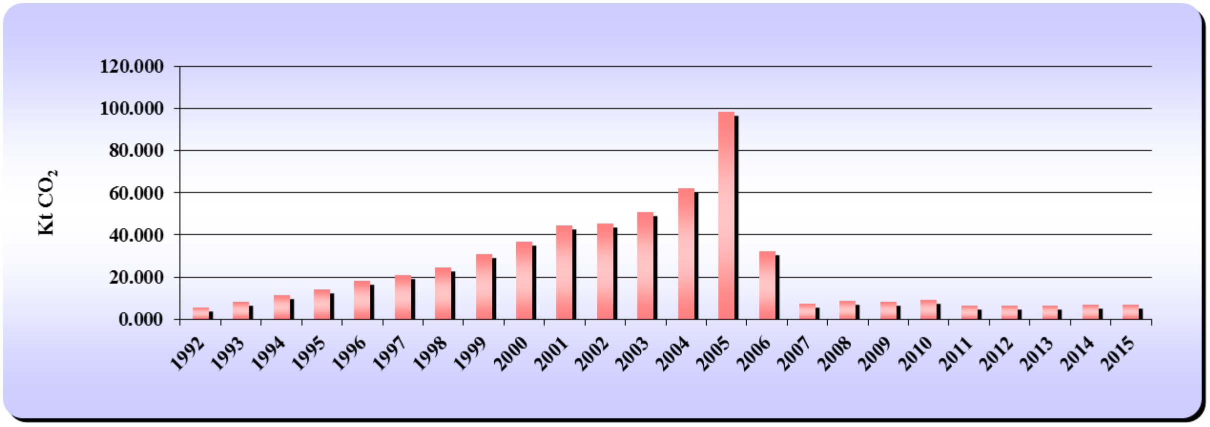


Figure 7.14 CH_4 emissions trend from waste incineration, for 1992–2015 period



The N_2O and CH_4 emissions from waste incineration were calculated for hazardous , clinical and biogenic waste.

For estimation of N_2O and CH_4 emissions from clinical waste incineration were used the amounts of waste incinerated provided by National Institute for Public Health. For N_2O emissions from hazardous and biogenic waste we used the data provided by 2013 study.

The amounts of hazardous and biogenic waste incinerated without heat recovery were estimated 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; 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 2013-2015 period the amounts of incinerated hazardous waste without heat recovery were provided by Waste Directorate of NEPA.

In 2007, quantity of industrial waste incinerated was much smaller than in previous years because many incinerators were closed, and the existing ones incinerated medical waste, that are reported at clinical waste incineration.

Figure 7.15 N_2O emissions trend from clinical waste incineration, for 1996–2015 period

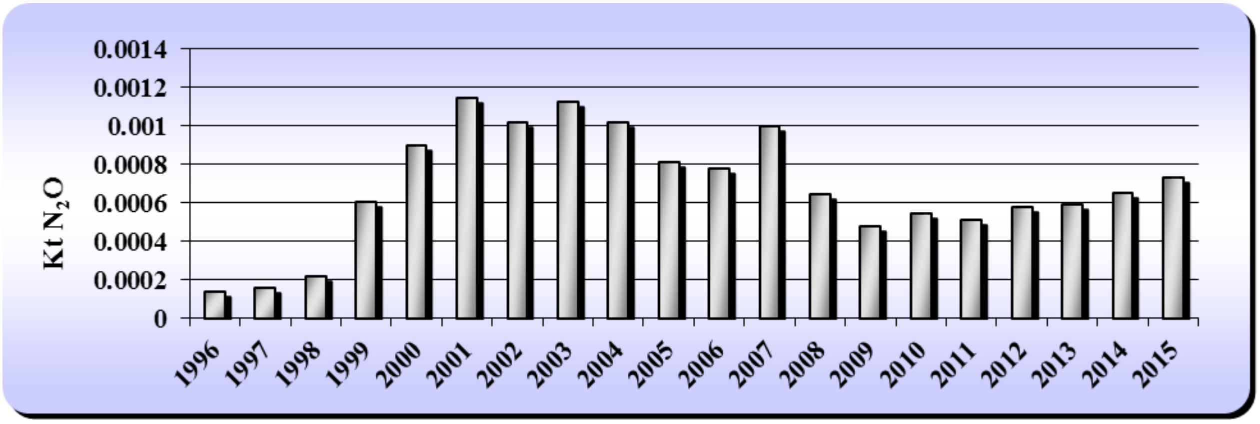


Figure 7.16 N_2O emissions trend from hazardous waste incineration, for 1992–2015 period

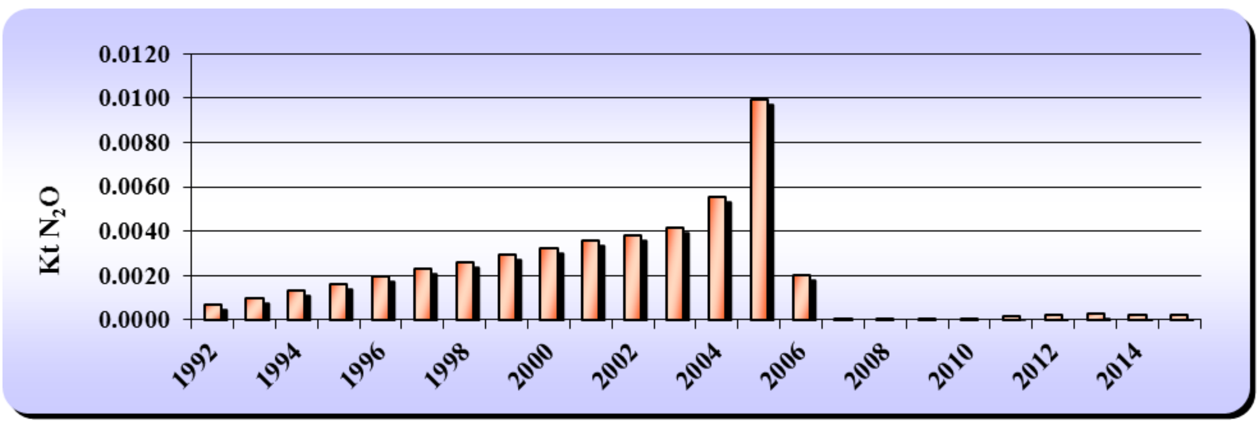


Figure 7.17 N_2O emissions trend from biogenic waste incineration, for 2001–2015 period

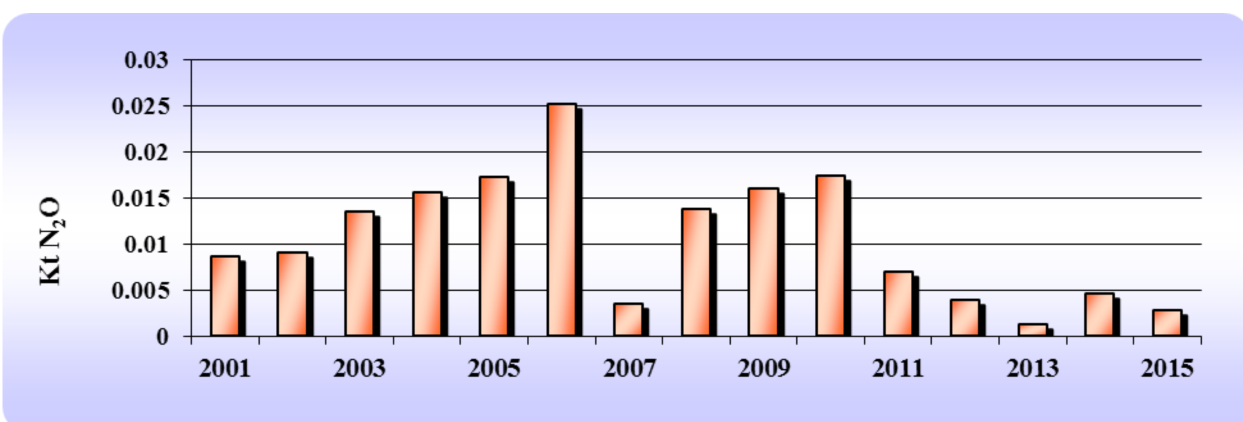


Figure 7.18 CH_4 emissions trend from clinical waste incineration, for 1996–2015 period

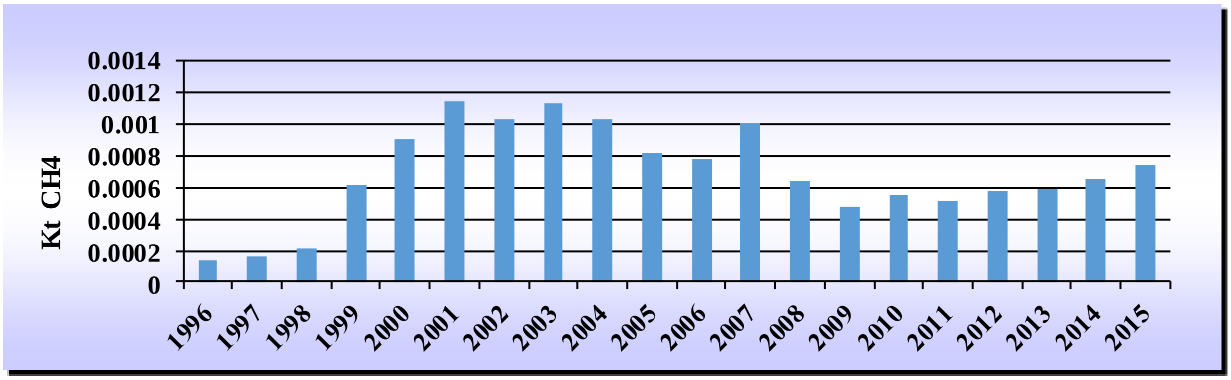


Figure 7.19 CH_4 emissions trend from hazardous waste incineration, for 1992–2015 period

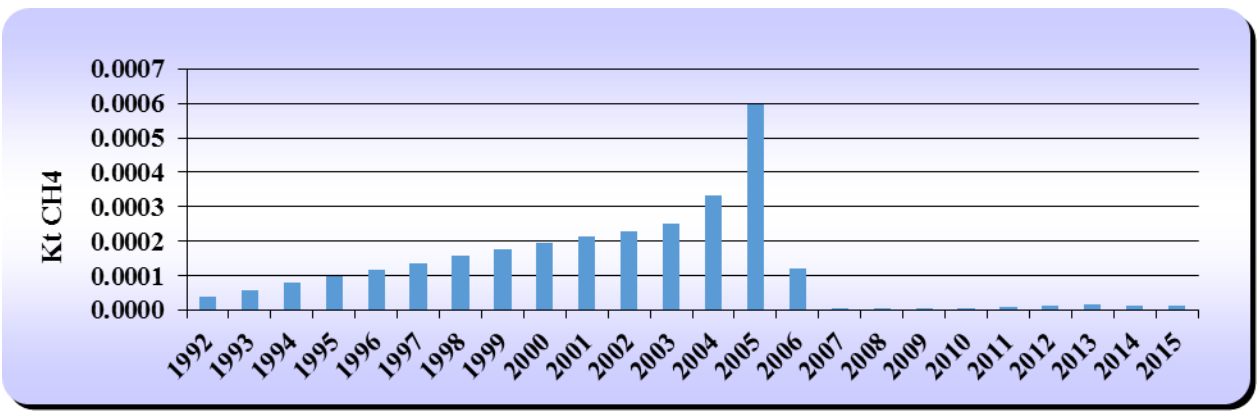
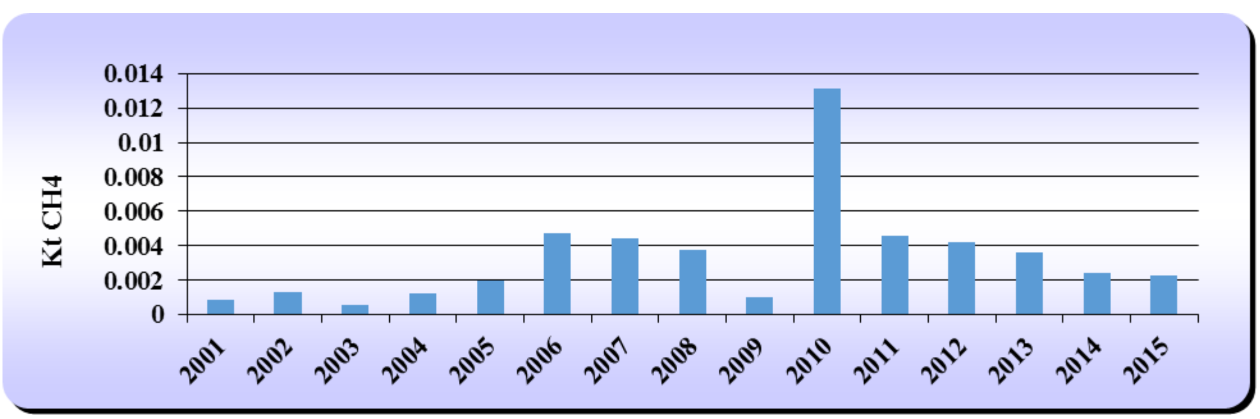


Figure 7.20 CH_4 emissions trend from biogenic waste incineration, for 2001–2015 period



7.4.2 Methodological issues

Methodology

To calculate carbon dioxide emissions from waste incineration, the equation 5.1 from page 5.7 of IPCC 2006.

To calculate nitrous oxide emissions from waste incineration, the Equation 5.5 from IPCC 2006 was used.

To calculate methan 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 7.16, Table 7.17.

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.

Table 7.16 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	95%	99.5%

Table 7.17 Default data for estimation of N_2O emissions from waste incineration (Source: IPCC 2006)

Type of incinerated waste	**N_2O emission factors, in gN_2O/t_{waste}**	**Source**
Clinical waste	100	IPCC 2006, for industrial waste, all incinerator types
Industrial waste	100	IPCC 2006, for industrial waste, all incinerator types
Animal cremation waste	226	Study "Danish Emissions Inventory for Waste Incineration and other Waste"
Sludge from waste water treatment	900 (wet condition)	IPCC 2006, for incinerator plants

Table 7.18 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) was provided 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 7.19).

Table 7.19 Amounts of clinical waste generated and incinerated (Source: ISPB and ICIM)

Year	Clinical waste generated	Clinical waste incinerated
	Unit [kt/yr]	
1996	4.05	2.35
1997	4.96	2.63
1998	6.47	3.63
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

Year	Clinical waste generated	Clinical waste incinerated
	Unit [kt/yr]	
2013	7.94	5.94
2014	7.72	6.53
2015	7.72	7.35

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 2003-2015 and the amounts of incinerated hazardous waste estimated for 1992-2002 period, using backward trend extrapolation, by expert judgment.

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 7.20 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
1992	6.64	Study 2013	-		-	-
1993	9.88		-	-	-	-
1994	13.11		-	-	-	-
1995	16.35		-	-	-	-
1996	19.58		2.35	ICIM	-	-
1997	22.82		2.63		-	-
1998	26.06		3.63		-	-
1999	29.29		10.15	Interpolation	-	-
2000	32.53		15.03	ISPB	-	-
2001	35.63		19.06		38.35	Study 2013
2002	38.06		17.03		40.42	
2003	41.70		18.79		60.02	

Year	Hazardous waste		Clinical waste		Biogenic	
	Incinerated waste[kt/yr]	Source	Incinerated waste[kt/yr]	Source	Incinerated waste[kt/yr]	Source
2004	55.33		17.03		69.42	
2005	99.54		13.55		76.33	
2006	20.06		12.61		218.40	
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		32.95	
2012	2.17		5.81		20.67	
2013	2.01		5.94		9.01	
2014	2.01		6.53		21.55	
2015	2.06		7.35		13.85	

* Preliminary data (final data for 2015 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 emissions from waste incineration.

Table 7.21 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 Fugitive emissions from fuels and transport category except road transportation category, 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

For this category no recalculations have been performed.

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 includes methane emissions from industrial and wastewater handling and nitrous oxide emissions from domestic. In Romania, the European legislation in the field of wastewater treatment and discharge into the environment has been implemented during 2002-2005, but further steps are necessary to comply fully implementing the requirements of the Directive.

Final transition period for implementation of this Directive has been set at December 31, 2018 year, with intermediate deadlines for urban wastewater collection and treatment.

In 2015, from a total volume of 2,066.34 million m3/year wastewater evacuated, 99.61% was wastewater which requiring treatment. From this, 67.03% was represented wastewater sufficient (appropriate) treated, 16.37% untreated wastewater and 16.21% insufficient treated wastewater (Table 7.22).

Table 7.22 Wastewater evacuated into Romania, in 2015 (Source: National Administration "Romanian Waters")

Wastewater category	Volume (mil. mc)	Percentage (%)
Total wastewater evacuated	2,066.34	-

Wastewater category	Volume (mil. mc)	Percentage (%)
Total domestic wastewater evacuated	907.80	43.93
Total industrial wastewater evacuated	1,123.89	54.39
Domestic wastewater treated	810.01	39.20
Industrial wastewater treated	865.38	41.88
Total wastewater requiring treatment	2,058.18	99.61
Sufficient treated wastewater	1,385.03	67.03
Insufficient treated wastewater	334.95	16.21
Untreated wastewater	338.19	16.37

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.

Wastewater treatment processes are: mechanical, mechanical- chemical and mechanical - biological methods, most of the times using a combination of these.

