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**National Environmental Protection Agency**

**Romania's Greenhouse Gas Inventory  
1989-2016**

**National Inventory Report**

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## Authors

**General responsibility:** Sorin Deaconu

### **Sectorial responsibility:**

- ✚ Executive Summary, Introduction: Sorin Deaconu;
- ✚ Trends in greenhouse gas emissions: Adarciza Brulea et al.;
- ✚ Energy: Maria-Letiția Stanciu, Pompilia State, Sorin Deaconu;
- ✚ Industrial Processes and Product Use: Adarciza Brulea;
- ✚ Agriculture: Luminița Olteanu;
- ✚ Land Use, Land-Use Change and Forestry: Brîndușa Paciurea;
- ✚ Waste: Oana Bădele;
- ✚ Recalculations and improvements: Adarciza Brulea et al.
- ✚ KP-LULUCF: Brîndușa Paciurea;
- ✚ Information on accounting of Kyoto units: Cătălin Dulgheru, Sorin Deaconu;
- ✚ Information on changes in national system: Sorin Deaconu;
- ✚ Information on changes in national registry: Cătălin Dulgheru;
- ✚ Information on minimization of adverse impacts in accordance with Article 3, paragraph 14: Sorin Deaconu;
- ✚ Annex 1: Sorin Deaconu;
- ✚ Annex 2: Oana Bădele, Sorin Deaconu et al.;
- ✚ Annex 3: Maria-Letiția Stanciu, Pompilia State, Sorin Deaconu, Adarciza Brulea, Luminița Olteanu;
- ✚ Annex 4: Maria-Letiția Stanciu, Pompilia State, Sorin Deaconu;
- ✚ Annex 5: Sorin Deaconu;

✚ Annexes 6: Maria-Letiția Stanciu, Pompilia State, Sorin Deaconu, Adarciza Brulea, Luminița Olteanu, Brîndușa Paciurea, Oana Bădele, Cătălin Dulgheru (Annexes 6.2, Annex 6.10).

<b>Authors .....</b>	<b>2</b>
<b>LIST OF ANNEXES.....</b>	<b>18</b>
<b>LIST OF FIGURES .....</b>	<b>21</b>
<b>LIST OF TABLES .....</b>	<b>28</b>
<b>LIST OF EQUATIONS .....</b>	<b>38</b>
<b>LIST OF ABBREVIATIONS .....</b>	<b>39</b>
<b>ES EXECUTIVE SUMMARY .....</b>	<b>46</b>
<b>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.....</b>	<b>46</b>
ES.1.1 Background information on climate change .....	46
ES.1.2 Background information on greenhouse gas inventories .....	46
ES.1.3 Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol.....	47
<b>ES.2 Summary of national emission and removal-related trends and emission and removals from KP-LULUCF activities.....</b>	<b>47</b>
ES.2.1 GHG inventory.....	47
ES.2.2 KP-LULUCF activities .....	49
<b>ES.3 Overview of source and sink category emissions estimates and trends, including KP-LULUCF activities .....</b>	<b>49</b>
ES.3.1 GHG inventory.....	49
ES.3.2 KP LULUCF activities.....	50
<b>ES.4 Other information .....</b>	<b>50</b>
<b>PART 1 ANNUAL INVENTORY SUBMISSION .....</b>	<b>51</b>
<b>1 INTRODUCTION .....</b>	<b>51</b>
<b>1.1 Background information on GHG inventories and climate change and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol .....</b>	<b>51</b>
1.1.1 Background information on climate change .....	51
1.1.2 Background information on greenhouse gas inventories .....	53
1.1.3 Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol.....	55



<b>1.2 A description of the national inventory arrangements and national system .....</b>	<b>55</b>
1.2.1 Institutional, legal and procedural arrangements and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol.....	55
1.2.2 Overview of inventory planning, preparation and management including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol.....	88
1.2.3 Quality assurance, quality control and verification plan on GHG inventory and KP-LULUCF inventory.....	91
1.2.4 Changes in the national inventory arrangements and national system since previous annual GHG inventory submission.....	105
<b>1.3 Inventory preparation, and data collection, processing and storage.....</b>	<b>105</b>
1.3.1 GHG inventory and KP-LULUCF inventory.....	105
1.3.2 Data collection, processing and storage, including for KP-LULUCF inventory.....	106
<b>1.4 Brief general description of methodologies and data sources used .....</b>	<b>113</b>
1.4.1 GHG inventory.....	113
1.4.2 KP-LULUCF activities .....	118
<b>1.5 Brief description of key categories, including KP-LULUCF key categories .....</b>	<b>118</b>
1.5.1 GHG inventory.....	118
1.5.2 KP-LULUCF activities .....	119
<b>1.6 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals.....</b>	<b>119</b>
1.6.1 GHG inventory.....	119
1.6.2 KP-LULUCF inventory .....	121
<b>1.7 General assessment of the completeness.....</b>	<b>121</b>
1.7.1 GHG inventory.....	121
1.7.2 KP-LULUCF.....	122
<b>2 TRENDS IN GREENHOUSE GAS EMISSIONS .....</b>	<b>123</b>
<b>2.1 Description and interpretation of emissions trends for aggregated GHG emissions .....</b>	<b>123</b>
2.1.1 Description and interpretation of emissions trends by gas.....	124
2.1.2 Description and interpretation of emissions trends for indirect greenhouse gases and SO <sub>2</sub> .....	126

<b>2.2 Description and interpretation of emissions trends by sector .....</b>	<b>127</b>
2.2.1 Description and interpretation of emissions trends for KP-LULUCF inventory in aggregate and by activity, and by gas .....	129
<b>3 ENERGY (CRF Sector 1) .....</b>	<b>130</b>
<b>3.1 Overview of the sector .....</b>	<b>130</b>
3.1.1 Key sources .....	136
<b>3.2 Fuel combustion (CRF 1.A) .....</b>	<b>138</b>
3.2.1 Comparison of the sectorial approach with the reference approach .....	138
3.2.2 International Bunkers fuels(CRF 1.D.1) .....	145
3.2.3 Feedstocks and non-energy use of fuels.....	148
3.2.4 Fuel combustion (CRF 1.A.).....	152
3.2.5 Fuel combustion, Energy Industry (CRF 1.A.1.).....	184
3.2.6 Fuel combustion, Manufacturing Industries and Construction (CRF 1.A.2.).....	194
3.2.7 Transport (CRF 1.A.3.) .....	208
3.2.8 Fuel combustion, Other Sectors (CRF 1.A.4.) .....	246
3.2.9 Fuel combustion, Other Sectors (Not specified elsewhere) - Stationary (CRF 1.A.5.a) .....	255
<b>3.3 Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production (CRF 1.B).....</b>	<b>257</b>
3.3.1 Solid Fuels (CRF 1.B.1).....	261
3.3.2 Oil and natural gas and other emissions from energy production(CRF 1.B.2).....	272
<b>3.4 CO<sub>2</sub> transport and storage (CRF 1.C) .....</b>	<b>297</b>
<b>4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF Sector 2) .....</b>	<b>298</b>
<b>4.1 Overview of sector .....</b>	<b>298</b>
<b>4.2 Mineral Industry (CRF 2.A).....</b>	<b>306</b>
4.2.1 Category description .....	306
4.2.2 Methodological issues .....	308
4.2.3 Uncertainties and time series consistency.....	328
4.2.4 Category-specific QA/QC and verification, if applicable.....	330
4.2.5 Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend.....	331

4.2.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	333
<b>4.3 Chemical Industry (CRF 2.B) .....</b>	<b>333</b>
4.3.1 Category description .....	333
4.3.2 Methodological issues .....	335
4.3.3 Uncertainties and time series consistency .....	353
4.3.4 Category-specific QA/QC and verification, if applicable .....	358
4.3.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend .....	359
4.3.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	361
<b>4.4 Metal Industry (CRF 2.C) .....</b>	<b>361</b>
4.4.1 Category description .....	361
4.4.2 Methodological issues .....	364
4.4.3 Uncertainties and time series consistency .....	386
4.4.4 Category-specific QA/QC and verification, if applicable .....	389
4.4.5 Category-specific recalculation, including changes made in response to the review process and impact on emission trend .....	390
4.4.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	390
<b>4.5 Non-energy products from fuels and solvent use (CRF 2.D) .....</b>	<b>390</b>
4.5.1 Category description .....	390
4.5.2 Methodological issues .....	392
4.5.3 Uncertainties and time series consistency .....	397
4.5.4 Category-specific QA/QC and verification, if applicable .....	399
4.5.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend .....	400
4.5.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	402
<b>4.6 Electronics Industry (CRF 2.E) .....</b>	<b>402</b>
4.6.1 Category description .....	402

4.6.2	Methodological issues .....	402
4.6.3	Uncertainties and time series consistency .....	404
4.6.4	Category-specific QA/QC and verification, if applicable.....	404
4.6.5	Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.....	405
4.6.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	405
<b>4.7</b>	<b>Product uses as substitutes for ODS (CRF 2.F).....</b>	<b>405</b>
4.7.1	Category description .....	405
4.7.2	Methodological issues .....	408
4.7.3	Uncertainties and time series consistency .....	448
4.7.4	Category-specific QA/QC and verification, if applicable.....	452
4.7.5	Category-specific recalculation, including changes made in response to the review process and impact on emission trend .....	453
4.7.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	454
<b>4.8</b>	<b>Other product manufacture and use (CRF 2.G) .....</b>	<b>454</b>
4.8.1	Category description .....	454
4.8.2	Methodological issues .....	455
4.8.3	Uncertainties and time series consistency .....	460
4.8.4	Category-specific QA/QC and verification, if applicable.....	461
4.8.5	Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.....	461
4.8.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	463
<b>5</b>	<b>AGRICULTURE (CRF Sector 3) .....</b>	<b>464</b>
<b>5.1</b>	<b>Overview of sector .....</b>	<b>464</b>
<b>5.2</b>	<b>Enteric Fermentation (CRF 3.A) .....</b>	<b>475</b>
5.2.1	Category description .....	475
5.2.2	Methodological issues .....	478
5.2.3	Uncertainties and time-series consistency .....	496