According to data provided by N.A. “Romanian Waters”, the largest amount of wastewater comes from industry, about 1154.68 million cubic metres.

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 2014 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. The number of municipal and industrial wastewater treatment plants, classified by appropriate treatment stage, as follows:

- primary stage: 57 treatment plants;
- secondary stage: 576 treatment plants;
- tertiary stage: 55 treatment plants.

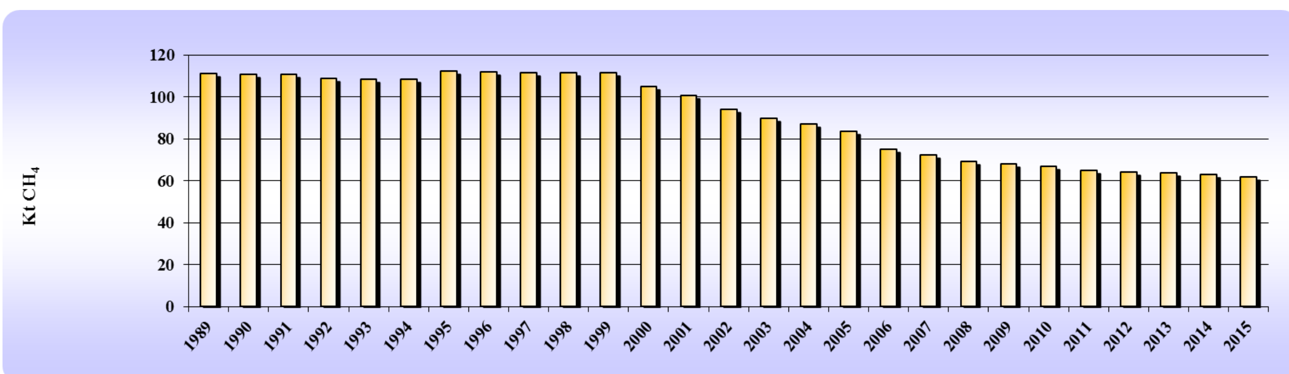
This situation is changing every year because the sewage system extends under projects financed by government programs, enhancing the connection to the sewerage and wastewater treatment.

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 7.21). The methane emissions level of 2015 compared to base year (1989) is in decreasing with 44.23 %.

Figure 7.21 CH_4 emissions trend from domestic/commercial wastewater and sludge treatment for 1989–2015 period



CH_4 emissions from industrial wastewater (CRF 5.D2)

Depending on the industry of origin, industrial wastewaters have a different composition.

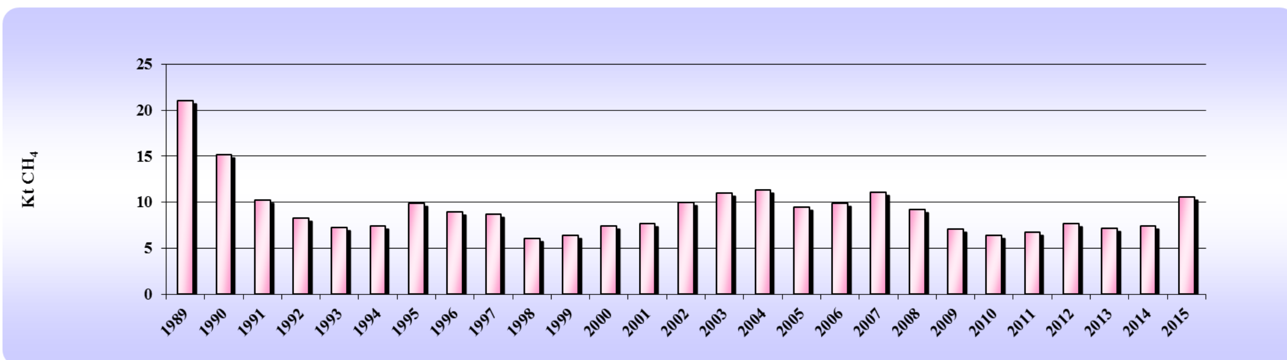
The sensitive issues of industrial wastewater treatment are associated with time-varying flows, extreme temperatures and excessive quantities of the following substances: petroleum products, organic oils, fats; acids and bases; materials in suspension; organic and inorganic substances; explosives and 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 7.22).

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 7.22 CH_4 emissions trend from industrial wastewater handling for 1989–2015 period



Compared with the base year (1989), CH_4 emissions from industrial wastewater treatment decreased with 62.72 %.

Table 7.23 Explanations on methane emissions estimates

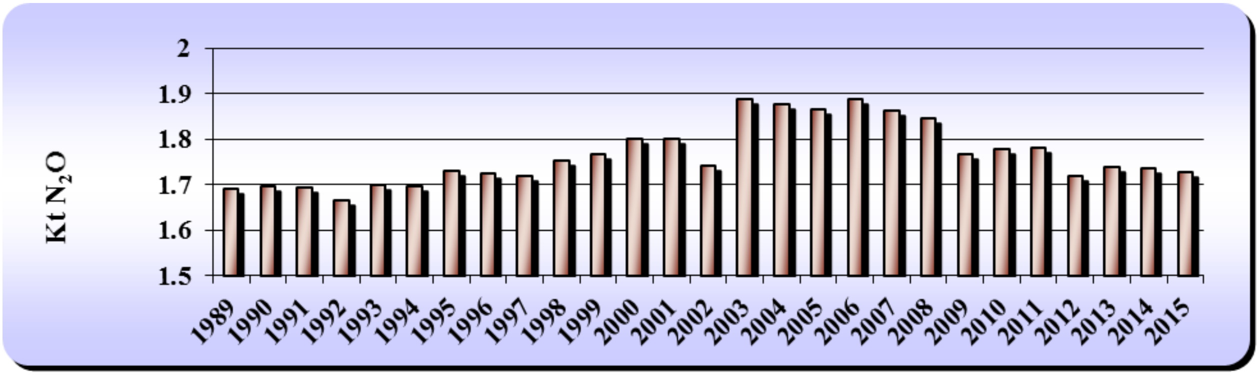
Period	Methane emissions from industrial wastewater treatment -Explanations
1989-1996	Values between 21.01–8.96 kt; These values are decreasing following decreasing industrial production.

Period	Methane emissions from industrial wastewater treatment -Explanations
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.
2005-2015	Values between 9.44 –10.54; Relatively lower values compared with 1997-2004 period, but since 2009 following a sharp decline due to economic crisis.

The same decreasing tendency is noted for CH_4 emissions from domestic/commercial wastewater (Figure 7.17).

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 provided by Food and Agriculture Organization of the United Nations and National Institute for Statistics. 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 recent economic crisis. (Figure 7.19 and Table 7.22).

Figure 7.23 N_2O emissions trend from domestic wastewater for 1989–2015 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 O2 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 O2, 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.

In Romania, most municipal treatment plants have old equipment and technologies, leading to low efficiency and quality of treated wastewater over the limit imposed by the Standard NTPA - 011. About 30% of treatment plants are equipped with sludge digestion tanks. Most of the sludge resulting from the treatment (70%) is deposited directly on drying platforms *(Source 2.13 – Development of national policy for managing sewage sludge, page 128).*

After 2000, number of projects for new wastewater plants and for rehabilitation and modernization begun to increase, in the period 2000-2007 the number of municipalities with wastewater treatment plants increasing to 45 cities.

Methodology

To estimate CH_4 emissions from domestic and commercial wastewater, we taking into account the decisions tree from IPCC 2006, page 6.10 and we used equation 6.1 page 6.11.

Were estimated CH_4 emissions both from the population connected to sewerage with treatment and population unconnected to sewerage.

The following steps were considered:

For calculation of Total Organic Wastewater were used equation 6.3 from IPCC 2006.

Emission factor

To calculate Emission Factor we 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.

The percentages of domestic/commercial wastewater treated anaerobically are presented in Table 7.24.

Table 7.24 Calculation of Emission Factors domestic/commercial wastewater, for 1989-2015 period

Parameter	**B_{oi}** (kg CH_4/kg BOD)	**MCF_j**	**EFs**
Population connected to sewerage without treatment	0.60	0.0	**0.00**
Centrazed, aerobic treatment plant	0.6	0.2	**0.12**
Population unconnected to sewerage	0.60	0.5	0.30
Source:	**IPCC 2006**	**Expert opinion**	**-**

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 thepopulation 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 7.25).

The data regarding population unconnected to sewerage were obtained making the difference between total population and population connected to sewerage.

Table 7.25 The sources of activity data used in methane emissions estimates from domestic/commercial wastewater treatment

Activity Data	Source
Total population [1000 persons]	*National Institute for Statistics*
Total population connected to sewerage with treatment [1000 persons] - $P_{tot\ tr}$	*1989 -2005 period:* $P_{tot\ tr} = P_{urb\ tr} + P_{rur\ tr}$; *2006 – 2015 : National Institute for Statistics*
Total population unconnected to sewerage [1000 persons] – $P_{tot\ uncon}$	*1989 -2005 period:* $P_{tot\ uncon} = P_{urb\ uncon} + P_{rur\ uncon}$ *2006 – 2015 :* $P_{tot\ uncon} = P_{tot} – P_{tot\ tr}$
Total population [1000 persons]	*National Institute for Statistics*

To calculate Total Organic Wastewater we used the parameters provided by the study (Table 7.26).

Table 7.26 Parameters used to estimate Total organic domestic/commercial wastewater (Source: Study finished in 2011)

Parameters	Years				
	1989-1999	**2000-2005**	**2006**	**2007**	**2008-2015**
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	0.60	0.60	0.60	0.63

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 2008-2015 period was provided by NIS. The other value of BOD is assumed by expert judgement and is provided through the study finalized in 2011.

CH_4 from domestic/commercial wastewater recovered and/or flared are reported NO. In the future we will investigate this issue by sending the specific questionnaires to the operators of the municipal wastewater treatment plants.

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 (1.4), 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).

Activity data

In estimation of N_2O emissions from domestic wastewater was taking into account the total population of our country. The number of population was provided by National Institute for Statistics for 1989-2014 period.

The data regarding Protein Consumption were provided by Food and Agriculture Organization site and by National Institute for Statistics being presented in the Table 7.27.

Table 7.27 Values of Protein Consumption for Romania in period 1989-2015

Year	Protein consumption [kg protein/person/yr]	Source
1989	33.22	Statistical Yearbook 2004-2006
1990	33.22	FAO - Romania Country Profile
1991	33.22	
1992	33.22	
1993	33.95	Interpolation between 1992 and 1994 by expert judgement
1994	33.95	Statistical Yearbook 2009
1995	34.68	FAO - Romania Country Profile
1996	34.68	
1997	34.68	
1998	35.41	Arithmetic average between 1997 and 1999
1999	35.77	Statistical Yearbook 2010
2000	36.50	FAO - Romania Country Profile
2001	36.50	
2002	36.50	
2003	39.79	Statistical Yearbook 2010
2004	39.79	
2005	39.79	

Year	Protein consumption [kg protein/person/yr]	Source
2006	40.52	FAO - Romania Country Profile
2007	40.52	
2008	40.88	National Institute for Statistics
2009	39.42	
2010	39.93	
2011	40.15	
2012	38.95	
2013	39.57	
2014*	39.57	
2015*	39.64	*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 we using 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.

Estimation of CH_4 emissions on the one hand for pulp, paper, petroleum refining and on the other hand separately for anaerobic and aerobic treatment in beer industry.

Methane is recovered only in beer industry which treating their wastewater in anaerobic conditions.

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 industrial branch. 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 .

In accordance with IPCC 2006 Guidelines, Methane Conversion Factor for aerobic treatment is 0.05 and for anaerobic treatment is 0.80.

In accordance with IPCC 2006 Guidelines, Methane Conversion Factor for aerobic treatment is 0.05 and for anaerobic treatment is 0.80.

Table 7.28 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 - 2015; 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 - 2015; 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

The activity data as regard industrial production of sectors taking into account have been provided by National Institute for Statistics (Table 7.29).

Table 7.29 Industrial production of the industrial sectors with the greatest potential for methane emissions (source: NIS - Statistical Yearbook 2014)

Year	Production (t/year)			
	Beer	Paper	Pulp	Petroleum Refining
1989	1,151,300	552,000	574,000	30,615,000
1990	1,052,700	427,000	380,000	23,664,000
1991	980,300	307,000	235,000	15,191,000
1992	1,001,400	262,000	171,000	13,299,000
1993	992,900	248,000	132,000	13,191,000
1994	904,600	262,000	128,000	14,744,000
1995	876,800	332,000	194,000	15,259,000
1996	811,800	299,000	177,000	13,426,000
1997	765,100	306,000	154,000	12,429,000
1998	998,900	281,000	129,000	12,520,000
1999	1,113,300	276,000	144,000	9,894,000
2000	1,266,400	328,000	187,000	10,532,000
2001	1,266,300	388,000	172,000	10,948,000
2002	1,162,700	421,000	199,000	11,906,000
2003	1,329,200	457,000	212,000	10,736,000
2004	1,440,600	492,000	187,000	12,371,000

Year	Production (t/year)			
	Beer	Paper	Pulp	Petroleum Refining
2005	1,529,500	385,000	103,000	13,890,000
2006	1,748,400	401,000	80,000	13,237,000
2007	1,921,300	461,000	86,000	13,006,000
2008	2,024,000	369,000	22,000	13,095,000
2009	1,809,000	310,000	*	11,340,000
2010	1,665,600	325,000	*	9,931,000
2011	1,723,900	335,000	*	9,516,000
2012	1,832,500	343,000	*	9,142,000
2013	1,751,900	372,000	*	9,366,000
2014	1,658,100	398,000	*	10,620,000
2015	1,809,100	459,000	*	10,477,000

* Confidential data

As regards Degradable Organic Component and Wastewater generated, we used the default values from IPCC 2006 (Table 7. 30).

Table 7.30 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 7.31).

Table 7.31 The amounts of CH_4 recovered from industrial wastewater treatment (Source: economic operators)

Year	Amount of Methane recovery Gg/year
1989-1997	-
1998	0.18
1999	0.28
2000	0.41
2001	0.54
2002	0.60
2003	0.61
2004	0.74
2005	0.84
2006	1.02
2007	1.14
2008	1.62
2009	2.17
2010	2.54
2011	2.51
2012	1.95
2013	2.59
2014	2.30
2015	3.02

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 7.32 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 7.33 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 7.34 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 Fugitive emissions from fuels and transport category except road transportation category, 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 7.36).

The data reported to EUROSTAT were estimated for 1 January of each year considered while the data taking into account in NGHGI 2014 were estimated for 1 July of each year. Both data are corrected and are provided by NIS.

Table 7.35 Comparison between data provided by EUROSTAT and data provided by NIS

Year	**Total number of population (1000 persons)**		**Difference (persons)**
	NGHGI 2015 (Source NIS) *1 July*	**EUROSTAT *1 January***	
1989	23,151.564	-	-
1990	23,206.720	23,211.395	4.675

Year	Total number of population (1000 persons)		Difference (persons)
	NGHGI 2015 (Source NIS) *1 July*	EUROSTAT *1 January*	
1991	23,185.084	23,192.274	7.190
1992	22,788.969	22,811.392	22.423
1993	22,755.260	22,778.533	23.273
1994	22,730.622	22,748.027	17.405
1995	22,680.951	22,712.394	31.443
1996	22,607.620	22,656.145	48.525
1997	22,545.925	22,581.862	35.937
1998	22,502.803	22,526.093	23.290
1999	22,458.022	22,488.595	30.573
2000	22,435.205	22,455.485	20.280
2001	22,408.393	22,430.457	22.064
2002	21,794.793	21,833.483	38.690
2003	21,733.556	21,772.774	39.218
2004	21,673.328	21,711.252	37.924
2005	21,319,673	21,382,354	62,681
2006	21,193,749	21,257,016	63,267
2007	20,882,980	21,130,503	247,523
2008	20,537,848	20,635,460	97,612
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	19985814	20020074	34,260
2014	19913193	19947311	34,118
2015	19819697	19870647	50,950

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

For this category no recalculations have been performed.

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

In order to improve the next submission, we will try to obtain more detailed data in respect to IPCC 2006.

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**

CO [kg/TJ]	Coal	Natural Gas	Oil	Wood/Wood Waste	Charcoal	Other Biomass and Wastes
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 2005–2013 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 2005–2013 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 2013, 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* category, 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.

See the corresponding Energy sector 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 CIVIL 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 emission inventory guidebook 2013.

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 Road Transport Subsector.

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

Recalculations for the 1989 – 2012 period due to changes methodology, update of value emission factors for fuel consumption.

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 2013.

Model Copert 4, Tier 1 was used in the absence of more detailed fleet data (for the period 1989-2004). Tier 1 emission factors of Copert 4 will give somewhat higher emission values as is the case of Romania than Tier 2 or 3 methodology for countries whose fleet comprises vehicles which comply with more recent (i.e. Euro 2 / Euro II and later) emission standards.

The maximum values for the emission factors used correspond to uncontrolled vehicle technology.