5.2.4	Category-specific QA/QC and verification, if applicable.....	496
5.2.5	Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.....	497
5.2.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	497
<b>5.3</b>	<b>Manure Management (CRF 3.B) .....</b>	<b>497</b>
5.3.1	Category description .....	497
5.3.2	Methodological issues.....	505
5.3.3	Uncertainties and time-series consistency .....	518
5.3.4	Category-specific QA/QC and verification, if applicable.....	519
5.3.5	Category-specific recalculations, including changes made in response to the review process and impact on emission trend .....	520
5.3.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	520
<b>5.4</b>	<b>Rice Cultivation (CRF 3.C) .....</b>	<b>521</b>
5.4.1	Category description .....	521
5.4.2	Methodological issues.....	522
5.4.3	Uncertainties and time-series consistency .....	525
5.4.4	Category-specific QA/QC and verification, if applicable.....	525
5.4.5	Category-specific recalculations, including changes made in response to the review process and impact on emission trend .....	526
5.4.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	526
<b>5.5</b>	<b>Managed soils (CRF 3.D).....</b>	<b>526</b>
5.5.1	Category description .....	526
5.5.2	Methodological issues.....	533
5.5.3	Uncertainties and time-series consistency .....	552
5.5.4	Category-specific QA/QC and verification, if applicable.....	553
5.5.5	Category-specific recalculations, including changes made in response to the review process and impact on emission trend .....	553
5.5.6	Category-specific planned improvements, if applicable, including tracking of those	

identified in the review process .....	553
<b>5.6 Prescribed Burning of Savannas (CRF 3.E) .....</b>	<b>554</b>
<b>5.7 Field Burning of Agricultural Residues (CRF 3.F) .....</b>	<b>554</b>
5.7.1 Category description .....	554
5.7.2 Methodological issues .....	556
5.7.3 Uncertainties and time-series consistency .....	556
5.7.4 Category-specific QA/QC and verification, if applicable .....	557
5.7.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend .....	558
5.7.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	558
<b>5.8 Liming (CRF 3G).....</b>	<b>558</b>
5.8.1 Category description .....	558
5.8.2 Methodological issues .....	559
5.8.3 Uncertainties and time-series consistency .....	560
5.8.4 Category-specific QA/QC and verification, if applicable .....	560
5.8.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend .....	560
5.8.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	560
<b>5.9 Urea fertilization (CRF 3H).....</b>	<b>561</b>
5.9.1 Category description .....	561
5.9.2 Methodological issues .....	561
5.9.3 Uncertainties and time-series consistency .....	562
5.9.4 Category-specific QA/QC and verification, if applicable .....	562
5.9.5 Category-specific recalculation, including change made in response to the review process and impact on emission trend .....	563
5.9.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	563
<b>6 LULUCF (CRF Sector 4) .....</b>	<b>564</b>
<b>6.1 Overview of sector.....</b>	<b>564</b>

<b>6.2 Land-use definitions and classification systems used and their correspondence to the land use, land-use change and forestry categories.....</b>	<b>578</b>
<b>6.3 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation.....</b>	<b>579</b>
<b>6.4 Forest Land (CRF 4.A) .....</b>	<b>582</b>
6.4.1 Category description .....	582
6.4.2 Methodological issues .....	583
6.4.3 Uncertainties and time-series consistency .....	596
6.4.4 Category-specific QA/QC verification, if applicable.....	597
6.4.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.....	598
6.4.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	598
<b>6.5 Cropland (CRF 4.B) .....</b>	<b>599</b>
6.5.1 Category description .....	599
6.5.2 Methodological issues .....	601
6.5.3 Uncertainties and time-series consistency .....	605
6.5.4 Category-specific QA/QC and verification, if applicable.....	605
6.5.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend .....	605
6.5.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	606
<b>6.6 Grassland (CRF 4.C).....</b>	<b>606</b>
6.6.1 Category description .....	606
6.6.2 Methodological issues .....	607
6.6.3 Uncertainties and time-series consistency .....	608
6.6.4 Category-specific QA/QC and verification, if applicable.....	608
6.6.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend .....	608
6.6.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	608

<b>6.7 Wetlands (CRF 4.D)</b>	<b>609</b>
6.7.1 Category description	609
6.7.2 Methodological issues	610
6.7.3 Uncertainties and time-series consistency	610
6.7.4 Category-specific QA/QC and verification, if applicable	611
6.7.5 Category-specific recalculations, including changes made in response to the review process and impact emission trend	611
6.7.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process	611
<b>6.8 Settlements (CRF 4.E)</b>	<b>611</b>
6.8.1 Category description	611
6.8.2 Methodological issues	612
6.8.3 Uncertainties and time-series consistency	614
6.8.4 Category-specific QA/QC and verification, if applicable	614
6.8.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend	614
6.8.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process	614
<b>6.9 Other land (CRF 4.F)</b>	<b>614</b>
6.9.1 Category description	614
6.9.2 Methodological issues	616
6.9.3 Uncertainties and time series consistency	616
6.9.4 Category specific QA/QC and verification, if applicable	617
6.9.5 Category specific recalculations, including changes made in response to the review process and impact on emission trend	617
6.9.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process	617
<b>6.10 Harvested wood products (CRF 4G)</b>	<b>617</b>
6.10.1 Category description	617
6.10.2 Methodological issues	620
6.10.3 Uncertainties and time series consistency	622



6.10.4 Category-specific QA/QC and verification, if applicable.....	623
6.10.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.....	623
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.....	623
<b>6.11 Nitrous oxide emissions from runoff associated to land conversions .....</b>	<b>624</b>
6.11.1 Description of sources of indirect emissions in GHG inventory .....	624
6.11.2 Methodological issues.....	624
6.11.3 Uncertainties and time-series consistency .....	624
6.11.4 Category-specific QA/QC and verification, if applicable.....	624
6.11.5 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.....	624
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 .....	624
<b>6.12 GHG emission from LULUCF sources.....</b>	<b>625</b>
6.12.1 Direct N <sub>2</sub> O emissions from N fertilization of Forest Land and Other (CRF Table 4(I))	625
6.12.2 Non-CO <sub>2</sub> emissions from drainage of soils and wetlands (CRF Table 4(II)).....	625
6.12.3 N <sub>2</sub> O emissions from disturbance associated with land-use conversion to cropland (CRF Table 4(III)) .....	625
6.12.4 N <sub>2</sub> O emissions from disturbance associated with land-use conversion to cropland (CRF Table 4(III)) .....	626
6.12.5 Biomass Burning (CRF Table 4(V)) .....	626
6.12.6 Category-specific planned improvements, including those in response to the review process.....	629
6.12.7 Recalculations of non CO <sub>2</sub> emissions from sources .....	629
<b>7 WASTE (CRF Sector 5) .....</b>	<b>631</b>
<b>7.1 Overview of the sector.....</b>	<b>631</b>
<b>7.2 Solid Waste Disposal (CRF 5.A).....</b>	<b>638</b>
7.2.1 Category description .....	638
7.2.2 Methodological issues.....	642
7.2.3 Uncertainties and time-series consistency .....	651

7.2.4	Category-specific QA/QC and verification, if applicable.....	652
7.2.5	Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend.....	653
7.2.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	654
<b>7.3</b>	<b>Biological Treatment of Solid Waste (CRF 5.B).....</b>	<b>654</b>
7.3.1	Category description .....	654
7.3.2	Methodological issues.....	656
7.3.3	Uncertainties and time-series consistency .....	656
7.3.4	Category-specific QA/QC and verification, if applicable.....	657
7.3.5	Category-specific recalculation, if applicable, including changes made in response to the review process and impact on emission trend.....	657
7.3.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	657
<b>7.4</b>	<b>Waste Incineration and Open Burning of Waste (CRF 5.C) .....</b>	<b>657</b>
7.4.1	Category description .....	657
7.4.2	Methodological issues.....	665
7.4.3	Uncertainties and time-series consistency .....	669
7.4.4	Category- specific QA/QC and verification, if applicable.....	670
7.4.5	Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend.....	670
7.4.6	Category-specific planned improvements, if applicable, including tracking of those identified in the review process .....	671
<b>7.5</b>	<b>Wastewater Treatment and Discharge (CRF 5.D) .....</b>	<b>671</b>
7.5.1	Category description .....	671
7.5.2	Methodological issues.....	678
7.5.3	Uncertainties and time-series consistency .....	688
7.5.4	Category-specific QA/QC and verification, if applicable.....	690
7.5.5	Category-specific recalculation, including changes made in response to the review process and impact on emission trend .....	692
7.5.6	Category-specific planned improvements, if applicable, including tracking of those	

identified in the review process .....	693
<b>7.6 Other (CRF 5.E) .....</b>	<b>693</b>
<b>7.7 Memo items (CRF 5.F).....</b>	<b>693</b>
<b>8 OTHER (CRF Sector 6) .....</b>	<b>694</b>
<b>9 Indirect CO<sub>2</sub> and nitrous oxide emissions .....</b>	<b>695</b>
<b>9.1 Sources of indirect emissions in GHG inventory.....</b>	<b>695</b>
9.1.1 ENERGY SECTOR (CRF Sector 1).....	695
9.1.2 INDUSTRIAL PROCESSES AND PRODUCT USE SECTOR (CRF Sector 2) .....	715
9.1.3 AGRICULTURE SECTOR (CRF Sector 3).....	745
9.1.4 WASTE SECTOR (CRF Sector 5) .....	754
<b>9.2 Indirect CO<sub>2</sub> and nitrous oxide emissions .....</b>	<b>756</b>
<b>10 Recalculations and improvements .....</b>	<b>757</b>
<b>10.1 Explanations and justifications for recalculations, including in response to the review process and for KP-LULUCF activities.....</b>	<b>766</b>
10.1.1 GHG Inventory.....	766
10.1.2 KP-LULUCF inventory .....	773
<b>10.2 Implications for emissions levels, including on KP-LULUCF emissions levels.....</b>	<b>774</b>
10.2.1 GHG inventory.....	774
10.2.2 KP-LULUCF inventory .....	782
<b>10.3 Implications for emissions trends, including time series consistency, and also for KP-LULUCF trends and time series consistency .....</b>	<b>782</b>
10.3.1 GHG inventory.....	782
10.3.2 KP-LULUCF inventory .....	782
<b>10.4 Planned improvements, including in response to the review process and for the KP-LULUCF activities.....</b>	<b>782</b>
10.4.1 GHG inventory.....	782
10.4.2 KP-LULUCF inventory .....	790
<b>PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1 .....</b>	<b>792</b>
<b>11 Supplementary information to be submitted for the first annual GHG inventory according to decision 2/CMP8 (according to Table 2.4.1).....</b>	<b>792</b>