Table 9.6 Emission Factors for Tier 1 method of Copert 4

Category	Fuel	CO (g/kg fuel)	NMVOC (g/kg fuel)	NOx (g/kg fuel)
Passenger Cars	Gasoline	269.5	34.42	29.89
Passenger Cars	Diesel	8.19	1.88	13.88
Passenger Cars	LPG	117	25.66	34.3
Light-Duty Vehicles	Gasoline	238.3	26.08	25.46

Category	Fuel	CO (g/kg fuel)	NMVOC (g/kg fuel)	NOx (g/kg fuel)
Light-Duty Vehicles	Diesel	11.71	1.96	18.43
Heavy-Duty Vehicles	Diesel	10.57	3.77	38.29
Two-Wheel Vehicles	Gasoline	664.5	364.8	10.73

CO, NOx, ch. Road transport GB 2013, table 3-5 and table 3-6 pag.25-26; NMVOC ch. Gasoline evaporation GB 2013, pag.8-9; SO_2 IPCC 1996, Vol.III, pag.1.44 Guidelines table 1-12 Default Values of Sulphur Content in gasoline(road), diesel(road) and jet kerosene).

The emissions of sulphur oxides (SO_2) are directly related to the sulphur content of the fuel:

Equation 9.1 The Emission Factor for SO_2

$$EF_{SO2}\ [kg/TJ] = 2 \times (s/100) \times 1/Q \times 10^6 \times (100 - r/100) \times (100 - n/100)$$

where:

- EF = Emission Factor (kg/TJ);
- 2 = SO_2/S [kg/kg];
- s = Sulphur content in fuel [%];
- r = Retention of sulphur in ash [%];
- Q = Net calorific value [TJ/kt];
- n = Efficiency of abatement technology and/or reduction efficiency [%].

Table 9.7 Default values of sulphur content (s) in fuel

Fuel (IPCC grouping)	Default value [%]
Diesel (road)	0.3
Gasoline (road)	0.1
Jet kerosene	0.05

- *Emission factors for period 2005-2013*

Model Copert 4, Tier 3 was used for the period 2005-2013, detailed statistics necessary to use higher level methods have allowed. For period 2005-2013 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 GPG 2000 and IPCC 2006.

9.1.1.3.3 Uncertainties and time-series consistency

Table 9.8 Uncertainties for road transport

Road Transport 1.A.3.b.	Uncertainty					Combined uncertainty			
	Activity Data	**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 Domestic Aviation, Railways, Domestic Navigation and Other Transportation, 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

Recalculations for the 1989 – 2012 period due to changes methodology, update of value emission factors for fuel consumption.

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* provided in the *Revised 1996 IPCC Guidelines* and EMEP/EEA emission inventory guidebook 2013.

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 emission inventory guidebook 2013.

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, of the EMEP/EEA emission inventory guidebook 2013.

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 Road Transport Subsector.

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

Recalculations for the 1989 – 2012 period due to changes methodology, update of value emission factors for fuel consumption.

9.1.1.4.6 9.1.3.6.Category-specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.1.5 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* provided in the *Revised 1996 IPCC Guidelines* and EMEP/EEA emission inventory guidebook 2013.

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, of the EMEP/EEA emission inventory guidebook 2013.

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 Road Transport Subsector.

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

Recalculations for the 1989 – 2012 period due to changes methodology, update of value emission factors for fuel consumption.

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 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 provided in the Revised 1996 IPCC Guidelines and EMEP/EEA emission inventory guidebook 2013.

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 emission inventory guidebook 2013.

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 Road Transport Subsector.

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

Recalculations for the 1989 – 2012 period due to changes methodology, update of value emission factors for fuel consumption.

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 2014.

Emission Factor

The default emission factors from Revised 1996 IPCC Guidelines and from EMEP/EEA Emission Inventory Guidebook 2013 have been used.

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 Emission Inventory Guidebook 2013.

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 Fuel Combustion Subsector.

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

No recalculations were performed.

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 9.9 Cement Production data and SO_2 emissions from Cement Production in the period 1989–2015

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
1991	6,692.00	0.30	2.01
1992	6,271.00	0.30	1.88
1993	6,158.00	0.30	1.85
1994	5,998.00	0.30	1.80
1995	6,842.00	0.30	2.05
1996	6,956.00	0.30	2.09
1997	6,553.00	0.30	1.97
1998	6,577.00	0.30	1.97
1999	5,580.00	0.30	1.67
2000	6,058.00	0.30	1.82
2001	5,668.00	0.30	1.70
2002	5,680.00	0.30	1.70
2003	5,992.00	0.30	1.80
2004	6,239.00	0.30	1.87
2005	7,043.00	0.30	2.11
2006	8,253.00	0.30	2.48

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]
2007	10,060.00	0.30	3.02
2008	10,660.00	0.30	3.20
2009	7,902.00	0.30	2.37
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

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 2013.

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 Transport and Fugitive Emissions from Fuels subsectors, 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 9.10 Ammonia Production data and CO and SO_2 emissions from Ammonia Production in the period 1989–2015

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
1991	1,185,525.00	7.9	0.03	9.366	0.036
1992	1,575,576.00	7.9	0.03	12.447	0.047
1993	1,466,671.00	7.9	0.03	11.587	0.044
1994	1,568,150.00	7.9	0.03	12.388	0.047
1995	1,641,398.00	7.9	0.03	12.967	0.049
1996	1,652,878.00	7.9	0.03	13.058	0.050
1997	836,927.00	7.9	0.03	6.612	0.025
1998	459,482.00	7.9	0.03	3.630	0.014
1999	824,867.00	7.9	0.03	6.516	0.025
2000	1,245,068.00	7.9	0.03	9.836	0.037
2001	1,149,376.00	7.9	0.03	9.080	0.034
2002	1,131,526.00	7.9	0.03	8.939	0.034
2003	1,435,176.00	7.9	0.03	11.338	0.043
2004	1,426,105.00	7.9	0.03	11.266	0.043
2005	1,601,724.00	7.9	0.03	12.654	0.048
2006	1,370,461.00	7.9	0.03	10.827	0.041
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

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
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

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 there are currently three chemical plants, where five 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" (6 facilities):

- 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 (one facility):

- 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 three chemical plants, where five HNO_3 production facilities are in operation;

- Five operating HNO_3 production facilities are fitted with nitrogen oxide reduction and emission monitoring systems;
- Upgrading efforts are made in all seven operating HNO_3 production facilities, to reduce nitrogen oxide emissions.

NOx emission level trend

- The emissions decreased between 1989 and 2001, 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.

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 9.11 Nitric Acid Production related to the NO_x emissions in the period 1989–2015

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
1991	741.95	0.27	5.39
1992	1,051.09	0.38	7.64
1993	1,024.76	0.37	7.45

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]
1994	884.85	0.12	6.56
1995	1,025.81	0.09	7.64
1996	1,057.15	0.04	7.90
1997	768.56	0.05	4.87
1998	547.69	0.04	3.82
1999	609.55	0.13	4.01
2000	874.12	0.22	5.42
2001	750.72	0.26	4.84
2002	795.35	0.09	5.27
2003	960.24	0.06	3.41
2004	1,059.14	0.37	1.87
2005	1,102.14	0.17	2.75
2006	869.25	0.30	2.01
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

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 9.12 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 9.13 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

Year	Amount of Adipic Acid Produced	NOx emissions kt	NMVOC emissions kt	CO emissions kt
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, methanol, acrylonitrile, ethylene dichloride, ethylene oxide, vinyl chloride monomer, propylene, polystyrene, polyethylene, sulphuric acid, phthalic anhydride, polypropylena, polyvinylchloride, 1, 2 dichloroethane). Carbon black and sulphuric acid 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 9.14 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
1991	0.02	0.47	4.42	13.18
1992	0.01	0.27	3.32	10.09
1993	0.01	0.27	3.67	9.31
1994	0.01	0.19	3.92	8.65
1995	0.01	0.22	4.82	8.42
1996	0.01	0.26	4.63	7.47
1997	0.01	0.21	5.01	5.82
1998	0.01	0.18	4.45	4.06
1999	0.00	0.12	4.78	4.13
2000	0.01	0.15	5.01	3.21
2001	0.01	0.16	5.51	1.06
2002	0.00	0.08	5.50	1.04
2003	0.00	0.02	6.11	1.14
2004	NO	NO	6.56	0.49
2005	NO	NO	6.74	0.19
2006	NO	NO	5.17	NO
2007	NO	NO	2.90	NO

Year	NOx emissions kt	CO emissions kt	NMVOC emissions kt	SO_2 emissions kt
2008	NO	NO	2.92	NO
2009	NO	NO	1.54	NO
2010	NO	NO	1.31	NO
2011	NO	NO	1.62	0.04
2012	NO	NO	1.23	NO
2013	NO	NO	1.59	NO
2014	NO	NO	1.23	NO
2015	NO	NO	1.11	NO

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 2013.

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 2013.

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 2013.

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 2013.

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 %;

- 125.90 % 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 2013.

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 2013.

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 Transport and Fugitive Emissions from Fuels subsectors, 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) and Aluminium Production (CRF 2.C.3).

9.1.2.3.2 Methodological issues

9.1.2.3.2.1 Iron and Steel Production (CRF 2.C.1)

Methodology

The NMVOC, NOx, CO and SO_2 emissions for the period 1989-2014 were estimated based on the Tier 1 methodology in IPCC 1996 (activity data x default emission factor).

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

The default emission factors of 0.112 kg CO/ tonne of product, 0.02 kg NMVOC/ tonne of product, 0.076 kg NOx/ tonne of product and 0.03 kg SO_2/ tonne of product are used (1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories - page 2.29).

Table 9.15 NMVOC emissions for category CRF 2.C.1 – Iron and Steel Production

Year	Iron production, t	Emission factor, kg/t	NMVOC emissions, t
1989	8,495,130	0.02	170
1990	5,916,270	0.02	118
1991	4,231,800	0.02	85
1992	3,001,320	0.02	60
1993	3,118,790	0.02	62
1994	3,421,210	0.02	68
1995	4,118,570	0.02	82
1996	3,905,790	0.02	78
1997	4,445,200	0.02	89
1998	4,463,690	0.02	89
1999	2,943,280	0.02	59
2000	3,041,540	0.02	61
2001	3,221,860	0.02	64
2002	3,969,800	0.02	79
2003	4,084,940	0.02	82
2004	4,246,500	0.02	85
2005	4,117,920	0.02	82
2006	3,984,650	0.02	80
2007	3,946,680	0.02	79
2008	3,238,790	0.02	65
2009	1,568,860	0.02	31
2010	1,721,750	0.02	34
2011	1,581,250	0.02	32
2012	1,468,160	0.02	29
2013	1,603,843	0.02	32
2014	1,631,338	0.02	33
2015	1,983,136	0.02	40

Table 9.16 NOx emissions for category CRF 2.C.1 – Iron and Steel Production

Year	Iron production, t	Emission factor, kg/t	NOx emissions, t
1989	8,495,130	0.076	646
1990	5,916,270	0.076	450
1991	4,231,800	0.076	322
1992	3,001,320	0.076	228
1993	3,118,790	0.076	237
1994	3,421,210	0.076	260
1995	4,118,570	0.076	313
1996	3,905,790	0.076	297
1997	4,445,200	0.076	338
1998	4,463,690	0.076	339
1999	2,943,280	0.076	224
2000	3,041,540	0.076	231
2001	3,221,860	0.076	245
2002	3,969,800	0.076	302
2003	4,084,940	0.076	310
2004	4,246,500	0.076	323
2005	4,117,920	0.076	313
2006	3,984,650	0.076	303
2007	3,946,680	0.076	300
2008	3,238,790	0.076	246
2009	1,568,860	0.076	119
2010	1,721,750	0.076	131
2011	1,581,250	0.076	120
2012	1,468,160	0.076	112
2013	1,603,843	0.076	122
2014	1,631,338	0.076	124
2015	1,983,136	0.076	151

Table 9.17 CO emissions for category CRF 2.C.1 – Iron and Steel Production

Year	Iron production, t	Emission factor, kg/t	CO emissions, t
1989	8,495,130	0.112	951
1990	5,916,270	0.112	663
1991	4,231,800	0.112	474
1992	3,001,320	0.112	336
1993	3,118,790	0.112	349
1994	3,421,210	0.112	383
1995	4,118,570	0.112	461
1996	3,905,790	0.112	437
1997	4,445,200	0.112	498
1998	4,463,690	0.112	500
1999	2,943,280	0.112	330
2000	3,041,540	0.112	341
2001	3,221,860	0.112	361
2002	3,969,800	0.112	445
2003	4,084,940	0.112	458
2004	4,246,500	0.112	476
2005	4,117,920	0.112	461
2006	3,984,650	0.112	446
2007	3,946,680	0.112	442
2008	3,238,790	0.112	363
2009	1,568,860	0.112	176
2010	1,721,750	0.112	193
2011	1,581,250	0.112	177
2012	1,468,160	0.112	164
2013	1,603,843	0.112	180
2014	1,631,338	0.112	183
2015	1,983,136	0.112	222

Table 9.18 SO_2 emissions for category CRF 2.C.1 – Iron and Steel Production

Year	Iron production, t	Emission factor, kg/t	SO_2 emissions, t
1989	8,495,130	0.03	255
1990	5,916,270	0.03	177
1991	4,231,800	0.03	127
1992	3,001,320	0.03	90
1993	3,118,790	0.03	94
1994	3,421,210	0.03	103
1995	4,118,570	0.03	124
1996	3,905,790	0.03	117
1997	4,445,200	0.03	133
1998	4,463,690	0.03	134
1999	2,943,280	0.03	88
2000	3,041,540	0.03	91
2001	3,221,860	0.03	97
2002	3,969,800	0.03	119
2003	4,084,940	0.03	123
2004	4,246,500	0.03	127
2005	4,117,920	0.03	124
2006	3,984,650	0.03	120
2007	3,946,680	0.03	118
2008	3,238,790	0.03	97
2009	1,568,860	0.03	47
2010	1,721,750	0.03	52
2011	1,581,250	0.03	47
2012	1,468,160	0.03	44
2013	1,603,843	0.03	48
2014	1,631,338	0.03	49
2015	1,983,136	0.03	59

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 9.19 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 9.20 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

Year	SO_2 emissions kt	CO emissions kt
1991	0.139	61.585
1992	0.096	42.877
1993	0.101	44.694
1994	0.106	47.280
1995	0.127	56.240
1996	0.126	56.092
1997	0.147	65.482
1998	0.157	69.885
1999	0.157	69.632
2000	0.156	69.308
2001	0.162	71.928
2002	0.168	74.636
2003	0.178	79.219
2004	0.194	86.103
2005	0.215	95.604
2006	0.230	102.330
2007	0.236	105.002
2008	0.239	106.095
2009	0.181	80.222
2010	0.186	82.688
2011	0.202	89.802
2012	0.182	80.830
2013	0.178	78.898
2014	0.176	78.0996
2015	0.185	82.352

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.

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 9.21 The SO_2 emissions from Magnesium Production

Year	SO_2 emissions, kt
1989	NO
1990	NO
1991	NO

Year	SO_2 emissions, kt
1992	NO
1993	NO
1994	NO
1995	NO
1996	NO
1997	NO
1998	NO
1999	NO
2000	NO
2001	NO
2002	NO
2003	NO
2004	NO
2005	NO
2006	NO
2007	NO
2008	NO
2009	NO
2010	NO
2011	NO
2012	NO
2013	NO
2014	NO
2015	0.164

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 2013.

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 2013.

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 2013.

***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 2013.

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 2013.

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 Transport and Fugitive Emissions from Fuels subsectors, 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 9.22 The NMVOC emissions from Road Paving with Asphalt Sector

Year	Activity data kt	NMVOC emissions kt
1989	NE	NE
1990	NE	NE
1991	NE	NE
1992	NE	NE
1993	NE	NE
1994	NE	NE
1995	NE	NE
1996	NE	NE
1997	NE	NE
1998	192.333	0.003
1999	171.577	0.003
2000	223.196	0.004
2001	155.441	0.002

Year	Activity data kt	NMVOC emissions kt
2002	155.89	0.002
2003	190.258	0.003
2004	952.121	0.015
2005	676.403	0.011
2006	949.411	0.015
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

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 9.23 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 9.24 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
1991	NE	NE	NE
1992	NE	NE	NE
1993	NE	NE	NE
1994	NE	NE	NE
1995	NE	NE	NE
1996	NE	NE	NE

Year	Activity data kt	CO emissions kt	NMVOC emissions kt
1997	NE	NE	NE
1998	NE	NE	NE
1999	NE	NE	NE
2000	NE	NE	NE
2001	NE	NE	NE
2002	NE	NE	NE
2003	NE	NE	NE
2004	NE	NE	NE
2005	12.144	0.00	0.03
2006	8.79	0.00	0.02
2007	C	0.00	0.01
2008	C	0.00	0.01
2009	C	0.00	0.01
2010	C	0.00	0.01
2011	C	0.00	0.24
2012	C	0.00	0.09
2013	C	0.00	0.00
2014	C	0.00	0.033
2015	C	0.00	0.09

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 2013.

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 2013.

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 Transport and Fugitive Emissions from Fuels subsectors, 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. Starting with 2009 the activity data are NO inside this category.

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 1989–2014.

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 Transport and Fugitive Emissions from Fuels subsectors, 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 MANURE MANAGEMENT (3B)

Indirect N_2O emissions from Manure management (3B 2.5)

9.1.3.1.1 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.

9.1.3.1.2 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 EF_4 (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.
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] and MS were established by expert opinion being explained in the section direct N_2O emissions.
The values for percent of managed manure nitrogen for livestock that volatilises as NH_3 and NO_x 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).

9.1.3.1.3 Uncertainties and time-series consistency

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

- AD: 10 %;
- EF: 2.6%;
- 10.33% 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 1989-2015 is consistent.

9.1.3.1.4 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 LULUCF, the results of these being mentioned on the Checklists level.

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.

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

The implications of all changes made on emission estimates are described in the Table 9.25.

Table 9.25 Implication of recalculations on emission estimates

The changes impacts on estimating indirect N_2O emissions due to leaching from manure management			
Years	**2016 v.4 submission N_2O emissions (Gg)**	**2017 v.1. submission N_2O emissions (Gg)**	**Difference**
1989	NO	0.002779096	-0.002779096
1990	NO	0.003026992	-0.003026992
1991	NO	0.002576414	-0.002576414
1992	NO	0.002040824	-0.002040824
1993	NO	0.001804478	-0.001804478
1994	NO	0.001449199	-0.001449199
1995	NO	0.001541703	-0.001541703
1996	NO	0.001504312	-0.001504312
1997	NO	0.001063044	-0.001063044
1998	NO	0.001066699	-0.001066699
1999	NO	0.000799596	-0.000799596
2000	NO	0.000700718	-0.000700718
2001	NO	0.000837806	-0.000837806
2002	NO	0.001080185	-0.001080185
2003	NO	0.00122258	-0.00122258
2004	NO	0.001650313	-0.001650313
2005	NO	0.001806552	-0.001806552
2006	NO	0.001904059	-0.001904059
2007	NO	0.001879751	-0.001879751
2008	NO	0.001838503	-0.001838503
2009	NO	0.001870514	-0.001870514
2010	NO	0.001719776	-0.001719776
2011	NO	0.001687287	-0.001687287
2012	NO	0.001664075	-0.001664075

The changes impacts on estimating indirect N_2O emissions due to leaching from manure management			
Years	**2016 v.4 submission N_2O emissions (Gg)**	**2017 v.1. submission N_2O emissions (Gg)**	**Difference**
2013	NO	0.001650006	-0.001650006
2014	NO	0.001581551	-0.001581551

9.1.3.1.6 Category-specific planned improvements, 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:

- ❖ percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NOx in the manure management system S, % ($Frac_{GasMS}$)

9.1.3.2 NON METHANE VOLATILE ORGANIC COMPOUNDS (NMVOC)

NMVOC emissions are not estimated in Romania.

9.1.3.3 MANAGED SOILS (3D)

Indirect N_2O emissions from Managed soils ***(3D2)***

9.1.3.3.1 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.

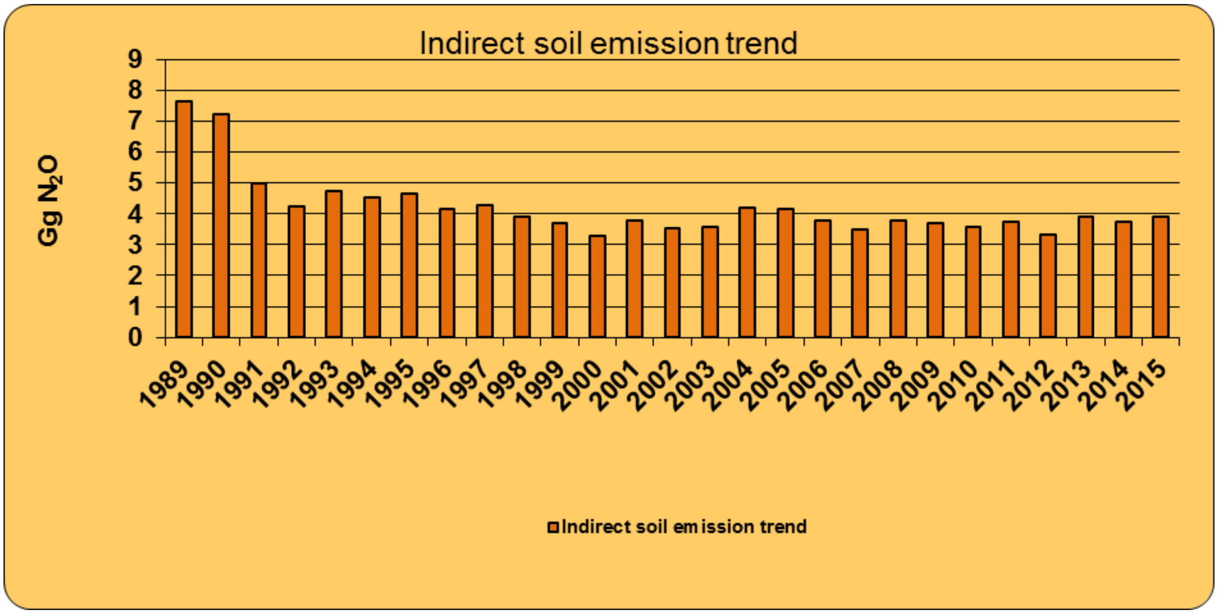
Microbial processes of nitrification and denitrification in agricultural soils produce indirect nitrous oxide emissions.

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}).

- ❖ the second source of N_2O emissions in the Agriculture sector (in 2015, N_2O Indirect soil emissions represented 20.29 % of total N_2O emissions in the Agriculture sector);
- ❖ is third source in the Agriculture sector (in 2015, N_2O Indirect soil emissions as CO_2 equivalent represented 6.26 % from Total Agriculture emissions);
- ❖ contributed with 1 % to Total GHG emissions of Romania.

Figure 9.1 Indirect N_2O emissions trends – Agricultural Soils



9.1.3.3.2 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.

9.1.3.3.3 Uncertainties and time-series consistency

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

- AD: 20 %;
- EF: 1.93%;
- 20.09% 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 1989-2015 is consistent.

9.1.3.3.4 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 LULUCF, 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.

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

Were made recalculations on emission estimates on *Indirect N_2O Emissions in Nitrogen leaching and run-off* for the 1989-2015 period.

The changes impacts on emission estimates are described in the Table 9.26.

Table 9.26 Implication of recalculations on emission estimates

The changes impacts on estimating Indirect N_2O emissions from Nitrogen leaching and run-off			
Years	***2016 v.4 submission N_2O emissions (kt)***	***2017 v.1. submission N_2O emissions (kt)***	***Difference***
1989	NO	4.923851291	-4.923851291
1990	NO	4.64463973	-4.64463973
1991	NO	3.216972274	-3.216972274
1992	NO	2.635065265	-2.635065265
1993	NO	3.034582911	-3.034582911
1994	NO	2.972872676	-2.972872676
1995	NO	3.07057262	-3.07057262
1996	NO	2.670579979	-2.670579979
1997	NO	2.892272214	-2.892272214
1998	NO	2.522172171	-2.522172171
1999	NO	2.417004585	-2.417004585
2000	NO	2.078128746	-2.078128746
2001	NO	2.556963224	-2.556963224

The changes impacts on estimating Indirect N_2O emissions from Nitrogen leaching and run-off			
Years	***2016 v.4 submission N_2O emissions (kt)***	***2017 v.1. submission N_2O emissions (kt)***	***Difference***
2002	NO	2.302302769	-2.302302769
2003	NO	2.334958824	-2.334958824
2004	NO	2.897833644	-2.897833644
2005	NO	2.772598577	-2.772598577
2006	NO	2.442445702	-2.442445702
2007	NO	2.143790904	-2.143790904
2008	NO	2.485694193	-2.485694193
2009	NO	2.412670985	-2.412670985
2010	NO	2.363069314	-2.363069314
2011	NO	2.562923026	-2.562923026
2012	NO	2.174824818	-2.174824818
2013	NO	2.663408294	-2.663408294
2014	NO	2.582315609	-2.582315609

9.1.3.3.6 Category-specific planned improvements, 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:

- fraction that volatilizes as NH_3 and NOx, specific to synthetic fertilizers nitrogen adjusted for volatilization ($Frac_{GASF}$);
- fraction that volatilizes as NH_3 and NOx, 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 ($Frac_{LEACH}$).

9.1.3.4 FIELD BURNING OF AGRICULTURAL RESIDUES (3F)

NOx and CO emissions

9.1.3.4.1 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“*.

9.1.3.4.2 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 9.27 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.

9.1.3.4.3 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 2014.

9.1.3.4.4 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 LULUCF, the results of these being mentioned on the Checklists level.

9.1.3.4.5 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.

9.1.3.4.6 Category-specific planned improvements, including tracking of those identified in the review process

No source-specific planned improvements are envisaged.

9.1.3.5 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 9.28 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
1991	56.51	50	0.79	0.7
1992	58.09	50	0.81	0.7
1993	59.48	50	0.83	0.7
1994	60.77	50	0.85	0.7
1995	62.83	50	0.88	0.7
1996	66.48	50	0.93	0.7
1997	69.93	50	0.98	0.7
1998	70.72	50	0.99	0.7
1999	73.03	50	1.02	0.7
2000	76.87	50	1.08	0.7
2001	82.24	50	1.15	0.7
2002	87.01	50	1.22	0.7
2003	92.81	50	1.30	0.7
2004	98.01	50	1.37	0.7
2005	102.60	50	1.44	0.7
2006	104.65	50	1.47	0.7
2007	111.38	50	1.56	0.7
2008	114.53	50	1.60	0.7
2009	118.82	50	1.66	0.7

Year	Greenhouse Gas			
	CH_4		NMVOC	
	kt	%	kt	%
2010	124.09	50	1.74	0.7
2011	105.12	50	1.47	0.7
2012	128.41	50	1.80	0.7
2013	140.32	50	1.96	0.7
2014	140.63	50	1.97	0.7
2015*	140.79	50	1.97	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

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 version 4 of the 2016 Greenhouse Gas Inventory submission and 2017 Greenhouse Gas Inventory submission. Since the 2016 version 4 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 version 4 of the 2016 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 version 4 of the 2016 NGHGI, are presented in Table 10.1

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	√	√	Chapter 3 of the National Inventory Report
2. Manufacturing industries and construction	√	√	Chapter 3 of the National Inventory Report
3. Transport			
4. Other sector			
5. Other			
B. Fugitive emissions from fuels			

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**
1. Solid fuels			
2. Oil and natural gas and other emissions from energy production			
C. CO_2 transport and storage			
2. Industrial processes and product use			
A. Mineral industry			
B. Chemical industry			
C. Metal industry			
D. Non-energy products from fuels and solvent use			
E. Electronic industry			
F. Product uses as substitutes for ODS			

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**
G. Other product manufacture and use			
H. Other			
3. Agriculture			
A. Enteric fermentation			
B. Manure management			
C. Rice cultivation			
D. Agricultural soils			
E. Prescribed burning of savannahs			
F. Field burning of agricultural residues			
G. Liming			
H. Urea application			
I. Other carbon containing			

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
fertilisers			
J. Other			
4. Land use, land-use change and forestry			
A. Forest land			
B. Cropland			
C. Grassland			
D. Wetlands			
E. Settlements			
F. Other land			
G. Harvested wood products			
H. Other			
5. Waste			
A. Solid waste disposal			
B. Biological treatment of			

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**
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			
Article 3.3 activities			
Afforestation/reforestation			
Deforestation			
Article 3.4 activities			
Forest management			
Cropland management (if			

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
elected)			
Grazing land management (if elected)			
Revegetation (if elected)			
Wetland drainage and rewetting (if elected)			
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:

Energy

➢ **Energy sector – stationary combustion**

Fuel combustion (1.A.)

CO_2 Emission factors:

- In the EU-ETS reports, the reported coal in 1.A.1.a was separated in lignite and sub-bituminous coal by the calorific power. The criteria used to separate these types of coal was the range for the calorific power of lignite and sub-bituminous coal provided in the IEA Statistic Manual. As consequence, the CO_2 CSEF for Sub-bituminous coal was determined and the CO_2 CS EF for lignite was modified accordingly.
- For the all fuels reported in the EU-ETS reports for 2013 and 2014, the CO_2 CSEFs were determined and used in the estimation of the CO_2 emissions in the categories where the corresponding consumption was reported.
- Further to the implementation of the 2006 IPCC Guidelines, the CO_2 CS EFs were modified in accordance with the reporting on the EU-ETS reports in the new categories 1.A.2.f and 1.A.2.g;

Net calorific values:

- The fuels which have determined or modified the CO_2 CS EF as above, the net calorific values were updated or determined, too.

Activity data:

- The usage of the EU-ETS data in 1.A.1.a category: the deployed procedures to establish the cause for differences between ETS consumption and the Energy Balance consumption in this category are still ongoing. Being that the EU-ETS reports are verified by accredited verifiers, the corresponding data have a higher degree of credibility. Thus, in 1.A.1.a the corresponding EU-ETS data were used on the ETS period (2007-2015), and for the fuels having a higher consumption in ETS than in the Energy Balance. This consumption was corrected with a factor determined as a weighted average of share of the ETS CO_2 emissions on 1.A.1.a category, in 2014, for the selected countries were detailed ETS data were available.
- 1.A.2.a - Further to some discussions with the National Institute for Statistics it was concluded that the used methodology in the Energy Balance to split the solid fuel consumption between combustion and processess conduct to the double accounting of the GHG emissions with the IPPU sector, 2.C.1 category. To solve the problem, the consumption considered in IPPU of coke_oven_coke, sub-bituminous coal and anthracite was subtracted from the corresponding sum of the consumption reported in transformation and combustion in iron & steel category in Energy Balance. Only the rest is considered as fuel combusted in 1.A.2.a – iron and steel category.

Energy Transport

➢ **Civil Aviation (1.A.3.a)**

Jet Kerosene

- The CO_2 emission values for Jet Kerosene for 2004 - 2014 period have been updated due to transcription error in CRF Reporter.

➢ **Railways (1.A.3.c)**

- The CO_2 emission values for 2013 and 2014 have been updated because the Country Specific Emission Factor values for 2013 and 2014 have been updated.

- **Domestic Navigation (1.A.3.d)**

- The CO_2 emission values for 2013 and 2014 have been updated because the Country Specific Emission Factor values for 2013 and 2014 have been updated.

- **Other Transportation (1.A.3.e)**

- The CO_2 emission value for 2004 have been updated due to a tehnical error of the CRF Reporter;
- The CO_2 emission values for 2012, 2013 and 2014 have been updated because the Country Specific Emission Factor values for 2012, 2013 and 2014 have been updated.

- **Feedstocks and non-energy use of fuels (1.AD)**

Liquid Fuels

Activity data

- The recalculations are mainly in 2013 and 2014 from the coke_oven_coke moved in transformation from the iron&combustion, as reported in the Energy Balance, and accounted as non-energy consumption.

Fugitive emissions from fuels (1.B)

- **Oil and natural gas (1.B.2)**

- Exploration oil (1.B.2.a.1) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value for 1989-2015 period have been updated.
- Production oil (1.B.2.a.2) category: the emission values for 1989-2015 period have been updated because the Activity Data values for 1989-2015 period have been updated;
- Refining / Storage (1.B.2.a.6) category: the emission values for 1989-2015 period have been updated because the Country Specific Emission Factor values for 1989-2015 period have been updated;

- Venting Gas (1.B.2.c.1.ii) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value and CO_2 Emission Factor values for 1989-2015 period have been updated;
- Flaring Gas (1.B.2.c.2.ii) category: the emission values for 1989-2015 period have been updated because the density of Natural Gas Liquids value and the CO_2, CH_4 and N_2O Emission Factor values for 1989-2015 period have been updated.

Industrial Processes and Product Use

- Recalculation have been made for the 2005-2014 period. Recalculations were made as a result of due to the changes in activity data for those years. (CRF Category 2.A.4 b)
- Recalculation have been made for the entire period 1989-2014. Recalculations were made as a result of due to recalculate the amount of CO_2 from urea use as fertilizer. (CRF category 2B.1)
- Recalculation have been made for the period 1989-2002. Recalculations were made as a result of due to the improvements on estimating CO_2 and PFC emissions. (CRF category 2.C.3)
- Recalculation have been made for the 2014 year. 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. (CRF Category 2.D.3.a)
- Recalculation of the HFC emissions have been made for the 2011-2014 year. Recalculations were made as a result of due to the changes in activity data for those years. (CRF Category 2.F.1.b)
- Recalculation of the HFC emissions have been made for the 2014 year. Recalculations were made as a result of due to the changes in activity data for this year. (CRF Category 2.F.1.c)
- Recalculation have been made for the entire period 1989-2014. Recalculations were made as a result of due to the improvements on estimating N_2O emissions. (CRF Category 2.G.3a and 2.G.3b)

Agriculture

- **Enteric fermentation (3A) - CH_4**

Activity data:

- The activity data on milk production from National Institute of Statistics was used for the calculation the values on gross energy intake for dairy cattle.

Emissions factors:

- The emissions factors has been recalculated for the 1989-2014 period after using milk production from National Institute of Statistics for dairy cattle.

- **Manure management (3.B.1) – CH_4**

Activity data:

- The activity data on milk production from National Institute of Statistics was used for the calculation the values on gross energy intake necessary in calculation daily volatile solid excreted for dairy cattle.
- Was estimates the emissions for rabbits.
- Due to errors transcription of the value energy digestibility (DE%) for sheep and goats and for the non estimation of the emissions for rabbits was made recalculation on CH_4 emissions.

Emissions factors:

- The emissions factors has been recalculated for the 1989-2014 period after using milk production from National Institute of Statistics for dairy cattle.