<b>11.1 Information on methods and approaches to estimate emissions and removals.....</b>	<b>792</b>
<b>11.2 Specific information for activities under Article 3, paragraphs 3 and 4.....</b>	<b>792</b>
11.2.1 Definition of the forest and any other criteria.....	792
11.2.2 Application of provision to exclude emissions from natural disturbance.....	793
11.2.3 Forest Management specific information.....	796
11.2.4 Supplementary information to be reported in the annual GHG inventory according to decision 2/CMP8 (according to Table 2.4.1) .....	798
<b>11.3 Land-related information .....</b>	<b>798</b>
11.3.1 Spatial assessment unit For forest related activities the assessment unit is 0.25 ha .....	798
11.3.2 Information on methods and approaches to estimate emissions and removals.....	802
<b>11.4 Activity-specific information .....</b>	<b>807</b>
11.4.1 Methods for carbon stock change and GHG emission and removal estimates .....	807
<b>11.5 Article 3.3 .....</b>	<b>809</b>
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 .....	809
11.5.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation .....	810
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.....	810
<b>11.6 Article 3.4 .....</b>	<b>810</b>
11.6.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced.....	810
11.6.2 Information relating to Revegetation .....	811
11.6.3 Information relating to Forest Management .....	811
<b>11.7 Other information .....</b>	<b>812</b>
11.7.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4 .....	812
<b>11.8 Information relating to Article 6.....</b>	<b>812</b>
<b>12 INFORMATION ON ACCOUNTING OF KYOTO UNITS .....</b>	<b>814</b>
<b>12.1 Background information.....</b>	<b>814</b>
<b>12.2 Summary of information reported in the SEF tables.....</b>	<b>815</b>

<b>12.3 Discrepancies and notifications .....</b>	<b>815</b>
<b>12.4 Publicly accessible information .....</b>	<b>815</b>
<b>12.5 Calculation of the commitment period reserve (CPR).....</b>	<b>816</b>
<b>12.6 KP-LULUCF accounting.....</b>	<b>817</b>
<b>13 INFORMATION ON CHANGES IN NATIONAL SYSTEM .....</b>	<b>818</b>
<b>14 INFORMATION ON CHANGES IN NATIONAL REGISTRY .....</b>	<b>819</b>
<b>15 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14 .....</b>	<b>822</b>
<b>16 OTHER INFORMATION .....</b>	<b>824</b>
<b>REFERENCES .....</b>	<b>825</b>

**LIST OF ANNEXES**

Annex 1	Key categories
Annex 2	Assessment of uncertainty
Annex 3	Detailed methodological descriptions for individual source or sink categories
Annex 3.1	Detailed discussion of methodology and data for estimating CO <sub>2</sub> emissions from fossil fuel combustion – stationary combustion
Annex 3.2	Detailed discussion of methodology and data for estimating CO <sub>2</sub> emissions from fossil fuel combustion - mobile combustion - road transport
Annex 3.3	Detailed data for estimating CH <sub>4</sub> and N <sub>2</sub> O emissions from national and international aviation
Annex 3.4	Industrial Processes Sector-ammonia production-Kellog process detailed description
Annex 3.5	Detailed data for estimating CH <sub>4</sub> and N <sub>2</sub> O Agriculture Sector related GHG emissions
Annex 4	The national energy balance for the most recent inventory year
Annex 5	Any additional information to be considered as part of the annual inventory submission and the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol or other useful reference information

- Annex 5.1      Assessment of completeness and sources and sinks of greenhouse gas emissions and removals excluded for the annual inventory submission
- Annex 5.2      Assessment of completeness and sources and sinks of greenhouse gas emissions and removals excluded for the KP-LULUCF inventory
- Annex 6        Additional information to be considered as part of the annual inventory submission and the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol or other useful reference information
- Annex 6.1      Global Warming Potential values used within the GHG Inventory
- Annex 6.2      GHG Emissions Registry related information
- Annex 6.2.1    SEF
- Annex 6.2.2    Other information on GHG Emissions Registry
- Annex 6.3      Uncertainty of Romanian GHG Inventory
- Annex 6.4      Elements on verification activities under the Energy Sector
- Annex 6.5      Comparison with ETS data
- Annex 6.6      Elements on verification activities under the Agriculture Sector
- Annex 6.7.1    Land use change matrix associated with the LULUCF under UNFCCC
- Annex 6.7.2    Land use change matrix associated with the LULUCF under KP

Annex 6.8      Changes in the National System performed before the submission of the 2017  
NGHGI

Annex 6.9      Comparison with air pollutants data

Annex 6.10     Information on steps to improve estimates

Annex 6.11     Comparison with F-gases data

Annex 6.12     Comparison on Reference Approach



## LIST OF FIGURES

Figure ES.1 The total GHG emissions in CO <sub>2</sub> equivalent during 1989-2015 period.....	49
Figure 1.1 Current national inventory system description.....	62
Figure 2.1 Trends of the aggregated GHG emissions.....	123
Figure 2.2 Indirect GHG emissions trends [kt].....	127
Figure 2.3 Trends by sector .....	128
Figure 2.4 Sectorial GHG emissions in 2016 [%] .....	129
Figure 3.1 The contribution of Energy Sector to the total GHG emissions in Romania, 2016.....	130
Figure 3.2 The energy sector emission trend for the period 1989-2016.....	131
Figure 3.3 The different GHG's contribution to the 2016 Energy sector .....	133
Figure 3.4 Key categories, both by level and trend criteria, overview – Energy Sector, 2016 ..	138
Figure 3.5 Comparison of the sectorial approach with the reference approach.....	141
Figure 3.6 Comparison of the sectorial approach with the reference approach – liquid fuels ....	141
Figure 3.7 Comparison of the sectorial approach with the reference approach – solid fuels .....	142
Figure 3.8 Comparison of the sectorial approach with the reference approach – gaseous fuels .	142
Figure 3.9 GHG emissions from International Aviation Subsector.....	145
Figure 3.10 Fuel consumption associated with the International Aviation Subsector, 1989-2016 period .....	146
Figure 3.11 The GHG emissions from International Navigation Subsector.....	147
Figure 3.12 Fuel consumption associated with the International Navigation Subsector, 1989-2016 period .....	147
Figure 3.13 Comparison between the energy and non-energy use of the fuels in the energy sector .....	151
Figure 3.14 The most important non-energy consumption of the fuels.....	152
Figure 3.15 Total GHG CO <sub>2</sub> equivalent. emissions associated with the Fuel Combustion Activities by categories.....	154
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 .....	155
Figure 3.17 Total CO <sub>2</sub> emissions [kt] from Fuel combustion by fuel type.....	156

Figure 3.18 Total GHG emissions trend for the subsector 1.A.1 Energy industries by category.....	185
Figure 3.19 GHG emissions trend for the subsector 1.A.1 Energy industries by type of fuels..	186
Figure 3.20 GHG emissions from 1.A.1.a Public Electricity and Heat Production .....	187
Figure 3.21 CO <sub>2</sub> emissions variation associated with the lignite usage in the 1.A.1.a - Public Electricity and Heat Production .....	188
Figure 3.22 GHG emissions from CRF 1.A.1.b Petroleum refining .....	190
Figure 3.23 GHG emissions from 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries .....	192
Figure 3.24 Total GHG emissions trend for the subsector 1.A.2. Manufacturing Industries and Constructions by category.....	194
Figure 3.25 GHG emissions trend for the subsector 1.A.2. Manufacturing Industries and Constructions by fuels.....	195
Figure 3.26 GHG emissions from 1.A.2.a – Iron and Steel, by fuels .....	196
Figure 3.27 GHG emissions from 1.A.2.c – Chemicals, by fuels.....	199
Figure 3.28 GHG emissions from 1.A.2.d – Pulp, Paper and Print, by fuels .....	201
Figure 3.29 GHG emissions 1.A.2.e – Food Processing, Beverages and Tobacco, by fuels .....	203
Figure 3.30 GHG emissions from 1.A.2.f – Other, by fuels .....	205
Figure 3.31 GHG emissions from 1.A.2.g – Other, by fuels .....	207
Figure 3.32 Contribution of each category to total fuel consumption in Transport Subsector...	209
Figure 3.33 The contribution of the emissions from different categories of Transport Subsector in 2016.....	210
Figure 3.34 GHG emissions Trend from 1A3a – Civil Aviation.....	211
Figure 3.35 Fuel consumption(Aviation gasoline) for Civil Aviation -1.A.3.a.....	214
Figure 3.36 Distribution of Road transportation emissions by fuel (Gg CO <sub>2</sub> eq.).....	217
Figure 3.37 Distribution of Road transportation emissions by type of vehicle (Gg CO <sub>2</sub> eq.) ....	218
Figure 3.38 Distribution of Road transportation emissions by type of vehicle (%) .....	219
Figure 3.39 Distribution of Road transportation emissions by gases (Gg CO <sub>2</sub> equivalent) .....	219
Figure 3.40 GHG emissions Trend from 1A3c – Railways.....	230
Figure 3.41 Fuel consumptionfor Railwais -1.A.3.c.....	231
Figure 3.42 GHG emissions from 1A3a – Navigation .....	235

Figure 3.43 Fuel consumption 1.A.3.d Navigation 1989-2016 period .....	236
Figure 3.44 The GHG emissions from 1A3e – Other transportation category .....	242
Figure 3.45 Fuel consumption 1.A.3.c Other transportation 1989 -2016 .....	243
Figure 3.46 GHG emissions from 1.A.4. – Other, by category .....	247
Figure 3.47 GHG emissions from 1.A.4. – Other, by fuels .....	248
Figure 3.48 GHG emissions from 1.A.4.a – Commercial / Institutional, by fuels .....	248
Figure 3.49 GHG emissions from 1.A.4.b – Residential, by fuels .....	251
Figure 3.50 GHG emissions from 1.A.4.c – Agriculture/Forestry/Fisheries, by fuels .....	253
Figure 3.51 GHG emissions from 1.A.5 – Other Sectors, by fuels .....	255
Figure 3.52 Total GHG emissions from Fugitive Emissions from Fuels Subsector .....	259
Figure 3.53 GHG emissions from Fugitive Emissions from Fuels Subsector, per gas .....	261
Figure 3.54 Fugitive Emissions of CH <sub>4</sub> from Solid Fuels (1.B.1).....	263
Figure 3.55 Lignite – Brown Coal Production trend.....	265
Figure 3.56 Underground Mines category and Solid Fuel Transformation category emissions trend .....	267
Figure 3.57 Total GHG Oil and Natural Gas source category emissions trend.....	274
Figure 3.58 The contribution of GHG s Fugitive emission per gas from Oil and Natural Gas source category .....	275
Figure 3.59 The different GHG's Fugitive emissions contribution from Oil sub-source category .....	276
Figure 3.60 The different GHG's Natural Gas sub-source category emissions contribution.....	282
Figure 3.61 The different GHG's Venting oil and Venting Gas emissions contribution .....	290
Figure 3.62 The different GHG's Flaring Oil and Flaring Gas emissions contribution .....	292
Figure 4.1 The contribution of Industrial Processes and Product Use Sector to the total GHG emissions in Romania, in 2016 year .....	301
Figure 4.2 Total GHG emissions trend in Industrial Processes and Product Use Sector, for 1989–2016 period .....	303
Figure 4.3 GHG emissions trends in Industrial Processes and Product Use Sector, by sub-sectors, for 1989–2016 period.....	304
Figure 4.4 Key categories in Industrial Processes and Product Use Sector in 2016 year, both by level and trend criteria .....	305

Figure 4.5 GHG emissions trend in the Mineral Industry Sub-sector for 1989–2016 period ....	306
Figure 4.6 Structure of the Mineral Industry Sub-sector, in 2016 year .....	307
Figure 4.7 CO <sub>2</sub> emissions from Other Process Uses of Carbonates in the 1989–2016 period...	328
Figure 4.8 GHG emissions trend in the Chemical Industry Sub-sector for 1989–2016 period..	334
Figure 4.9 The trend of CO <sub>2</sub> emissions from Ammonia Production in the 1989–2016 period..	340
Figure 4.10 The trend of CO <sub>2</sub> emissions from Nitric Acid Production, 1989–2016 period .....	345
Figure 4.11 CO <sub>2</sub> emissions from Soda Ash Production in the 1989–2016 period .....	351
Figure 4.12 GHG emissions trend in the Metal Industry Sub-sector for 1989–2016 period .....	362
Figure 4.13 Structure of the Metal Industry Sub-sector, in 2016 year .....	363
Figure 4.14 The trend of CO <sub>2</sub> emissions from Iron and Steel Production (BOF, EAF and OHF) in the 1989–2016 period .....	373
Figure 4.15 The trend of CO <sub>2</sub> emissions from Iron and Steel Production in the 1989–2016 period .....	374
Figure 4.16 The trend of PFC emissions from Primary Aluminium Production Sub-sector in the 1989–2016 period .....	383
Figure 4.17 CO <sub>2</sub> emissions trend in the Non-energy products from fuels and solvent use Sub-sector for 1989–2016 period .....	391
Figure 4.18 The trend of CO <sub>2</sub> emissions resulted from Solvent Use Sector, in the 2016 year ...	396
Figure 4.19 GHG emissions trend in the Product uses as substitutes for ODS Sub-sector for 1995–2016 period .....	406
Figure 4.20 Actual F-gases emissions by source for 1989–2016 period .....	407
Figure 4.21 Actual emissions of the Comercial Refrigeration for 1989–2016 period.....	409
Figure 4.22 Actual emissions of the Domestic Refrigeration for 1989–2016 period .....	412
Figure 4.23 Actual emissions of the Industrial Refrigeration for 1989–2016 period .....	416
Figure 4.24 Actual emissions of the Transport Refrigeration for 1989–2016 period.....	419
Figure 4.25 Actual emissions of the Mobile Air-Conditioning for 1989–2016 period .....	424
Figure 4.26 Actual emissions of the Stationary Air-Conditioning for 1989–2016 period .....	434
Figure 4.27 Actual emissions of the Foam Blowing for 1989–2016 period.....	439
Figure 4.28 Actual emissions of the Fire Protection for 1989–2016 period.....	443
Figure 4.29 Actual emissions of the Aerosols/Metered Dose Inhalers for 1989–2016 period...	446

Figure 4.30 GHG emissions trend in the Other product manufacture and use Sub-sector for 1995–2016 period .....	454
Figure 4.31 Actual emissions of the Electrical Equipment for 1989–2016 period.....	456
Figure 5.1 Total GHG emissions trend in Agriculture for 1989–2016 period.....	468
Figure 5.2 Contribution of the sub-sectors in the total GHG emissions from Agriculture, in 2016 year.....	468
Figure 5.3 Key Categories in Agriculture, both by level and trend .....	474
Figure 5.4 Methane emission trend due to the Enteric Fermentation .....	476
Figure 5.5 Overall trends of emissions from Manure Management .....	499
Figure 5.6 Methane emission trend due to the Rice Cultivation.....	522
Figure 5.7 Overall emissions trend of Agricultural Soils .....	528
Figure 5.8 Direct N <sub>2</sub> O emissions trends – Agricultural Soils.....	529
Figure 5.9 Cumulative emissions trend - Field Burning of Agricultural Residues .....	555
Figure 5.10 CO <sub>2</sub> emissions from liming application soils .....	559
Figure 5.11 CO <sub>2</sub> emissions from Urea fertilization .....	561
Figure 6.1 Key categories from LULUCF sector .....	577
Figure 6.2 Emissions for 4.A.1 - Forest Land remaining Forest Land and 4.A.2 - Land converted to Forest Land (kt CO <sub>2</sub> ).....	583
Figure 6.3 Removals and emissions for 4B1 - Cropland remaining Cropland (kt CO <sub>2</sub> ) and 4B2 - Land converted to Cropland (kt CO <sub>2</sub> ).....	600
Figure 6.4 Emissions/removals for 4.C.1 – Grassland remaining grassland and 4.C.2 - Land converted to Grassland (kt CO <sub>2</sub> ).....	606
Figure 6.5 Emissions for 4D2 - Land converted to Wetlands (kt CO <sub>2</sub> ).....	609
Figure 6.6 Emissions for 4.E.2 - Land converted to Settlements (kt CO <sub>2</sub> ).....	612
Figure 6.7 Emissions for 5.F.2 - Land converted to Other land (kt CO <sub>2</sub> ).....	615
Figure 6.8 Emissions for 5.G - Harvested wood products (kt CO <sub>2</sub> ) .....	618
Figure 6.9 Emissions for 5.G - Harvested wood products (kt CO <sub>2</sub> )- Solid Wood, Paper and paperboard, Other (please specify) .....	620
Figure 6.10 Oven dry density of wood (g·cm <sup>-3</sup> ) species harvested in Romania.....	621
Figure 6.11 Changes made on emissions estimates .....	623
Figure 7.1 The contribution of Waste Sector to the total GHG emissions in Romania, 2016 .....	633

Figure 7.2 Total GHG emissions trend from Waste Sector for 1989–2016 period .....	634
Figure 7.3 Contribution of the sub-sectors in the total GHG emissions from Waste Sector in 2016 .	635
Figure 7.4 Key categories in Waste Sector both by level and trend criteria, in 2016.....	636
Figure 7.5 GHG emissions trend from Waste Sector, by sub-sectors for 1989–2016 period.....	638
Figure 7.6 CH <sub>4</sub> emissions trend from waste disposed to managed sites for 1995–2016 period.	641
Figure 7.7 CH <sub>4</sub> emissions trend from waste disposed to unmanaged sites for 1989–2016 period .....	642
Figure 7.8 CH <sub>4</sub> emissions trend from composting , for 2003–2016 period.....	655
Figure 7.9 N <sub>2</sub> O emissions trend from composting , for 2003–2016 period.....	655
Figure 7.10 CO <sub>2</sub> emissions trend from waste incineration, for 1992–2016 period .....	658
Figure 7.11 CO <sub>2</sub> emissions trend from clinical waste incineration, for 1996–2016 period .....	660
Figure 7.12 CO <sub>2</sub> emissions trend from hazardous waste incineration, for 1992–2016 period ...	660
Figure 7.13 N <sub>2</sub> O emissions trend from waste incineration, for 1992–2016 period .....	661
Figure 7.14 CH <sub>4</sub> emissions trend from waste incineration, for 1992–2016 period.....	661
Figure 7.15 N <sub>2</sub> O emissions trend from clinical waste incineration, for 1996–2016 period.....	662
Figure 7.16 N <sub>2</sub> O emissions trend from hazardous waste incineration, for 1992–2016 period...	663
Figure 7.17 N <sub>2</sub> O emissions trend from biogenic waste incineration, for 2001–2016 period .....	663
Figure 7.18 CH <sub>4</sub> emissions trend from clinical waste incineration, for 1996–2016 period .....	664
Figure 7.19 CH <sub>4</sub> emissions trend from hazardous waste incineration, for 1992–2016 period ..	664
Figure 7.20 CH <sub>4</sub> emissions trend from biogenic waste incineration, for 2001–2016 period.....	665
Figure 7.21 CH <sub>4</sub> emissions trend from domestic/commercial wastewater and sludge treatment for 1989–2016 period .....	675
Figure 7.22 CH <sub>4</sub> emissions trend from industrial wastewater handling for 1989–2016 period .....	676
Figure 7.23 N <sub>2</sub> O emissions trend from domestic wastewater for 1989–2016 period .....	677
Figure 9.1 Indirect N <sub>2</sub> O emissions trends – Agricultural Soils .....	749
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 2017 submission.....	771
Figure 10.2 Category total emissions/removals change, for all gases, and for the entire time series, in comparison to the figures in the 2017 submission.....	773
Figure 10.3 Effects of recalculations (presented in the 2018 submission) for 1989, by gas .....	775
Figure 10.4 Effects of recalculations (presented in the 2018 submission) for 2015, by gas .....	777

Figure 10.5 Changes of 1989 emissions/removals, in respect to the 2018 figures .....	779
Figure 10.6 Changes of 2014 emissions/removals, in respect to the 2018 figures .....	781
Figure 11.1 Windfall blown down wood volume in Romania.....	793