- **Manure management (3.B) - N_2O**

- Due to of the errors calculation on Direct N_2O emissions for poultry was made recalculation for 1989-2014.

- **Manure management (3.B) - Indirect N_2O emissions from N Leaching**

Activity data:

- Were been made recalculations for improving the completeness by characterizing of the emissions for the first time from N losses due to leaching.

- **Indirect N_2O emissions (3.D.2)**

Nitrogen Leaching and Run-off (3.D.2.2)

Activity data:

- Were been made recalculations for improving the completeness by characterizing of the emissions from N leaching/runoff.

- **Urea application (3.H)**

- Were been made recalculations on urea application for the 1989-2014 period. Was divided annual amount of urea fertilization by 0.46 being the percentage of N in uree.

LULUCF

In the current submission no recalculations were made in respect to the LULUCF Sector.

Waste

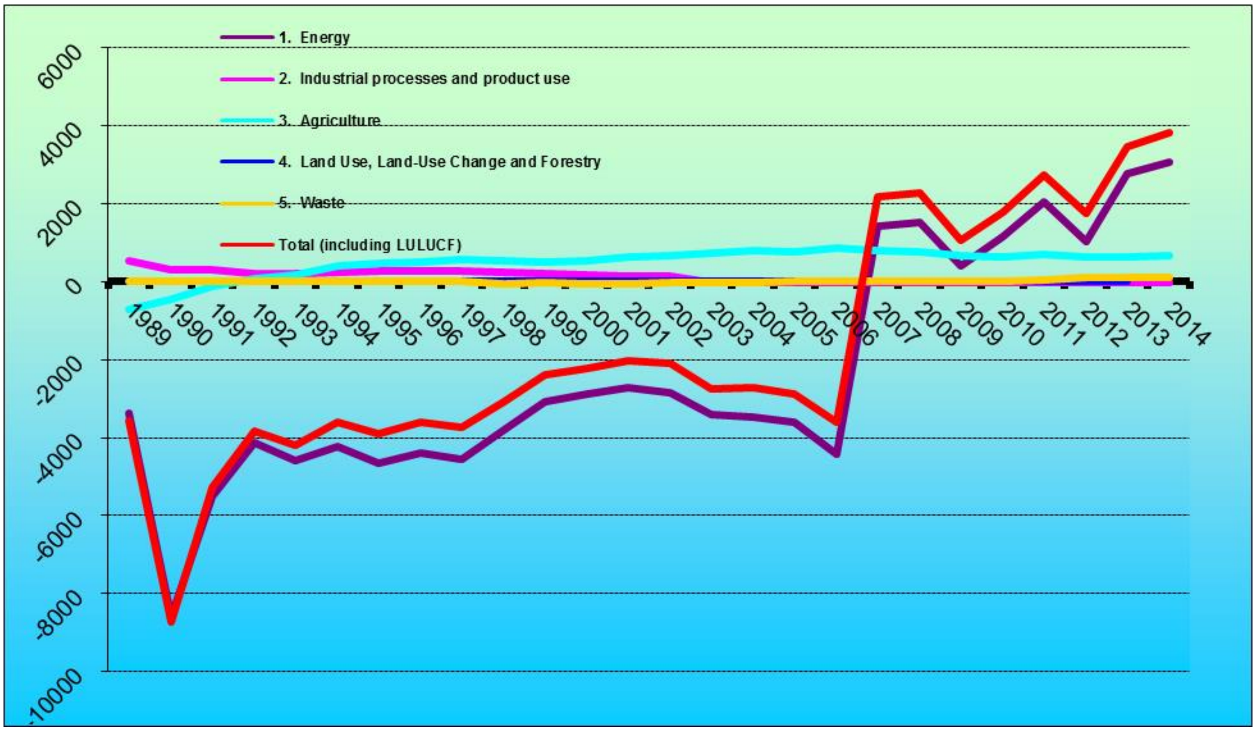
- **Solid Waste Disposal (5.A)**

- The amount of MSW deposited in managed and unmamaged SWDS in 2010-2014 period was updated based on recalculations made by Waste directorate of NEPA;
- The amount of CH_4 recovery was updated for 2011-2014 period due to an error of reporting data;
- The NMVOC emissions were updated based on revised methane emissions for 2010-2014 period.

- **Waste Incineration and Open Burning of Waste (5.C)**

- CH_4 emissions for the entire period have been calculated for the first time using methodology and default EFs from 2006 IPCC GL.

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 2016 version 4 report



Recalculations by gases

CO_2 recalculations were carried out in the following sectors:

- Public electricity and heat production (1.A.1.a);
- Iron and steel (1.A.2.a);
- Domestic Aviation (1.A.3.a);
- Railways (1.A.3.c);
- Domestic Navigation (1.A.3.d);
- Other transportation (1.A.3.e);

- Exploration oil (1.B.2.a.1);
- Production oil (1.B.2.a.2);
- Refining / Storage (1.B.2.a.6);
- Venting Gas (1.B.2.c.1.ii);
- Flaring Gas (1.B.2.c.2.ii);
- Other uses of Soda Ash (2.A.4.b);
- Ammonia Production (2.B.1);
- Aluminium Production (2.C.3);
- Solvent Use (2.D.3.a);

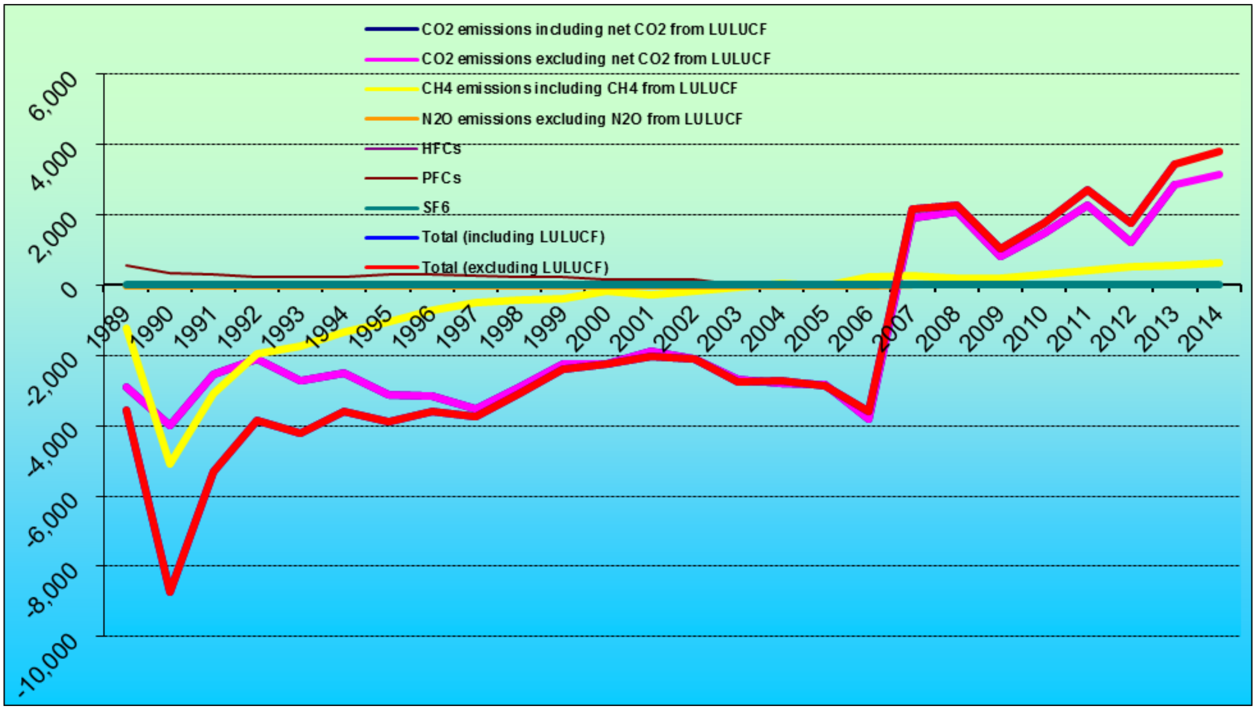
CH_4/N_2O recalculations were carried out in the following sectors:

- Exploration oil (1.B.2.a.1);
- Production oil (1.B.2.a.2);
- Flaring Gas (1.B.2.c.2.ii);
- N_2O from Product Uses - Medical Applications (2.G.3.a);
- N_2O from Product Uses - Other (2.G.3.b);
- Enteric fermentation (3A);
- Manure management CH_4 (3.B.1);
- Manure management N_2O (3.B.2);
- Managed soils - N_2O (3.D);
- Urea application (3.H);
- Solid Waste Disposal (5.A);

HFC/PFC/SF_6 recalculations were carried out in the following sectors:

- Refrigeration and Air-Conditioning - Domestic refrigeration (2.F.1.b)
- Refrigeration and Air-Conditioning - Industrial refrigeration (2.F.1.c);
- Aluminium Production (2.C.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 2016 version 4 submission



10.1.2 KP-LULUCF inventory

Recalculations by categories

No changes are caused in the current submission in activity data, for forest and forest management activity.

Emission and C stock change factors are not changed at all.

Recalculations by gases

Not applicable.

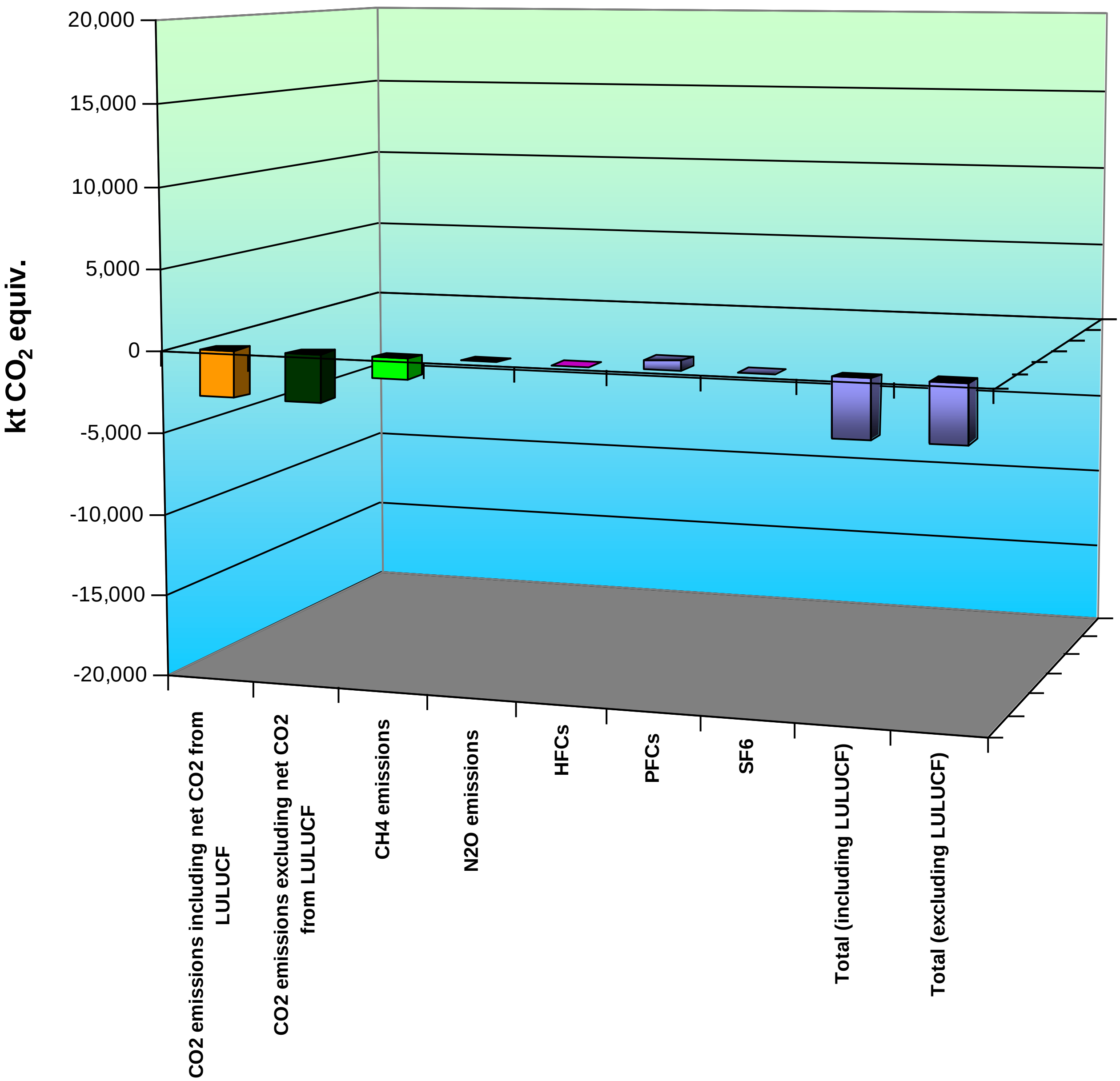
10.2 Implications for emissions levels, including on KP-LULUCF emissions levels

10.2.1 GHG inventory

Emissions changes due to recalculations, for 1989 are as follows:

- CO_2 including LULUCF (-1.49%), CO_2 excluding LULUCF (-1.36%);
- CH_4 including and excluding LULUCF (-1.72%);
- N_2O including and excluding LULUCF (-0.07%);
- HFC (0.00%);
- PFC (14.39%)
- SF_6 (0.00%);
- Total GHG including LULUCF (-1.23%);
- Total GHG excluding LULUCF (-1.17%).

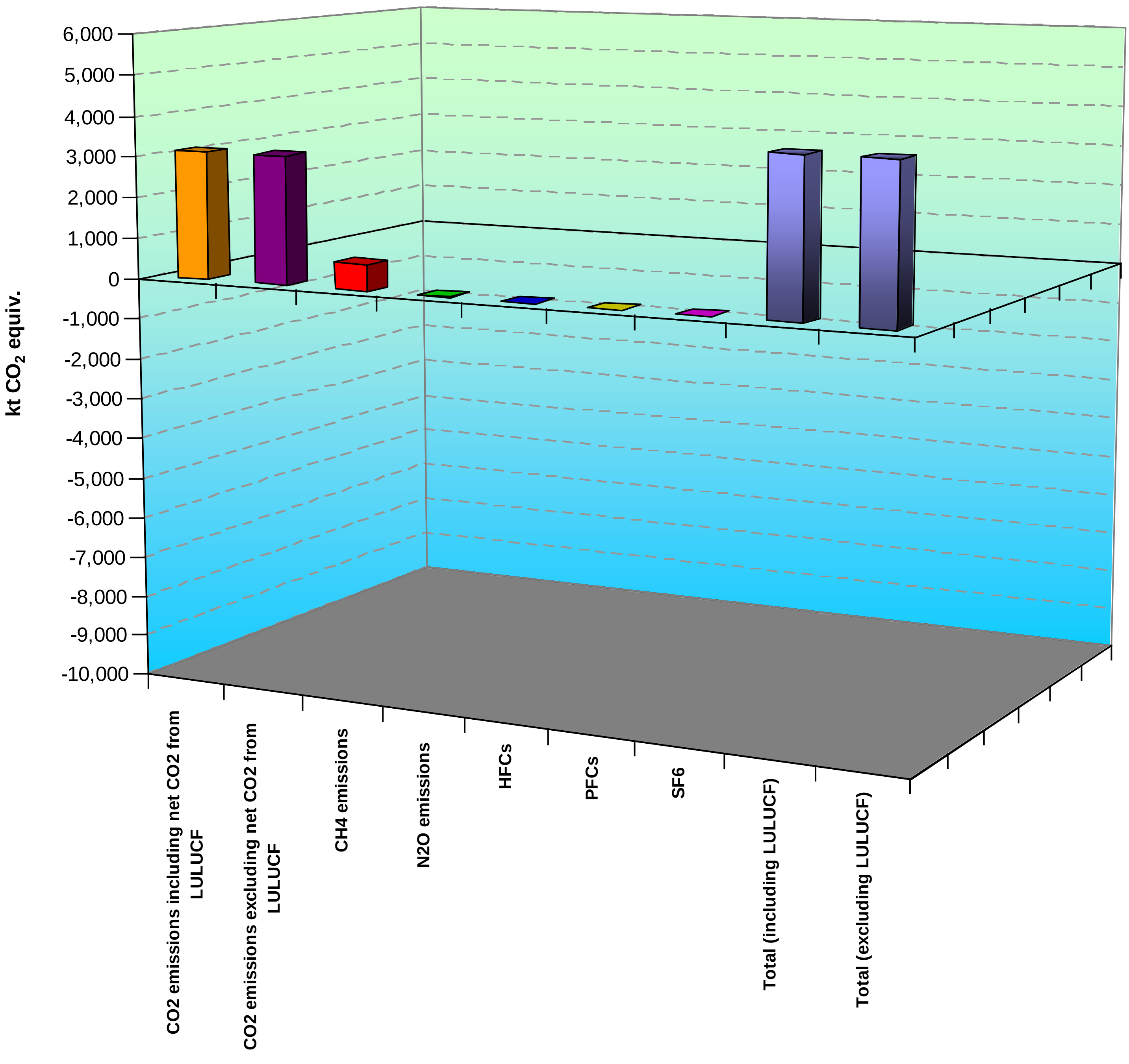
Figure 10.3 Effects of recalculations (presented in the 2017 submission) for 1989, by gas



Emissions changes due to recalculations, for 2014, are as follows:

- CO_2 including LULUCF (5.84%), CO_2 excluding LULUCF (4.25%);
- CH_4 including and excluding LULUCF (2.22%);
- N_2O including LULUCF (0.05%), N_2O excluding LULUCF (0.07%);
- HFC (-0.01%);
- PFC (0.00%);
- SF_6 (0.00%);
- Total GHG including LULUCF (4.07%);
- Total GHG excluding LULUCF (3.40%).

Figure 10.4 Effects of recalculations (presented in the 2017 submission) for 2014, by gas



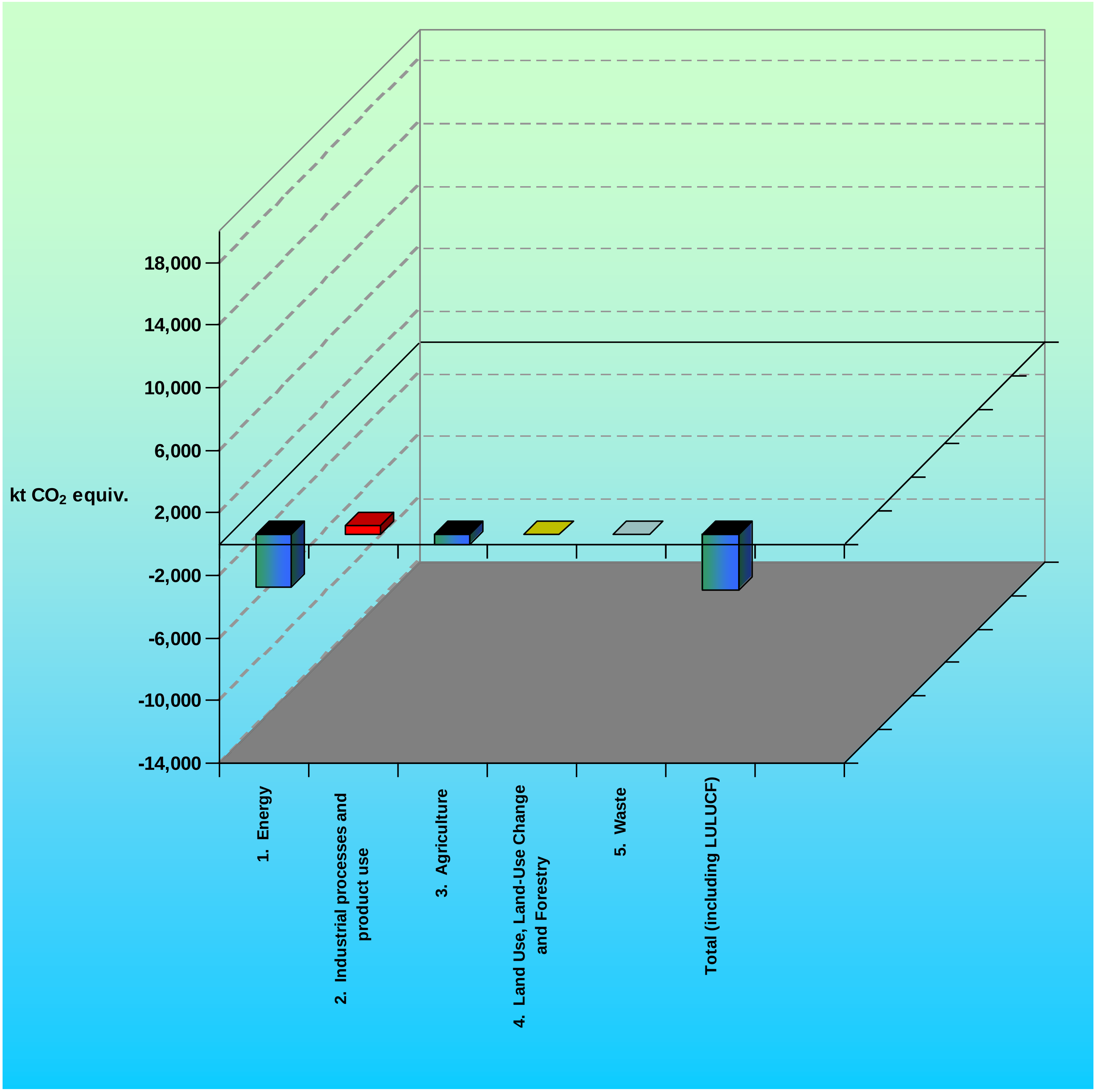
Impacts on 1989 emissions levels

Total emissions in 1989 including LULUCF have decreased by 1.23% compared to the 2016 version 4 submission.

Table 10.2 Recalculation of total emissions/removals, by sector, for all gases, for 1989

Differences for 1989 estimates	**Differences**		**2017 v. 1**	**2016 v. 4**
	kt CO_2 eq.	**%**	**kt CO_2 eq.**	**kt CO_2 eq.**
1. Energy	-3,381.65	-1.54	216,894.83	220,276.48
2. Industrial Processes and Product Use	522.47	1.27	41,819.65	41,297.18
3. Agriculture	-702.43	-1.84	37,508.85	38,211.29
4. Land Use, Land-Use Change and Forestry	0.00	0.00	-16,326.88	-16,326.88
5. Waste	0.04	0.00	5,135.66	5,135.62
Total (including LULUCF)	-3,561.57	-1.23	285,032.12	288,593.69

Figure 10.5 Changes of 1989 emissions/removals, in respect to the 2017 figures

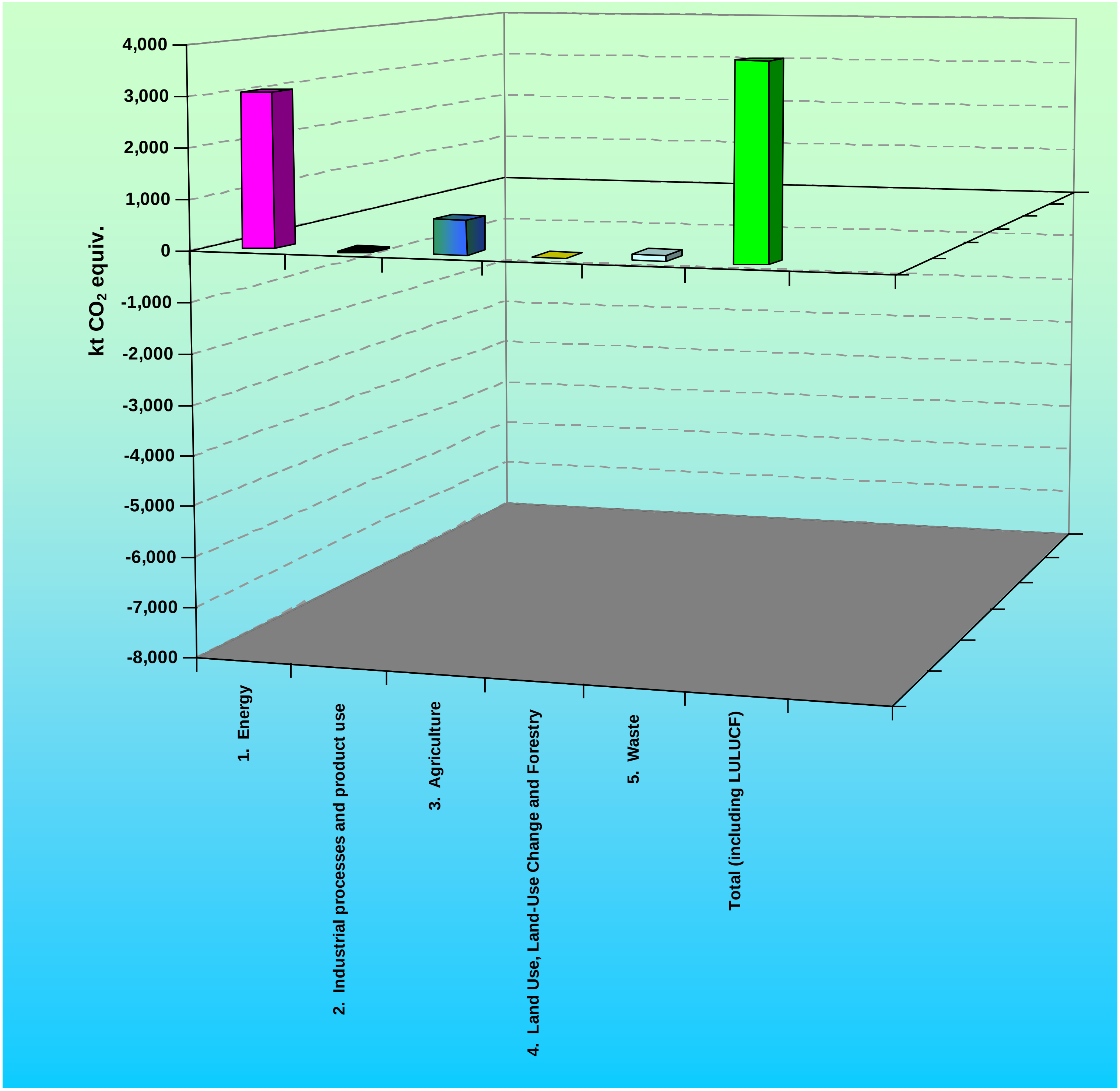


Total emissions in 2014, including LULUCF have increased with 4.07% compared to the 2016 submission Version 4.

Table 10.3 Recalculation of total emissions/removals, by sector, for all gases, for 2014

Differences for 2014 estimates	**Differences**		**2017 v.1**	**2016 v.4**
	kt CO_2 eq.	**%**	**kt CO_2 eq.**	**kt CO_2 eq.**
1. Energy	3,042.38	3.96	79,835.39	76,793.01
2. Industrial Processes and Product Use	-29.24	-0.25	11,522.48	11,551.72
3. Agriculture	667.78	3.81	18,190.23	17,522.45
4.Land Use, Land-Use Change and Forestry	0.00	0.00	-18,258.18	-18,258.18
5. Waste	119.46	2.08	5,865.10	5,745.63
Total (including LULUCF)	3,800.39	4.07	97,155.02	93,354.63

Figure 10.6 Changes of 2014 emissions/removals, in respect to the 2017 figures



10.2.2 KP-LULUCF inventory

No recalculations were implemented in respect to KP-LULUCF inventory.

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

No recalculations were implemented in respect to KP-LULUCF inventory.

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
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

No.	Category subject to improvement	Description of improvement
		fully correspondence concerning the definitions (fuel's calorific power) and quantities of the fuels, between the declarations of the operators under EU-ETS and, respectively, to NIS. A further analysis, in co-operation with the National Institute for Statistics, on the EU-ETS reporting will be conducted in order to take into consideration these emissions data, in the context of Tier 3 approach, on the activity category where these operators have to report. Annualy analysis on the EU-ETS reporting in comparison with Large Combustion Plants reporting, in order to check the concistency of the reported data, will be performed. For the current submission no necessary resources were available for these activities. ***Emission Factors:*** Following the same procedure used until now, based on EU-ETS operators reporting, the country-specific CO_2 emission factors will be calculated and included in the next inventory submission. In response of ERT recommendation, "Romania further investigate and elaborate on the non-energy use of fuels reported in the energy balance, which is not reported in the energy sector, and assess whether the country specific carbon storage factors are appropriate", Romania analysed the non-energy use of the fuels as activity data provided through

No.	Category subject to improvement	Description of improvement
		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.	Public Electricity And Heat Production (CRF 1.A.1.a)	It is planned 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. See the Chapter 3.2.4.6 for more details.
3.	Petroleum Refining (CRF 1.A.1.b)	It is planned 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. See the Chapter 3.2.4.6 for more details.
4.	Manufacture of Solid Fuels and Other Energy Industries (CRF 1.A.1.c.)	It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the chapter 3.2.4.6 for more details.
5.	Fuel combustion, Manufacturing Industries and Construction - Iron and Steel (CRF 1.A.2.a)	It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.
6.	Fuel combustion, Manufacturing Industries and Construction,	It is planned to take into consideration the emissions from the operators reporting on EU-ETS

No.	Category subject to improvement	Description of improvement
	Chemicals (CRF 1.A.2.c.)	(having their reports verified by accredited verifiers) in order to achieve a higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.
7.	Fuel combustion, Manufacturing Industries and Construction, Pulp, Paper and Print (CRF 1.A.2.d.)	It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.
8.	Fuel combustion, Manufacturing Industries and Construction, Food Processing, Beverages and Tobacco (CRF 1.A.2.e.)	It is planned 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. See the Chapter 3.2.4.6 for more details.
9.	Fuel combustion, Manufacturing Industries and Construction, Non-metallic minerals (CRF 1.A.2.g.)	It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the Chapter 3.2.4.6 for more details.
10.	Fuel combustion, Manufacturing Industries and Construction, Other (please specify) (CRF 1.A.2.f.)	It is planned 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 higher tier approach in the estimation of the CO_2 emissions. See the chapter 3.2.4.6 for more details.
11.	Transport- Civil aviation	Analysis will be continued with the collaborating

No.	Category subject to improvement	Description of improvement
	(CRF 1.A.3.a)	institutions in order to have a fully correspondence concerning the quantities of the fuels.
12.	Transport – Railways (CRF 1.A.3.c)	Analysis will be continued with the collaborating institutions in order to have a fully correspondence concerning the quantities of the fuels.
13.	Transport- Navigation (CRF 1.A.3.d)	Analysis will be continued with the collaborating institutions in order to have a fully correspondence concerning the quantities of the fuels.
14.	Transport - Other Transportation (CRF 1.A.3.e)	Analysis will be continued with the collaborating institutions in order to have a fully correspondence concerning the quantities of the fuels.
15.	Fuel combustion, Other Sectors – Commercial / Institutional (CRF 1.A.4.a)	See the chapter 3.2.4.6 for more details.
16.	Fuel combustion, Other Sectors – Residential (CRF 1.A.4.b)	See the chapter 3.2.4.6 for more details.
17.	Fuel combustion, Other Sectors – Agriculture / Forestry / Fisheries (CRF 1.A.4.c)	See the chapter 3.2.4.6 for more details.
18.	Fuel combustion, Other (Not specified elsewhere) – Stationary (CRF 1.A.5.a)	See the chapter 3.2.4.6 for more details.
Industrial Processes		
1.	All categories	Will need investment of resources to address changes to be compliant with IPCC 2006.
Agriculture		
1.	Source category Enteric Fermentation	Aiming to their incorporation into next inventory submissions, the development of national values for

No.	Category subject to improvement	Description of improvement
	(CRF source category 3.A)	the methane conversion rate (Y_m), for significant categories, is envisaged.
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); 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).
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.
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: 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.	Source category Field Burning of	Aiming to their incorporation into next inventory

No.	Category subject to improvement	Description of improvement
	Agricultural Residues (CRF source category 3.F)	submissions, the development of national values for activity data in totality, for to significant species, is envisaged.
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.
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.
Waste		
1.	Source category Solid Waste Disposal (CRF sector 5.A)	In order to improve the next submission, we will try to obtain more detailed data in respect to IPCC 2006.
LULUCF		
1.	Forest Land (CRF sector 4.A.)	There is an ongoing improvement on land use assessment system for all land categories and C stock change in biomass. The shift consists in the use of all relevant land spatial databases available in the country, as mentioned under chapter 1.3. Development of the entire time series since 1970 for land matrix is expected to finish in the next year submission, including quality assurance and quality control. The project is financed on annual basis by the Ministry of Environment, Forests and Waters and implemented by Forest Research Management and Planning Institute with various partners. Second, C stock change data is also under improvement. With the availability of data from second NFI cycle it is endeavoured a shift to stock

No.	Category subject to improvement	Description of improvement
		change method to estimate the change in living biomass. Although new annual increment data is available from NFI1, harvest data is still only available from the National Statistics (which seems much underestimated). For this reason current gain-loss method would be replaced by stock change entirely based on NFI data, likely starting next submission. New approach will also ensure implementation of all requirements from 2/CM7 (e.g. plantations replacing natural forests) and 2006 Guidelines (e.g. use of different biomass growth rates for forests naturally re-growing on abandoned lands and for forest plantations).
2.	Cropland (CRF sector 4.B.)	For the estimation of C stock changes in soils of land “remaining croplands” there is an improvement plan available, related to the development of national system to respond accounting requirements set in decision 529/2013/UE. According to this decision a reporting to European Commission on the national estimating system for cropland management and grazing land management is due annually for 2016-2018 while provide preliminary estimates before 2022 and final estimates with a deadline in 2022.
3.	Grassland (CRF sector 4.C.)	For the estimation of C stock changes in soils of land “remaining grasslands” there is an improvement plan available, related to the development of national system to respond

No.	Category subject to improvement	Description of improvement
		accounting requirements set in decision 529/2013UE. According to this decision a reporting to European Commission on the national estimating system for cropland management and grazing land management is due annually for 2016-2018 while provide preliminary estimates before 2022 and final estimates in the final deadline in 2022.
4.	Wetlands (CRF sector 4D)	Improvements cover preparation to shift to post-2014 reporting requirements spelled out in GL 2006 and previsions of Wetland supplement 2014.
5.	Settlements (CRF sector 4E)	Improvements under this land category are related to the targets assumed for the other land categories and expected under the same schedule. Reference C stock in the soils under settlements could be reanalyzed as well as the transition period to this category.
6.	Harvested Wood Products (HWP) (CRF sector 4G)	Current approach is to build capacity to cover HWP, to better understand the estimation methodologies and requirements, as well as available data.