## LIST OF TABLES

Table ES.1 Share of each direct GHG in total emissions in 1998, 2010, respectively 1989-2015 period.....	48
Table 1.1 Overview of the Romanian GHG Inventories review under Article 8 of the KP .....	54
Table 1.2 Schedule of training of new staff part of the NEPA team dedicated to the administration of the NS and NGHGI .....	67
Table 1.3 Main activity data sources .....	113
Table 2.1 Trends by gas [Gg CO <sub>2</sub> equivalent] .....	124
Table 2.2 Indirect GHG emissions levels [Gg] .....	126
Table 3.1 Shares of GHG emission categories within the Energy sector, in 2016 .....	133
Table 3.2 Status of emissions estimation within the Energy Sector for 2016 .....	134
Table 3.3 Key categories overview - Energy 2016 .....	136
Table 3.4 Non-energy use of fuels compared to total apparent energy consumption .....	150
Table 3.5 Country-Specific CO <sub>2</sub> emission factors for stationary combustion, without oxidation included, from ETS verified reports .....	163
Table 3.6 Country-Specific CO <sub>2</sub> emission factors for stationary combustion, oxidation included, from ETS verified reports .....	165
Table 3.7 Country-specific emission factors 2007-2010 period weighted averages .....	166
Table 3.8 Share of the EU-ETS installations to the National Energy Balance, 2008 year .....	171
Table 3.9 The impact of recalculations on GHG emission estimates in the sub-sector 1.A 1. - Energy Industry .....	179
Table 3.10 The impact of recalculations on the GHG emission estimates in the sub-sector 1.A 2. - Manufacturing Industries and Constructions .....	180
Table 3.11 The impact of recalculations on GHG emission estimates in the sub-sector 1.A 4. - Other Sectors .....	182
Table 3.12 The impact of recalculations on the GHG emission estimates in the sub-sector 1.A 5. - Other non-specified sectors .....	183
Table 3.13 Country specific characteristics for gasoline and diesel oil according Decision no 689/2004, update by Decision no. 15/2006 .....	226



Table 3.14 Uncertainties for road transport .....	227
Table 3.15 Effects of data changes on CO <sub>2</sub> emissions level .....	239
Table 3.16 Effects of data changes on CH <sub>4</sub> emissions level .....	240
Table 3.17 Effects of data changes on N <sub>2</sub> O emissions level .....	240
Table 3.18 The contribution of Fugitive Emissions from Fuels Subsector emissions to the total GHG in Romania, for 1989–2016 period .....	258
Table 3.19 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 – 2016 period .....	260
Table 3.20 Fugitive Emissions of CH <sub>4</sub> from Underground Mines and CH <sub>4</sub> Recovered for energy use .....	268
Table 3.21 Change made at activity data and their effects on CO <sub>2</sub> emission estimates .....	295
Table 3.22 Change made at activity data and their effects on CH <sub>4</sub> emission estimate .....	296
Table 4.1 Status of emissions estimation within the Industrial Processes Sector .....	298
Table 4.2 Key categories in Industrial Processes and Product Use Sector in 2016 year .....	305
Table 4.3 CO <sub>2</sub> emissions in the Mineral Industry Sub-sector, in the 2016 year .....	307
Table 4.4 Clinker Production data and CO <sub>2</sub> emissions from Clinker Production in the 1989–2016 period .....	310
Table 4.5 Value of the stoichiometric report for high calcium lime .....	314
Table 4.6 Value of the stoichiometric report for high calcium lime .....	315
Table 4.7 Average content of CaO in the high calcium lime .....	316
Table 4.8 Average content of CaO in the high calcium lime .....	317
Table 4.9 The weights value for the comercial lime (under EU–ETS) from the total lime production .....	318
Table 4.10 CO <sub>2</sub> emissions from Lime Production in the period 1989–2016 .....	318
Table 4.11 CO <sub>2</sub> emissions from Glass Production in the 1989–2016 period .....	323
Table 4.12 Amount of Other Process Uses of Carbonates and CO <sub>2</sub> emissions in the 1989–2016 period .....	326
Table 4.13 The effects of recalculations in Mineral Industry Sub–sector .....	331
Table 4.14 Recalculations of CO <sub>2</sub> emissions in the Other Process Uses of Carbonates Sub–sector .....	332

Table 4.15 GHG emissions from the Chemical Industry Sector, in 2016 year .....	335
Table 4.16 Ammonia Production related to the CO <sub>2</sub> emissions in the 1989–2016 period .....	339
Table 4.17 Nitric Acid Production related to the N <sub>2</sub> O emissions in the 1989–2016 period.....	343
Table 4.18 The default EFs used to estimate emissions from Adipic Acid Production .....	346
Table 4.19 CO <sub>2</sub> emissions from Calcium Carbide Production in the 1989–2016 period .....	349
Table 4.20 CO <sub>2</sub> emissions from Soda Ash Production in the 1989–2016 period .....	351
Table 4.21 The effects of recalculations in Chemical Industry Sub-sector .....	359
Table 4.22 The effects of recalculations in Ammonia Production Sub-sector .....	360
Table 4.23 GHG emissions from Metal Industry Sub-sector, in the 2016 year .....	363
Table 4.24 Data requested for the sinter production process .....	365
Table 4.25 Data types for the iron and steel production on the integrated flow .....	365
Table 4.26 CO <sub>2</sub> emissions estimated for the 1989–2016 period .....	368
Table 4.27 CO <sub>2</sub> emissions estimated for the 1989–2016 period .....	370
Table 4.28 CO <sub>2</sub> emissions for steel production in OHF .....	371
Table 4.29 CO <sub>2</sub> emissions from Iron and Steel Production for the 1989–2016 period .....	372
Table 4.30 CH <sub>4</sub> emissions for Iron and Steel production for the 1989-2016 period .....	374
Table 4.31 CO <sub>2</sub> emission from Ferroalloys Production in the 1989–2016 period .....	376
Table 4.32 CH <sub>4</sub> emission from Ferroalloys Production in the 1989–2016 period .....	377
Table 4.33 The activity data, PFC and CO <sub>2</sub> emissions from Aluminium Production Sub-sector in the 1989–2016 period .....	380
Table 4.34 CO <sub>2</sub> emissions from Non-energy products from fuels and solvent use Sub-sector, in the 2016 year .....	391
Table 4.35 Correspondence between IPCC categories and SNAP codes.....	394
Table 4.36 CO <sub>2</sub> emissions resulted from Solvent Use in the 1989–2016 period .....	395
Table 4.37 The effects of recalculations in Non-energy products from fuels and solvent use Sector .....	400
Table 4.38 The effects of recalculations in Solvent use Sub-sector .....	401
Table 4.39 The Actual emissions in the Product uses as substitutes for ODS Sub-sector for 1989 – 2016 period .....	406
Table 4.40 The quantity of banked HFC of the Commercial Refrigeration for 1989–2016 period .....	409

Table 4.41 The result detailed of the Domestic Refrigeration for 1989–2016 period .....	413
Table 4.42 Assumptions on data for imports in Bulgaria for Domestic Refrigeration .....	414
Table 4.43 The quantity of banked HFC of the Industrial Refrigeration for 1989–2016 period .....	417
Table 4.44 The quantity of banked HFC of the Transport Refrigeration for 1989–2016 period .....	420
Table 4.45 The total number of Refrigeration trucks with HFC-containing units for 1993–2016 period .....	421
Table 4.46 The quantity of banked HFC of the Mobile Air-Conditioning for 1989–2016 period .....	425
Table 4.47 The number of new cars, all cars, trucks and busses with HFC-containing units of MAC for 1993–2016 period .....	427
Table 4.48 The values from EC 2011 study .....	430
Table 4.49 The quantity of banked HFC of the Domestic Air-Conditioning for 1989–2016 period .....	435
Table 4.50 Assumptions on data for imports in Bulgaria for Domestic Air-Conditioning .....	436
Table 4.51 Assumptions on data for imports in Bulgaria for Domestic Air-Conditioning .....	438
Table 4.52 The quantity of banked HFC of the Foam Blowing for 1989–2016 period .....	440
Table 4.53 The quantity of banked HFC of the Fire Protection for 1989–2016 period .....	443
Table 4.54 The quantity of banked HFC of the Aerosols/Metered Dose Inhalers for 1989–2016 period .....	446
Table 4.55 The effects of recalculations in Product uses as substitutes for ODS Sub-sector....	453
Table 4.56 The quantity of banked HFC of the Electrical Equipment for 1989–2016 period ...	456
Table 4.57 The effects of recalculations in Other Product Manufacture and Use Sector.....	461
Table 4.58 The effects of recalculations in N <sub>2</sub> O from Product Uses Sub-sector .....	462
Table 5.1 Status of emissions estimation within the Agriculture Sector .....	464
Table 5.2 Contribution of Agriculture sector in total GHG emissions, in 1989-1990, 1995, 2000, 2005, 2007–2016 .....	473
Table 5.3 Key categories overview – Agriculture, 2016 .....	474
Table 5.4 Observations on source category 3A – “Enteric Fermentation” .....	476
Table 5.5 Calculation of feed digestible energy .....	480

Table 5.6 Milk production in cows and and buffalo in the period 1989-1990, 1995, 2000, 2005, 2007–2016 (NIS) .....	482
Table 5.7 The factors emission (kg CH <sub>4</sub> /head/year) used for calculation of methane emissions from enteric fermentation of livestock and data necessary for their calculation, in the 1989-2016 period .....	486
Table 5.8 The factors emission (kg CH <sub>4</sub> /head/year) used for calculation of methane emissions from enteric fermentation of dairy cattle and data necessary for their calculation, , in the 1989-1990, 1995, 2000, 2005,2007–2016 period .....	488
Table 5.9 The values energy digestible expressed in Mj/day and percent and weight (kg) for livestock, in the 1989-2016 period .....	489
Table 5.10 Observations on source category 4B – “Manure Management” .....	499
Table 5.11 The values used in the calculation of emissions factors from Manure management for 1989-2016 .....	508
Table 5.12 The values used in the calculation of emissions factors from Manure management for 1989-1990, 1995, 2000, 2005,2007–2016 period for dairy cattle .....	511
Table 5.13 The values MCF used in calculation of emissions factor for each manure system management for all livestock in the 1989-2016 period .....	512
Table 5.14 N <sub>2</sub> O emission factors [kg N <sub>2</sub> O-N/kg N excreted] for animal waste per AWMS .....	514
Table 5.15 Data necessary for calculating the rate of excretion of nitrogen, in the 1989-2016 period .....	515
Table 5.16 Recalculations on CH <sub>4</sub> emission estimates .....	520
Table 5.17 Observations on source category 4C – “Rice Cultivation” .....	522
Table 5.18 Rice residues productivity values and default values for the scaling factor to account for the type and amount of amendment applied (SF <sub>O</sub> ) ) for 1989-1990, 1995, 2000, 2005,2007–2016 period .....	523
Table 5.19 Harvested area data series for 1989-2016.....	524
Table 5.20 Observations on source category 3D – “Managed Soils” .....	530
Table 5.21 Activity data series used for calculation of F <sub>SN</sub> , , for 1989-1990, 1995, 2000, 2005,2007–2016 period .....	534
Table 5.22 The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989-1990, 1995, 2000, 2005,2007–2016 period .....	536

Table 5.23 The data on Crop production of nitrogen fixing crop obtained through the dedicated study (tonnes/year), in the 1989-1990, 1995, 2000, 2005,2007–2016 period .....	538
Table 5.24 The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-1990, 1995, 2000, 2005,2007–2016 period .....	539
Table 5.25 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 1989-2016 period .....	546
Table 5.26 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 1989-2016 period .....	547
Table 5.27 Observations on source category 4F – “Field Burning of Agricultural Residues”...	555
Table 5.28 Default emission ratios for agricultural residue burning of residues calculations ...	556
Table 6.1 GHGs emissions and removals for the LULUCF Sector in 1989 (BY) - 2016 .....	565
Table 6.2 LULUCF GHG emissions and removals for the period 1989-2016 ("-"CO <sub>2</sub> removals, "+" GHG emissions, in kt) .....	566
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) .....	567
Table 6.4 Key categories overview – LULUCF, 2016 .....	576
Table 6.5 Land use matrix for 1989 – 2016 (kHa) .....	580
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) .....	585
Table 6.7 Parameter values used to estimate annual increment of living biomass .....	586
Table 6.8 Activity data for harvested wood volume during 1989-2016 (Thousands cubic meters / year) .....	589
Table 6.9 Annual amount of C (t/ha) sequestered in biomass in forestry plantations .....	592
Table 6.10 Annual change in litter pool .....	594
Table 6.11 National reference C stocks in mineral soils on land use categories (tC/ha) and annual C stock change (tC ha <sup>-1</sup> yr <sup>-1</sup> ) in conversions from to, assuming 20 years transition period .....	595
Table 6.12 Wood volume by wood product and production categories used in the calculation of the carbon stock changes of the HWP pool. ....	619

Table 6.13 Factors for conversion to carbon .....	621
Table 6.14 Forest fires area .....	627
Table 7.1 Status of the direct GHG emissions estimation in the Waste Sector .....	631
Table 7.2 The contribution of Waste Sector to the total GHG emissions in Romania, for 1989–2016 period .....	633
Table 7.3 Key categories in Waste Sector based on the level and trend assessment in 2016 .....	635
Table 7.4 Total amount of collected waste MSW, in 2016 (Source www.anpm.ro) .....	639
Table 7.5 Number of Solid waste Disposal Sites (Source Waste Directorate of NEPA) .....	640
Table 7.6 The percentage composition of municipal solid waste .....	643
Table 7.7 Other parameters used to calculate the emission factors (SWDS) for municipal solid waste disposed to SWDS .....	644
Table 7.8 Parameters used to calculate the emission factors (SWDS) for sewage sludge disposed to SWDS .....	645
Table 7.9 Total annual MSW disposed to Solid Waste Disposal Sites .....	646
Table 7.10 Total annual sewage sludge disposed to Solid Waste Disposal Sites (1950–2016 period) .....	647
Table 7.11 The amounts of CH <sub>4</sub> recovered from managed SWDS (Source: operators of landfills) .....	649
Table 7.12 Percentage of direct and indirect Greenhouse Gas emissions from waste category 5A (Source: International Solid Waste Association – “Landfill Operational Guideline, 2 <sup>nd</sup> Edition”).....	651
Table 7.13 Uncertainties associated with CH <sub>4</sub> emissions estimates from managed and unmanaged SWDS .....	652
Table 7.14 Changes made parameters and their effects on emission estimates .....	653
Table 7.15 Uncertainties for estimation of CH <sub>4</sub> and N <sub>2</sub> O emissions from composting .....	656
Table 7.16 Default data for estimation of CO <sub>2</sub> emissions from waste incineration (Source: IPCC 2006, table 5.2) .....	666
Table 7.17 Default data for estimation of N <sub>2</sub> O emissions from waste incineration (Source: IPCC 2006) .....	666
Table 7.18 Default data for estimation of CH <sub>4</sub> emissions from waste incineration (Source: IPCC 2006, Vol.5: Waste, p.5.20, Table 5.3). .....	667
Table 7.19 Amounts of clinical waste generated and incinerated (Source: ISPB and ICIM) ....	667

Table 7.20 Amounts of hazardous, clinical and biogenic waste incinerated .....	668
Table 7.21 Uncertainties for estimation of CO <sub>2</sub> emissions from waste incineration .....	669
Table 7.22 Changes made on emission estimates .....	671
Table 7.23 Wastewater evacuated into Romania, in 2016 (Source: National Administration “Romanian Waters”) .....	672
Table 7.24 Explanations on methane emissions estimates .....	676
Table 7.25 Calculation of Emission Factors domestic/commercial wastewater, for 1989-2016 period .....	680
Table 7.26 The sources of activity data used in methane emissions estimates from domestic/commercial wastewater treatment .....	681
Table 7.27 Parameters used to estimate Total organic domestic/commercial wastewater (Source: Study finished in 2011) .....	681
Table 7.28 Values of Protein Consumption for Romania in period 1989-2016 .....	683
Table 7.29 The Emissions Factors for aerobic and anaerobic treatment .....	685
Table 7.30 Industrial production of the industrial sectors with the greatest potential for methane emissions (source: NIS - Statistical Yearbook 2016) .....	686
Table 7.31 Parameters used to estimate Total organic industrial wastewater (Source:IPCC 2006, table 6.8) .....	687
Table 7.32 The amounts of CH <sub>4</sub> recovered from industrial wastewater treatment (Source: economic operators) .....	688
Table 7.33 Uncertainties for estimation of CH <sub>4</sub> emissions from industrial wastewater .....	689
Table 7.34 Uncertainties for estimation of CH <sub>4</sub> emissions from domestic/commercial Wastewater .....	689
Table 7.35 Uncertainties for estimation of N <sub>2</sub> O emissions from domestic wastewater .....	690
Table 7.36 Comparison between data provided by EUROSTAT and data provided by NIS .....	691
Table 7.37 Changes made on emission estimates .....	692
Table 9.1 NO <sub>x</sub> emission factors for different fuels .....	696
Table 9.2 CO emission factors for different fuels .....	696
Table 9.3 NMVOC emission factors for different fuels .....	697
Table 9.4 Default Emission Factors for SO <sub>2</sub> Emissions .....	698
Table 9.5 Country Specific SO <sub>2</sub> emission factors – 1.A.1.a, solid fuel .....	699

Table 9.6 Emission Factors for Tier 1 method of Copert 4 .....	705
Table 9.7 Default values of sulphur content (s) in fuel .....	706
Table 9.8 Uncertainties for road transport .....	707
Table 9.9 Cement Production data and SO <sub>2</sub> emissions from Cement Production in the period 1989–2016 .....	716
Table 9.10 Ammonia Production data and CO and SO <sub>2</sub> emissions from Ammonia Production in the period 1989–2016 .....	719
Table 9.11 Nitric Acid Production related to the NO <sub>x</sub> emissions in the period 1989–2016 ....	722
Table 9.12 The default EFs used to estimate emissions from Adipic Acid Production .....	723
Table 9.13 Adipic Acid Production related to the NO <sub>x</sub> , NMVOC and CO emissions in the period 1989–2001 .....	723
Table 9.14 The NO <sub>x</sub> , CO, NMVOC and SO <sub>2</sub> emissions for Petrochemical and carbon black Production Sub-sector .....	725
Table 9.15 NMVOC emissions for category CRF 2.C.1 – Iron and Steel Production .....	729
Table 9.16 NO <sub>x</sub> emissions for category CRF 2.C.1 – Iron and Steel Production .....	730
Table 9.17 CO emissions for category CRF 2.C.1 – Iron and Steel Production .....	731
Table 9.18 SO <sub>2</sub> emissions for category CRF 2.C.1 – Iron and Steel Production .....	731
Table 9.19 Emission factors for CO and SO <sub>2</sub> from primary Aluminium Production .....	733
Table 9.20 The CO and SO <sub>2</sub> emissions from primary Aluminium Production .....	733
Table 9.21 The SO <sub>2</sub> emissions from Magnesium Production .....	734
Table 9.22 The NMVOC emissions from Road Paving with Asphalt Sector .....	739
Table 9.23 Emission factors for NMVOC, CO from Asphalt Roofing Production Sector .....	740
Table 9.24 The CO and NMVOC emissions from Asphalt Roofing Production Sector .....	740
Table 9.25 Default emission factors for various types of burning .....	753
Table 9.26 Percentage of direct and indirect Greenhouse Gas emissions from waste category 5A (Source: International Solid Waste Association – “Landfill Operational Guideline, 2 <sup>nd</sup> Edition”) ....	755
Table 10.1 Major changes in methodological descriptions in the present NIR, comparing to the NIR part of the 2017 NGHGI, are presented in Table 10.1 .....	758
Table 10.2 Recalculation of total emissions/removals, by sector, for all gases, for 1989 .....	778
Table 10.3 Recalculation of total emissions/removals, by sector, for all gases, for 2015 .....	780
Table 10.4 Summary of planned improvements GHG Inventory activities .....	782



Table 10.5 Summary of planned improvements KP-LULUCF Inventory activities .....	791
Table 11.1 Background level values (GgCO <sub>2</sub> /yr) for natural disturbances for FM and AR .....	794
Table 12.1 Information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Romanian registry at 31.12.2017 .....	814
Table 14.1 Changes to the national registry .....	819