The work of historical reconstruction of data is expected to be included in the next year submission, including QA/QC. QA/QC would be achieved by ancillary data (Landsat, various available GIS maps and field checks for share of deforested areas and conversions to forest, e.g. orchards and vineyards after incorporating LPIS data).

10.4.2 KP-LULUCF inventory

The planned improvements for KP-LULUCF Inventory activities are presented in table below:

Table 10.5 Summary of planned improvements KP-LULUCF Inventory activities

No.	Category subject to improvement	Description of improvement
KP - LULUCF		
1.	Forest Management	Recalculations only affect forest management estimates where area subject to forest management increased by 10% following rigorous implementation of forest definition by new land assessment method.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 Supplementary information *to be submitted for the first annual GHG inventory* according to decision 2/CMP8 (according to Table 2.4.1)

11.1 Information on methods and approaches to estimate emissions and removals

Identification of elected activities. Romania reports GHG emissions and CO_2 removals on afforestation/reforestation and deforestation (ARD), forest management (FM) and revegetation (Rv). The accounting will be done at the end of the commitment period (in the year 2022).

Forest management and *Re-vegetation* activities accounted in the first commitment period under the Kyoto Protocol continues to be accounted during the second commitment period. The land area reported and changes in land area subject to the various activities during 1990, 2013-2015 are reported in KP-LULUCF NIR-2 table.

How land activities are identified and tracked in time. Romania implements a spatially explicit statistical method for land classification and identification (Approach 3, Reporting Method 1) for area of forest management and deforestation, while for afforestation/reforestation and revegetation it implements forest authority historical records (Approach 3, Reporting method 2).

Romania does not apply CEFC provision and does not count removal of natural forests by plantations (an assessment of such need is underway based on latest NFI data).

11.2 Specific information for activities under Article 3, paragraphs 3 and 4

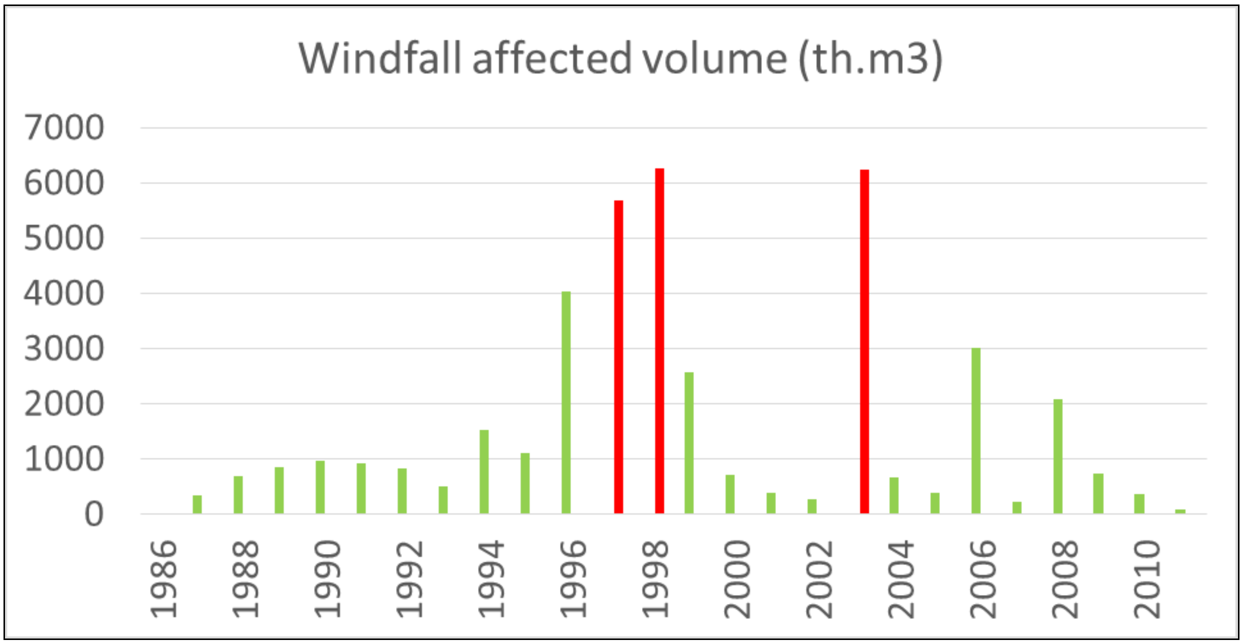
11.2.1 Definition of the forest and any other criteria

Area under forest management matches the area of forests, as defined by the forest parameters (canopy cover 10%, minimum area 0.25ha and tree height at maturity of 5m, as well as forest belts wider than 20 m).

11.2.2 Application of provision to exclude emissions from natural disturbance

Two types of disturbances are quantitatively relevant for forestland in Romania: wildfires and windfalls. Such events associated in the past with extreme intensity, e.g. over 1986-2010 there were 3 major windfalls (> 5.6mil.m3/year affected, which is more than 32% of total annual regular harvest).

Figure 11.1 Windfall blown down wood volume in Romania



For this reason Romania intends to apply the provisions to exclude emissions from natural disturbances for the accounting for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and for forest management under Article 3, paragraph 4, of the Kyoto Protocol, during the second commitment period. Assumption in the FMRL is that volume affected by disturbance was fully subject to salvage logging, an approach consistent between national GHG inventory and Forest Management (FM) activity estimates (i.e. fully included in the annual wood harvest reported by the National Statistics and included in the gain-loss). This assumption is now slightly revised, as resulted from a survey of professional foresters, in the sense that some 10 % of affected standing volume of large windfalls may not be actually harvested (e.g. left untouched in scattered forest small areas and because of inaccessibility). A windfall is assumed large when annual estimated affected volume was above 5 mil. m3 (see previous figure). This is also supported by low level of damage, according forestry statistics more than 90% of affected area is graded as slightly damaged (e.g. low volume on large areas), which makes economically unattractive harvesting. Conservatively, estimates are now established for the background level, although investigations on actual biomass left in forests continue and the assumption will be also incorporated into FMRL's technical correction.

Table 11.1 Background level values ($GgCO_2$/yr) for natural disturbances for FM and AR

Parameter	FM value	AR value
Background level	66	0.20
Margin	61	0.22
Background level plus margin	188	0.64
Background group for windstroms/ Background group for widlfires Years excluded (outliers)	1986-2009/ 1986-2009/ 1997, 1998, 2002	-/ 1990-2009/ 1990, 1992, 2000, 2002

Information how background level was estimated for Forest Management activity

GHG emissions from forest wildfire. Cumulative net emission from these sources is negligible, representing less than 1 % (~10GgCO_2eq/year, reported by national GHG inventory) of the annual net CO_2 removals. Associated GHG emissions are calculated using Equation 2.27 and default factors (combustion factor, emission factors for CH_4, N_2O) from IPCC 2006. Activity data is the annual area of the event (following annual survey and report by Forest Authority). Combustible amount is given by average DOM amount in Romanian (from NFI 2010). Calibration period covers 1986 - 2010. Forest area changes of +5% from 1970 to 2009 was taken into account 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 starting 1986 to 2010. Estimation of CO_2 emission associated to background level assumed:

a) from affected area/standing volume 90% is resinous species and 10% are broadleaved;
b) 10% of affected standing stock volume of large windfalls (max 1.7mil.m3 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) 90% rest of the affected volume is harvested. Traditionally, “salvage logging” from disturbance events receive highest priority to harvesting, which ensures rather constant harvest across time.
d) entire affected volume is transferred to DOM pool in the calendar year of the event;
e) decay of such additional DOM input occurs following decomposition function with half-time of 5 years. Thus, CO_2 emission associated to disturbance event occurs over following next 10 years, e.g. at the end of 10th year some 88% (or 91% in 12th year) of original biomass/carbon is lost and assumed emitted to atmosphere.

Information how background level was estimated for afforestation/reforestation activity

For afforestation/reforestation *forest fires* are only relevant. A background level was established assuming the same share of burnt area as AR to FM total area (i.e. 0,042%). Because of the size of trees in young plantations entire living biomass is assumed completely affected by fires, along with litter and dead wood pools (total of 12.4tC/ha, as estimated from an afforestation project monitored for emissions reduction transaction purpose).

Expectation of net credits or debits

In theory salvage logging always follow any disturbance in Romania, although there is some doubt that entire volume affected is actually collected especially after windfalls. Exclusion from accounting of disturbance related emissions will be first supported by an in-depth analysis of the actual rate of salvage logging. New NFI data would allow better sampling of windfalls events, and better data.

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) as well as any abandonment of forest area affected. In the FMRL, DOM and SOM changes were both assumed as “no change”, while also assumed that entire affected standing volume affected was subject to salvage logging (slightly revised now and subject to further checks).

Information how the margin is established, if needed

Frequency distributions for CO_2/CO_2eq emission estimates from disturbance events are not normal, which means a larger number of disturbances are classified as extreme when the normal distribution assumption is used (since it underestimates the 97.5% bound of the distribution). This is more relevant for AR where there is no baseline, and inclusion/exclusion of high emissions is sensitive to 97.5% value. In any case, distribution type is not relevant for FM when exclusion occurs for FMRL too. Margin value was nevertheless estimated as the value corresponding to 97.5% on normal distribution of area-specific emissions for each of FM and AR time series of emissions from disturbances (following KP supplement 2013 guidance).

11.2.3 Forest Management specific information

11.2.3.1 Forest Management specific information

Currently, Romania’s reference level relies on projection achieved by a collaboration with Joint Research Center of the European Commission. Forest Inventory 1985 and other forest statistics provided the historical activity data for the greenhouse gas inventory. Romania included in its submission the estimated age-class distribution as modelled by EFISCEN (European Forest Information Scenario Model, from the European Forest Institute) and assumed that wood resulted from disturbance is entirely subject to salvage logging. Under a ‘business as usual’ scenario, Romania anticipates a slow decrease in CO_2 removals from forest management for the period 2012–2020.

Forest Management Reference Level in the “Report of the technical assessment of the forest management reference level submission of Romania” submitted in 2011 (http://unfccc.int/resource/docs/2011/tar/rou01.pdf) is -15.444 Gg CO_2 equivalent (assuming instantaneous oxidation) and -15.793 Gg CO2 equivalent (applying first-order decay function for HWP).

It was recalculated in comparison to the “Submission of information on forest management reference levels by Romania” (http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_romania_2011.pdf).

A technical correction is necessary, in order to ensure methodological consistency and use of updated forestry data for the estimation of emissions and removals of forestland, for ensuring a consistent FMRL and for the estimation of FM accounting amount over the 2nd commitment period.

For accounting purpose a technical correction is needed to the reference level established by TAR. Correction is caused by the change of the methodological elements: new increment data from NFI, possible adjustment of historical harvest data based on NFI data, different age structure estimated by NFI than simulated by EFISCEN model (based on old national data) and inclusion of dead organic matter pool in order to account for emissions from natural disturbance over calibration period 1990-2009. It may include a change from projected to historical data based on NFI, with a change from current ‘gain-loss’ to ‘stock-change’ for annual estimation over the CP2. Technical correction is expected at the latest in the next year submission.

Currently a preliminary TC estimated by simple calibration of FMRL to average of sinks in 2013 and 2014 was used.

11.2.3.2 Harvested wood products in FMRL.

Emissions from harvested wood products originating from forests prior to the start of the second commitment period have been calculated in the FMRL using the stock change approach defined in IPCC 2006 (data used were associated with years starting with 1900).

11.2.4 Supplementary information to be reported in the annual GHG inventory according to decision 2/CMP8 ***(according to Table 2.4.1)***

11.3 Land-related information

Information on geographical location and identification of land. National boundary applies for all activities. Nevertheless, more explicit sub-national boundary can apply for AR and RV.

11.3.1 Spatial assessment unit For forest related activities the assessment unit is 0.25 ha

Afforestation and Reforestation

Artificial plantations of forest trees on lands which are expected to meet forest definitions thresholds are reported as AR. Currently, data provided by National Statistics is used, but the system improves to provide better data by statistical sampling associated to NFI combined with spatial information from afforestation projects (publically funded, in GIS). NFI implements field checks able to differentiate between natural expansion of forest vegetation and AR (e.g. presence of tree lines and soil disturbance) and remote sensing checks (re-assessments), also by their combination. Noteworthy, Romania implements an afforestation/reforestation JI under Kyoto protocol. The emissions reduction associated to this project are highlighted in the Table 4(KP-I)A1.1. in a separate line.

Forest management

Forest management applies to all forests in Romania, including forests under management plans, forest currently without management plans and forests under direct anthropogenic impact by wood harvesting. All forest are considered managed. All these types of activities on land are shown by NFI data.

Deforestation

The area of deforestation is derived from statistical sampling grid of NFI. According current preliminary assessment, annual area of deforestation between 1990 and 2005 is some 15 kha/year. This seems overestimated for which reason the time series would include additional assessments to be included in the following submission.

11.3.1.1 Methodology used to develop the land transition matrix

Methodology for the preparation of the land use change matrix is described in the LULUCF section 6.2 and 6.3. There were two matrices developed: one that starts in 1970, developed for the inventory purpose (which covers GHG inventory 1989-2015) and another one that starts in 1990 developed for the Kyoto Protocol reporting and accounting purpose. The two are fully consistent, the difference is that Convention's one implements 20 years transition period, and also by that some lands are associated to particular KP activity under KP matrix (i.e. lands under conversions to forestland which resulted from natural expansion of forest are reported under FM). Since 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, which includes the time series from 1970. The complete matrix used for estimation of emission/removals on KP eligible lands is available in NIR-2.

11.3.1.2 Maps and/or database to identify the geographical locations

Afforestation and reforestation (AR) - mapping and identification

The identification of land area eligible as AR activities could be done based on forest management plans and their forest maps (1/5000), in which these areas are included after the conversion to the forest fund. Thus, the explicit location and plantation/stand description is available for each such area. According to national forest code, the respective areas are included in the forest fund based on a set of legal documents, which allow funding of afforestation related work.

The land "entering into the forest fund" are registered in the management plan documentation and are 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 is measured and temporarily mapped, while it is fully included in the forest maps with next 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 far as the number (code) remains unchanged over the planning cycles. A piece of land "entering" the forest fund is subject of plantation and, if necessary, repeated gap filling according technical norms for afforestation. If still the area is not covered by forest it will be declared "non-productive land" and further reported in statistics as part of "other lands from the forest fund".

Deforestation (*D)* ***- mapping and identification***

Deforested lands are identified by statistical sampling method implemented with NFI grid.

*Revegetation (Rev****)*** *- mapping and identification.* Activity data on land areas eligible for the revegetation activities are provided by SILV 4, with possibility to make an explicit 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.

11.3.1.3 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.

Information on how lands subject to activities are identified. According to the Romanian legislation, **"afforestation/reforestation"** means "conversion of non-forest land through forest plantations", which implies direct anthropogenic intervention on land. These areas are annually reported in the statistical surveys SILV 4 – "Works of forest regeneration executed in the forest fund, on degraded lands and other lands from outside the forest fund".

Specifically the statistical reports are built based on forest management planning documentation, which allows any parcel to be tracked back in time and down to the land. This activity is reported under SILV-4's Chapter 1 "Regenerated areas on land categories", under the following indicators:

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 in Romania does not distinguish between afforestation (A) and reforestation activities (R) in the sense of the Marrakesh Accord, so they were treated similarly in the national GHG inventory and supplementary reporting. A/R works has been funded totally or partially from public funds, and it is considered directly human induced. This lands are included under 4.A.2 conversions to forest lands.

Once a piece of non-forest land starts the procedure of afforestation in an afforestation project, the work has to be started in maximum two years, according to the Forest Code. This rule has to be implemented by the forestland administrator and is checked by forest authority.

Natural expansion of forest vegetation on other lands is not considered direct human induced action, what explains less 4.A.2 area reported as AR. Further on, area of natural expansion of forest become automatically subject to management planning, for which reason these areas are included under FM area and not under AR, what explains larger area under FM than 4.A.1.

According to Romanian legislation the "**deforestation**" (D) is identified with the "definitive leave of a land from the national forest fund", which means permanent "change of the forest destination of a land to another destination by the law". For the purpose of the GHG inventory the new system implements more strict definition that any permanent change from forest to another land use is deforestation.

"**Forest management**" (FM) applies to all forests in the country, i.e. all forest are managed. The management of majority of the forests is regulated by forest management plans consistent with the environmental, economic and social objectives of the forests. Forest management activity is associated with the subcategory "Forest Land remaining Forest Land – 4.A.1", plus part of the areas reported under 4.A.2 Land converted to Forest land resulted as natural expansion of forest vegetation.

"**Revegetation**" is identified with areas created by planting of trees (thus directly human induced)**.** Such tree planting areas do not meet the forest definition parameters (at least one, usually minimum area). Re-vegetation is currently associated to tree planting reported in statistical report SILV 4, derived from following additional indicators:

i. plantations on excessively degraded lands outside the forest fund;
ii. plantations on degraded lands not included in the national forest fund;
iii. trees plantations including: tree lines (like along roads), belts for field protection (implemented according the Law 83/1993, Law 107/1999), green belts around urban and industrial platforms, anti-erosional plantations and land amelioration perimeters (implemented according 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".
Current submission is consistent with previous submission under first commitment period of the Kyoto Protocol, in the sense that emissions were not underestimated and sink was not overestimated. Improvement of land assessment system is underway.