## LIST OF EQUATIONS

Equation 4.1 Calculation of EF for clinker .....	310
Equation 4.2 The quantity of banks for Domestic Refrigeration.....	415
Equation 4.3 The total number of cars with Mobile Air-Conditioning units in year y.....	429
Equation 4.4 The quantity of banks of the Domestic Air-Conditioning.....	437
Equation 5.1 Calculation of energy gross intake .....	479
Equation 5.2 Nitrogen excretion .....	515
Equation 6.1 Estimation of C stock change uses .....	584
Equation 6.2 The average annual increment in biomass ( $G_{TOTAL}$ ) .....	585
Equation 6.3 Annual decrease of carbon stock due to biomass loss.....	588
Equation 6.4 Annual carbon loss due to wood harvesting.....	588
Equation 6.5 Other annual carbon losses .....	589
Equation 6.6 Annual C stock change on lands with woody perennial crops .....	601
Equation 6.7 Annual C stock increase on lands with woody perennial crops .....	601
Equation 6.8 Annual C stock decrease on lands with woody perennial crops .....	602
Equation 6.9 GHG emissions from forest fires.....	628
Equation 6.10 Calculation of absolute CO <sub>2</sub> and non-CO <sub>2</sub> emissions from forest fires .....	629
Equation 9.1 The Emission Factor for SO <sub>2</sub> .....	706
Equation 9.2 The SO <sub>2</sub> emissions from cement production .....	716
Equation 9.3 CO emissions from ammonia production .....	718
Equation 9.4 SO <sub>2</sub> emissions from ammonia production .....	719

**LIST OF ABBREVIATIONS**

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 <sub>0</sub>	Maximum methane (CH <sub>4</sub> ) 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 <sup>nat</sup>	National Oxidation Factor expressed in Carbon content
C <sub>2</sub> F <sub>6</sub>	Hexafluoroethane
CaCO <sub>3</sub>	Calcium Carbonate (limestone)
CaO	Calcium Oxide (lime)
CaO*MgO	Dolomitic lime
CAP	Agricultural Production Cooperatives
Cel B	Gross Pulp
CF <sub>4</sub>	Tetrafluoromethane
CH <sub>4</sub>	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 <sub>2</sub>	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 <sub>s</sub>	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 <sub>F</sub>	Fraction of DOC Dissimilated
DOM	Dead Organic Matter
DS <sub>dom</sub>	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 <sup>nat</sup>	National Emission Factor without Factor Oxidation
EF-Ox <sup>nat</sup>	National Emission Factor with Factor Oxidation
EF <sub>s</sub>	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 <sub>s</sub>	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 <sup>3</sup>	meter cubic
mm	millimeter
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 <sub>3</sub>	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 <sub>2</sub> O	Nitrous Oxide
NACE	National Classification of Economic Activities
NCV <sub>s</sub>	Net Calorific Values
NEPA	National Environmental Protection Agency
N <sub>ex</sub>	Available for annual average N excretion per head of species/category
NFI	National Forest Inventory
NGHGI	National Greenhouse Gas Inventory
NH <sub>3</sub>	Ammonia
NIM	National Institute of Meteorology
NIR	National Inventory Report
NIS	National Institute for Statistics
NMVOC	Non-methane Volatile Organic Compound
NO	Not occurred
NO <sub>x</sub>	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 <sub>s</sub>	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 <sub>6</sub>	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 <sub>2</sub>	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 <sub>x</sub>	Fraction of wastewater treated anaerobically										
Y <sub>m</sub>	Methane conversion rate as the fraction of gross energy in feed converted to methane										
YR	Year										
%	Percent										
Notation Keys	<table> <tr> <td>IE</td><td>Included elsewhere</td></tr> <tr> <td>NA</td><td>Not Applicable</td></tr> <tr> <td>NE</td><td>Not Estimated</td></tr> <tr> <td>NO</td><td>Not occurring</td></tr> <tr> <td>C</td><td>Confidential</td></tr> </table>	IE	Included elsewhere	NA	Not Applicable	NE	Not Estimated	NO	Not occurring	C	Confidential
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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<sub>2</sub> atmospheric concentration would double, it is expected for the coming decades that the average global temperature will increase by 2.4-7.4°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 26th version of the National Inventory Report (NIR) submitted by Romania, covering the national inventories of GHG emissions/removals for the period 1989-2016. This inventory (comprising the current National Inventory

Report and the associated CRF tables) represents the 2018 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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>, NF<sub>3</sub> and indirect GHGs: NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>. 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<sub>2</sub> equivalent using the Global Warming Potential values provided by IPCC in the Fourth 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

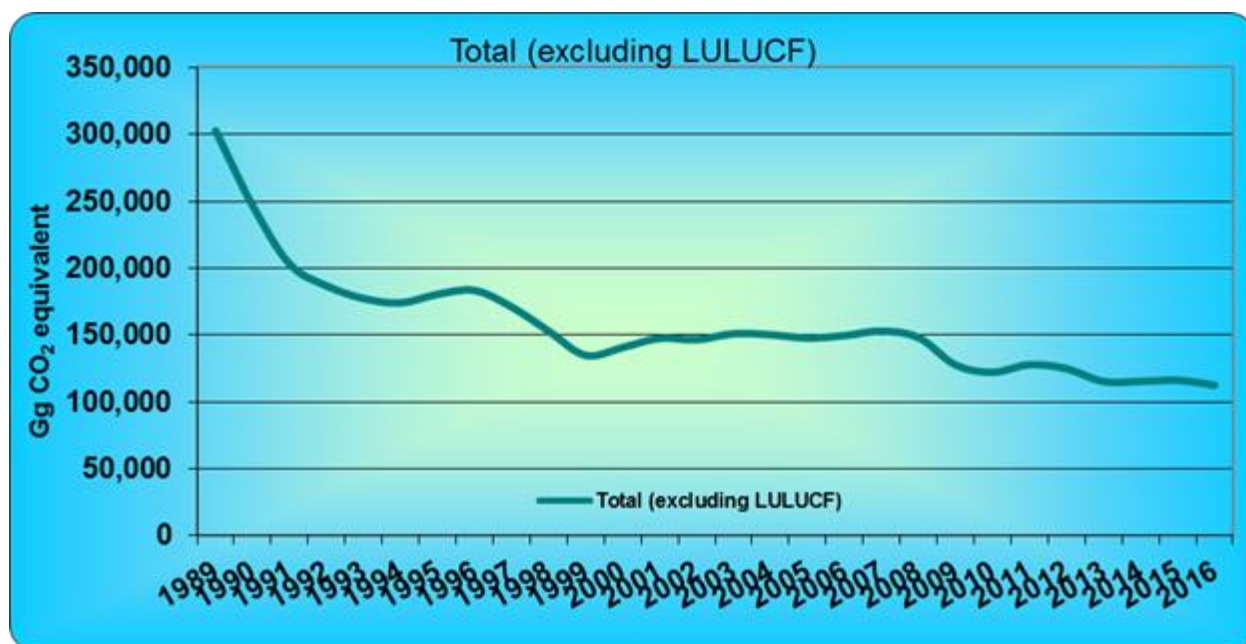
increase after 1999 as a consequence of the economy revitalization; in 2009, the emissions decreased significantly comparing to the level in 2008 while in 2010 they continued to decrease, due to the economic crisis. In 2011, the emissions started to increase again while in 2012-2013 they decreased; in 2014-2015 they slowly increased and in 2016 they increased following the economic activities level.

The largest contributor to the total national GHG emissions is CO<sub>2</sub>, followed by CH<sub>4</sub> and N<sub>2</sub>O. The share of each direct GHG in total emissions in 1989 and, respectively 2016, and the average share of each direct GHG in total emissions for 1989-2016 period are presented in the Table ES.1.

The total GHG emissions excluding LULUCF, in CO<sub>2</sub> equivalent, during 1989-2016 period, are presented in the Figure ES.1.

***Table ES 1 Share of each direct GHG in total emissions in 1989, 2016, respectively 1989-2016 period***

<b>GHG</b>	<b>1989 (%)</b>	<b>2016 (%)</b>	<b>Average share for 1989-2016 period (%)</b>
<b>CO<sub>2</sub></b>	69.26%	66.69%	68.55%
<b>CH<sub>4</sub></b>	23.19%	25.37%	24.28%
<b>N<sub>2</sub>O</b>	6.08%	6.21%	6.15%
<b>HFCs</b>	0.00%	0.0168%	0.39%
<b>PFCs</b>	1.47%	0.00%	0.62%
<b>SF<sub>6</sub></b>	0.00%	0.00044%	0.02%
<b>NF<sub>3</sub></b>	0.00%	0.00%	0.00%

**Figure ES 1 The total GHG emissions in CO<sub>2</sub> equivalent during 1989-2016 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 1989–2016 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<sub>2</sub>);
- ❖ methane (CH<sub>4</sub>);
- ❖ nitrous oxide (N<sub>2</sub>O);
- ❖ hydrofluorocarbons (HFCs);
- ❖ perfluorocarbons (PFCs);
- ❖ sulphur hexafluoride (SF<sub>6</sub>);
- ❖ nitrogen trifluoride (NF<sub>3</sub>).

The report also contains data on calculations of emissions of the indirect GHGs: NO<sub>x</sub>, NMVOC, CO and SO<sub>2</sub>, 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 6.0.4.