11.3.1.4 Natural disturbances

No natural disturbances were recorded in 2013-2015.

11.3.1.5 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

The ranking of priority is given in this order: Deforestation – Afforestation – Revegetation - Forest management. Revegetation activity is associated strictly with non-forest lands categories, and do not interfere with any other activity under the Kyoto Protocol, under strict implementation of forest regime.

Revegetation can be easily identified through indicators outlined in 11.1 and is identified by project documentations and NFI based on these indicators (planted trees on line or grids).

11.3.2 Information on methods and approaches to estimate emissions and removals

Description of methodologies used methods used for calculating the reference level and the associated background level of emissions from natural disturbances. Implementation of 2006 Guidelines has affected insignificantly the estimates for KP activities. All emissions are estimated, none is considered as insignificant in the sense of para 37 of the Annex to decision 24/CP19.

11.3.2.1 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

DW in Afforestation/Reforestation and Revegetation is reported as NR (as not occurring or it is considered as a very small sink since initial mass is null, then it could only increase in time, or in any case it cannot decrease).

Afforestation/Reforestation- Litter and dead wood pools

Litter becomes a measurable pool in AR lands in some 4 years since planting (sampled data is available from Romanian JI and national FORLUC project mentioned under AFOLU sector chapter), thus C stock change is estimated and reported. Instead, DW cannot be defined as a standing alone pool, also recalling that dead wood is considered under same definition and dimensional thresholds as in NFI. Nevertheless, by the age of 20 years old of stands, the dead trees barely occur caused by natural mortality and especially by competition. This should lead to a continually increasing number of dead trees, thus expected that inputs are larger than decomposition. With such argumentation, we can safely and conservatively assume that DW is not a net source of emissions on AR lands.

Forest Management – C stock changes in organic matter pool of mineral soils

Quantitative and qualitative arguments are involved to demonstrate that SOC, DW and LT are not sources of emissions over CP, as follows:

Quantitative data

As explained in the chapter 6.4.2.1, the arguments are each based on own source and methodological approach, independent by each other, showing that mineral soil carbon pool most likely behave as an extremely small sink or rather as a neutral, in which case "not a source" applies (key category NR is reported in NIR-2 and NE in sectoral table 4.A.1 Cropland remaining Cropland).

Recent improvement with regard to reporting CSC in **forest mineral soils** consisted in prioritizing quantitative assessments of several existing datasets, focusing on two approaches:

i. *First approach.* Simulation by CBM-CFS of C stocks in mineral soils with data from IFN 1984 and NFI 2010. Validation exercise involve the actual NFI data of C stocks in available pools (dead wood and organic matter in mineral soils). Validation of simulations outputs is done with data from soil database of the forest management plans (FMP) combined with the 2010 NFI soil data.

ii. *Second approach* consisted in 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 in accordance with 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) associated reporting of 2014", funded by the Ministry of Environment and Climate Change). It contains soil analysis to forest management plans since 1970 on. Datasets include humus (%, relative humus content for 30 cm depth), among many other soils chemical parameters, as well as site and stand descriptors. Limitation could come from the particularity of sampling points which were randomly and non-repetitively located. In Romanian forest management planning system, the country national forest fund was several times completely "screened" every 10 years since 1960, so a time series is available. Nevertheless, soil analysis data was retrieved for a number of 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 altitudinal gradient. Data was processed on strata fully 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 first measurement (TSFM, 22 years over 1979-2011 with few gaps) and 2 soils horizons (A horizon of 0-20 and B of 20-30 cm depth).

- Simple linear regressions of humus content (%) vs. TSFM shows a very small positive slope (e.g. almost horizontal), which can be interpreted as this pool most likely behaves as sink or source in time.
- Multiple analysis of variance of humus content (%) against all independent variables counted above also shown non-significant differences for humus content.

All these arguments support a not changing soil C pool, thus reported in CRF files as NO.

Qualitative information

This quantitative information to demonstrate that at national level mineral soils are not a source is further supported by a number of additional arguments of ecological reasoning nature:

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 standing stock and likely of the lying dead wood under natural competition;

b) very low rate of forest cover change as impact of forest management, i.e. annual clear cut area is reported by National Statistics 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 results that only half of the annual harvest results from clear cut, while rest from other less intensive forest operations (thinning, extensive regenerations cuts).

c) negligible area of fire and non-fire disturbances over 1990-2015.

Forest management - Dead wood and Litter pools

There is no historical quantitative data on dead organic matter pool in Romanian forests, except time-point estimates from 1st NFI (mid-year 2010). In order to derive time series for 1990-2015, C stock change from dead wood pool is simulated with a model based on the forest inventory data. Pools were finally validated against sampled NFI data and further judgement was made if changes in this pool are significant or negligible over CP. For such simulation, Forest Research and Management Institute Bucharest (FRMI) has retrieved entire database of the inventory of forest fund 1984 (e.g. standing volume, annual growth, species composition and age structure) at most disaggregate level available (namely 400 forest districts covering entire country), and ran CBM-CFS3 (Carbon Budget Model of the Canadian Forest Sector) developed by Werner A. Kurz and CFS Carbon Accounting Team of Natural Resources Canada, Canadian Forest Service, Victoria, BC). This work is ongoing, as long as the NFI final results were released and 2nd NFI cycle started.

Similar approach applied to Litter pool, modeled data is validated against sampled data from 1st NFI and further judgment was made if changes in this pool are significant or negligible over CP.

CBM outputs as well as additional ecological reasoning based information from points (a) to (c) under mineral soils item prove DW and LT are not net sources of emissions under Forest management lands. CBM and Yasso07 runs were achieved and under ongoing improvements in order to support better the reporting (i.e. models parameterization of soils pools is difficult under missing national data).

11.3.2.2 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Available activity data and methodologies did not allow the exclusions of indirect and natural GHG emissions from the present estimation of anthropogenic GHG emissions for the relevant activities.

11.3.2.3 Changes in data and methods since the previous submission (recalculations)

No recalculations were implemented in the current submission.

11.3.2.3.1 Information that demonstrates methodological consistency between the reference level and reporting for forest management

In order to avoid expectance of net debits and credits, during the second commitment period, the consistency of parameters used for FMRL and estimates over the CP2 has to be ensured for, i.e. area accounted for, the treatment of harvested wood products, and the accounting of any emissions from natural disturbances.

11.3.2.3.2 Technical corrections

A technical correction is planned in the light of new data available from NFI (for 2008-on).

11.4 Activity-specific information

11.4.1 Methods for carbon stock change and GHG emission and removal estimates

11.4.1.1 Description of the methodologies and the underlying assumptions used

Afforestation/reforestation

Net changes in C stocks in aboveground and belowground biomass, and for the litter and soil organic matter pools during each year of the annual commitment period are estimated and reported for accounting purposes under Tier 2.

DW is reported as NR (not reported) as such pool does not occur in young plantations (less than 20 years old), while in any case initial stock is zero. Further on based on measurement in the JI project and reasoning based on ecosystem functioning it could only occur an increase of C stock in this pool.

Estimation methodology and data used are thoroughly described under chapter 4, section 4A2 - Land converted to Forest Land (item B. Artificial plantations). Currently there are no areas of afforestation which have been subject to harvest (mainly because large planting schemes and slow growing long cycles planted species). The AR is a key category under KP.

Deforestation

Emissions are calculated using Tier 2 methods and input data as described under the chapter 6.8.1.1. All carbon pools are reported and D is not a key activity under KP.

Forest management

FM area is consistent with forest area reported under 4A1 – Forest Land remaining Forest Land, plus the conversions to forests resulted by natural expansion of forest vegetation (excluding artificial plantations from 4A2 which are reported as AR).
Emissions/removals from FM activity have been calculated, using the same assumptions, formulas and parameters as used for the estimation of the GHG inventory (see section 6.4.2. of the NIR). C pools reported are aboveground and belowground biomass. Change in soil organic matter, dead wood and litter are reported under Ch.6. FM is a key category.

Revegetation

Net estimate for the base year 1989 took into consideration all areas subject to revegetation established since 1970. Net estimate for the commitment period years takes into consideration all revegetated areas existing in the years of CP. This approach is consistent with 2014 KP supplement (IPCC, 2014).
Actual revegetation data is drawn from statistics back till 1974, while for 1970-1974 data is linearly extrapolated. For GHG inventory purpose, this activity is entirely included with 4B1 Cropland where such emissions are reported in the national GHG inventory (following current NFI assessment this assumption, first by splitting this area between croplands and grasslands).

This activity is subject of “net-net accounting” (i.e. the difference between the annual sinks in 1989 and 2015 on land which is subject to revegetation in each year).

C pools are estimated exactly as in the case of 4A2 land converted to forestland (artificial plantations) under 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 cycles of about 25 years, thus it is estimated that after the first cycle of 25 years the biomass growth follows same pattern as in the initial plantation, while all other pools are assumed as not changing (following reasoning under Tier 1 of IPCC as supported by data shown under AR). These assumptions consisted in nil change for C stock change in SOC and LT for revegetation land after 25 years since the establishment. DW change was always assumed as nil. Revegetation is not a key activity under KP, but in any case a Tier 2 estimate is achievable under the type of data available for the estimation.

11.4.1.2 Uncertainty estimates

New sound estimates ware under development since new sampling based activity data estimates are under preparation.

As highlighted in the section 6.4.3, the uncertainty reported under 4.A.2 Land converted to Forest Land was estimated for the artificial plantations aged less than 10 years on some 6 kha included under the JI project. The uncertainty of the cumulated C stock was ± 9% (for 95% confidence interval). The area the uncertainty was less than 1%.

11.4.1.3 Information on other methodological issues

Similar methodological approaches were implemented under the convention and KP reporting. Estimation of GHG emissions from sources is consistent with data and methods used in the convention estimation are described under section 6 of the NIR.

11.4.1.4 The year of the onset of an activity, if after 2008

Data on the year of onset of activity is reflected in the time series used to derive the activity data. Under current method, which determines the land use change periodically, interpolation is used between successive moments in time.

11.5 Article 3.3

11.5.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

Afforested areas are reported by the national statistics (SILV 4) in the year when the planting work starts, which may be later than the year when land entered into the forest fund, so true year of planting activity is reported (actually with soil preparation).
In any case, reporting of all AR and D related indicators is annual, which ensures the capture of the initiation of any activity. Afforestation could only occur on non-forest land, which is observed by the approval of documentation for funding. Otherwise it is “reforestation after wood harvesting” under national forestry regime (and included under forest management). According to current sampling based land assessment system D was forest at 1 January 1990 and it is not forest anymore in 2015. Tree plantations under Revegetation is identified exactly under same manner as AR, reported under different headings of statistical report SILV 4.

11.5.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

The forest disturbance alone cannot trigger land conversions from forestland, i.e. land is subject to further forest management. Thus 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 legal obligation for the forest owner/administrator to maintain the land under forests category and forestry regime (including tree harvest based on permit), to apply the forest management plans specifications and regenerate it within a given timeframe (maximum 2 years); 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.

11.5.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

A basic requirement of the forest regime is that an area has to be afforested in maximum 2 years, without reference to a minim area. In practice, such lands can regenerate either by plantations (usually followed by state forests) or by assisted natural regeneration (in private forests), or by mixed ways. Its implementation is observed by public authority responsible for forestry. These areas cannot be confounded with deforested areas as far as they are subject to continuous planning and management (i.e. planting/ gap filling, maintenance, etc).

11.6 Article 3.4

11.6.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Confirmation that the FM activity is human induced and occurred since 1990 is given by the fact that 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 in any case. Revegetation activity occurs on non-forest lands. They result by tree planting (also publically funded at the time of their establishment since 1970 on).

11.6.2 Information relating to Revegetation

This activity has no direct equivalent in Romanian forestry or land management system, but correspondences with plantation of trees on non-forest lands and can be associated with forest belts. Its election for KP compliance was due under the initiative to develop a national forest belt system, initially thought flexible in terms of meeting forest definition thresholds, legal classification of the land, ownership, management obligations and administration patterns (which actually did not start yet).

Activity data is available either as 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 SILV 4, their management is in the competence of the land owners of the agricultural land or companies that own/administrate infrastructure (e.g., railways, roads, etc.), and thus there is no guarantee that area initially planted is maintained but the acknowledged practice is that trees are always replanted (so this is the scenario we assume in GHG estimations).

11.6.3 Information relating to Forest Management

Forest management activity refers to forest for which a management plan has been set up (some 90% of forests) while rest are subject to wood harvesting permission. First category are managed according to management plans, they are continuously surveyed for disturbances; forest operations and harvesting are subject to 10 years cycle planning; forest regeneration is closely and intensively assisted. Such lands are mapped, landmarked and annually up-dated in statistics. The forestry regime relies primarily on the forest law, then in subsequent legislation and technical norms, in order to ensure sustainable forests management at national scale.

11.7 Other information

11.7.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

In the national GHG inventory, the Tier 1 analysis (Level Assessment, including LULUCF), showed that the CO_2 removals from the category 4.A.1 Forest Land remaining Forest Land is a key category.

Country specific data is used for this category, noting that reporting some C pools are still achieved according to Tier 1. Significant change regarding the two related estimates ("Forest Land remaining Forest Land" under the Convention tables and "Forest Management" activity under the KP) are not expected for the following years.

11.8 Information relating to Article 6

Romania is implementing an AR activity project as Joint Implementation flexible mechanism under Article 3.3 of the Kyoto Protocol. The project lasts from 2002 to 2017. The transaction of the emission reductions 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 partners agreed monitoring plan, while emission reduction/removals amount is subject to an independent verification. First verification was performed in 2007 and second one in 2014 (overlapping on pre-CP1 and CP1 (under JI Track II scheme). The estimates are calculated for the commitment period and reported in CRF, as a separate division under Table 4(KP-I) A1.1. This approach is consistent with KP supplement 2014). CO_2 removals from the JI project activities will be further allocated to third parties (project partners) following internationally agreed procedures. Project methodology provides net removals and associated non-CO_2 emissions in pre-2008, 2008-2012 and 2014-2017. Meanwhile activity data is reported according to the annual afforestation area in the project.

Amount of tradable emission reduction associated with the project is determined for three consecutive stages:

- for the pre-commitment period (until the end of 2007) for which there is already an independent verification report available. The net removals reported for the period 1 January 2002 to 31 December 2007 are 10767 $MgCO_2eq$ on a total area of 6.033 kha on which plantations have started in 2002 and are under various stages of development Uncertainty of the net removals estimate was ±14%;
- net removals for the Kyoto I commitment period (2008-2014) coinciding with the 2nd project verification period is also available, as follows:
  - Claimed verified amount for 2nd verification was 229641 tCO_2 with an uncertainty of ±8.5%. Largest contribution is given by removals of living biomass, DOM and SOM pools of 240361 $MgCO_2$;
  - 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 consumptions 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 2016 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 31.12.2016 as well as information on transfers of the units in 2016 to and from other Parties of the Kyoto Protocol (Table 12.1). Neither AAUs, nor RMUs have been issued in the Romanian Registry in 2016.

Table 12.1 Information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Romanian registry at 31.12.2016

Annual Submission Item	Reporting
15/CMP.1 annex I.E paragraph 11: Standard Electronic Format (SEF)	**12.2**. The Standard Electronic Format report for 2016 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 2015
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2015
15/CMP.1 annex I.E paragraph 15: List of non-replacement	No non-replacement occurred in 2015

Annual Submission Item	Reporting
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2015
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
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 website: http://rnges.anpm.ro/
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 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.

[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).

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 2017 submission as the most recently reviewed inventory, multiplied by 8 results in:

116,426,728 * 8 = 931,413,822 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 2016 NGHGI are presented in Annex 6.8.

Changes implemented after submitting the 2016 NGHGI

No changes occurred after submitting the 2016 NGHGI.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Romania have therefore occurred in 2016.

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	Starting with 25.04.2016, Mr. Alin Daniel Serban is a new member of the RO Registry team and Mrs. Adriana CRISTEA come back from maternity leave starting with 25 July 2016.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There was no change to the database structure as it pertains to KP functionality in 2015. Versions of the CSEUR released after 6.3.3.2 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex 6.2.2. No change to the capacity of the national registry occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.3.3.2 of the national registry are listed in Annex 6.2.3. 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 were successfully carried out prior to the relevant major release of the version to Production (see Annex 6.2.3). Annex 6.2.4 testing was carried out in February 2016 and the test report is attached. No other change in the registry's conformance to the technical standards occurred for the reported period.
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 change of security measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	The list was updated with the following public information: - Legal context; - International legislation; - National legislation; - List of RENAR verifiers accredited; - List of verified emission on the 2008-2015 years; - Contact list; - List of account holders; - List of JI projects; - NER allocation; - Assign amount for CP2; - Reserve Commitment Period for CP2;

Reporting Item	Description
	- Fees for opening and administration account in the registry.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	http://rnges.anpm.ro/
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.3.3.2 of the national registry are listed in Annex 6.2.3. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex 6.2.3. Annex 6.2.4 testing was carried out in February 2016 and the test report is attached.

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 Moldavia 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 Moldavia.

16 OTHER INFORMATION

There is no other relevant information which needs to be reported.

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