### *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<sub>x</sub>, NMVOC, CO and SO<sub>2</sub>) 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<sub>2</sub>, NO<sub>x</sub> 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 2016 year, the forest land area accounted for approximately 7 006,6 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<sub>2</sub> 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 26th 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 2018 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 1989-2016 period and the National Inventory Report. The greatest attention during the preparation was paid to the direct GHGs mentioned through

Annex A of the Kyoto Protocol - CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub> and NF<sub>3</sub>. In addition, the indirect GHGs (NO<sub>x</sub>, CO, NMVOCs, and SO<sub>2</sub>) 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***

<b>Year</b>	<b>Submission</b>	<b>Review process</b>
<b>2002</b>	CRF tables and draft NIR submitted (late submission)	No Review
<b>2003</b>	CRF tables and NIR submitted	In - country Review
<b>2004</b>	CRF tables and NIR submitted	Desk Review
<b>2005</b>	CRF Reporter database, CRFs for LULUCF and NIR submitted	Centralized Review
<b>2007</b>	2 <sup>nd</sup> version of the 2006 submission: CRF Reporter database, CRF Tables and NIR + Initial Report of Romania under the Kyoto Protocol	In - country Review
<b>2008</b>	2007 and 2008 submissions: CRF Reporter database, CRF Tables and NIR	Centralized Review
<b>2009</b>	2009 submission: CRF Reporter database, CRF Tables and NIR	Centralized Review
<b>2010</b>	2010 submission: CRF Reporter database, CRF Tables and NIR	Centralized Review
<b>2011</b>	3 <sup>rd</sup> version of the 2011 submission	In - country Review
<b>2012</b>	2 <sup>nd</sup> version of the 2012 submission	Centralized Review
<b>2013</b>	1 <sup>st</sup> version of the 2013 submission	Centralized Review
<b>2014</b>	1 <sup>st</sup> version of the 2014 submission	Centralized Review
<b>2016</b>	2 <sup>nd</sup> 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 relating 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 Urgency 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<sub>2</sub>O 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<sub>6</sub>), 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<sub>6</sub> data and information.

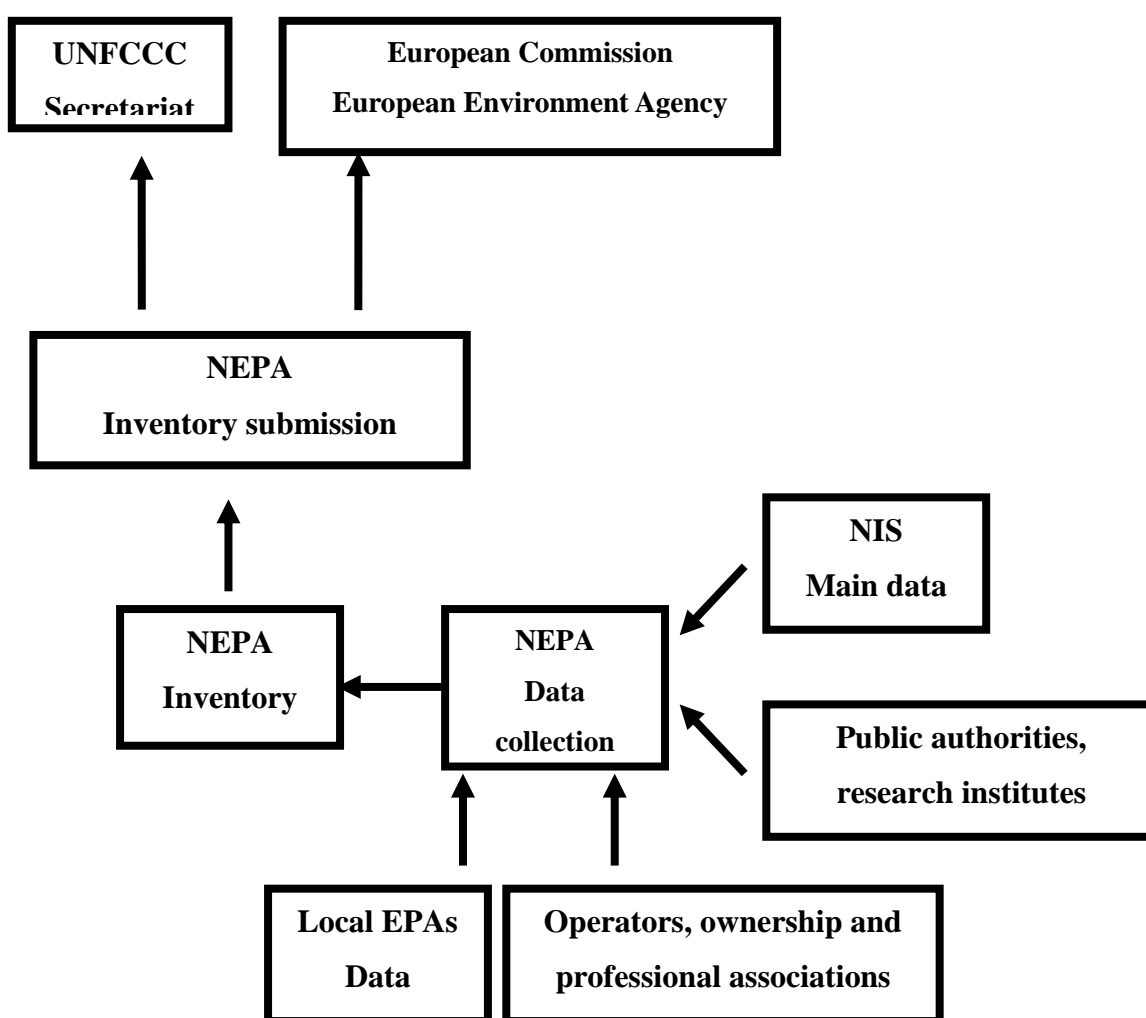
- ❖ the “Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO<sub>2</sub>) and other greenhouse gas emissions” study was carried out in 2011 by the Institute for Studies and Power Engineering (ISPE); specific elements comprise:

- 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 and approves the National GHGI; NEPA submits the National GHGI to the UNFCCC Secretariat, the European Commission and the European Environment Agency taking into account the specific deadlines.

*Figure 1.1 Current national inventory system description*



### *Legal and procedural arrangements*

The legal and procedural framework specific to the NS include:

- ❖ GD no. 1022/2016 and 120/2014 for modifying and completing the GD no. 1570/2007 for establishing the National System for the estimation of anthropogenic greenhouse gas emissions levels from sources and removals by sinks of all GHGs, regulated through the KP, and also for establishing some measures on implementing the Regulation (EU) no. 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing 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<sub>2</sub> 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<sub>2</sub> 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 Decision 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:
  - appropriate working space and facilities have been provided;
  - the necessary IT equipment has been procured through the support of study “Environmental Integrated Informational System”;
  - training the dedicated staff was subject to the UNFCCC training courses and of the study performed in 2011 “Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO<sub>2</sub>) and other greenhouse gas emissions”; additionally, the European Environment Agency (EEA) through the European Topic Centre for Air pollution and Climate change Mitigation provided both in 2011 and 2012 technical assistance to the NS/NGHGI dedicated team;
  - on contractual basis, the NEPA personnel administrating the NGHGI Energy Sector received in 2011 technical assistance from the Environment Agency of Austria, the results being incorporated in the NGHGI 2012;
  - training was based on the Schedule for training of new staff part of the NEPA team

- dedicated to the administration of the NS and the NGHGI, respectively (Table 1);
- general training session for improving the expertise of the personnel working in the climate change field, at the central administration and subsequent level, including personnel from NGHGI data/information providers/potential providers, was held in 2011 in the context of the “Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO<sub>2</sub>) 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 (NS) and the Greenhouse Gas Inventory (NGHGI)	1 September 2011-10 March 2012	All new Sectorial Experts (SEs)	GHG Inventory coordinator	Governmental Decision (GD) no. 1570/2007, Ministry of Environment Order (MoEO) no. 1376/2008 for approving the Procedure on NGHGI reporting and the modality for answering to the observations and questions raised following the NGHGI review; MoEO no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI; NEPA's President Decision no. 23/2009 for approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels; NEPA's President Decision no. 24/2009 for approving the QA/QC Procedure related to the NGHGI, National Inventory Report-Romanian version-NGHGI 2009, NGHGI 2011, 2010, 2009, Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11 (UNFCCC Reporting Guidelines), IPCC good practice guidance (IPCC GPG 2000), IPCC good practice guidance for LULUCF (IPCC GPG 2003), IPCC 1996.
2.	Training in the context of the study "Support for the implementation of the European Union requirements on the monitoring and reporting of the carbon dioxide (CO <sub>2</sub> ) and other greenhouse gas emissions"	31 October 2011	All new SEs	GHG Inventory coordinator	

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



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

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

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

Specific elements comprise:

- ❖ as a Party to the UNFCCC, KP and as a Member State of the European Union, Romania annually submits the GHGI;
- ❖ 2017 submission of the NGHGI constitutes the 25<sup>th</sup> 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 Independenței 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](mailto: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<sub>6</sub>), 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<sub>2</sub>O 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”.
- 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<sub>6</sub>), 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<sub>2</sub>O 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:
  - 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<sub>6</sub>), 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<sub>2</sub>O 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<sub>6</sub>), 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<sub>2</sub>O 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<sub>6</sub>), 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<sub>2</sub>O 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, 2016 and 2017, 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<sub>2</sub>O 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<sub>6</sub>), 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<sub>6</sub> 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<sub>6</sub>), 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<sub>2</sub>O 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 1<sup>st</sup> 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 15<sup>th</sup> 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<sub>6</sub>), 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<sub>2</sub>O 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, 2016 and 2017, 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<sub>2</sub> 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<sub>4</sub> 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<sub>6</sub>), 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<sub>2</sub>O 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 2016, 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<sub>6</sub>), 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<sub>2</sub>O 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<sub>6</sub>), 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<sub>2</sub>O 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 were/are also implemented within the collaboration between:

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

### ***Data archive***

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

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
<b>Energy</b>	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
<b>Industrial Processes and Product Use</b>	National Institute for Statistics- Statistical Yearbook and other data sources Industrial operators through 42 Local/Regional Environmental Protection Agencies Direct information from industrial operators
<b>Agriculture</b>	National Institute for Statistics

Sector	Data sources
<b>LULUCF</b>	National Institute for Statistics through Statistical Yearbook Ministry of Agriculture, Forests and Rural Development (MADR)-Forests General Directorate (2007-2008); Ministry of Environment and Forests-Forests General Directorate (2009-2011); MECC-Department for Waters, Forests and Fish Farming (2012) National Forest Administration (RNP)
<b>Waste</b>	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<sub>6</sub>), 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<sub>2</sub>O 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<sub>6</sub>), 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 2016 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 2016, 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<sub>6</sub>), 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<sub>2</sub>O 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.

*Considering the 2018 NGHGI and the Tier 1 method:*

- ❖ the total NGHGI uncertainty for 2016 excluding LULUCF was 11.9%, while including LULUCF was 19.6%;
- ❖ the uncertainty introduced into the trend in total national emissions, for 2016, was 2.1% when considering excluding LULUCF criteria and 5.9%, including LULUCF.

Based on data and information associated with the 2018 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 1989-2016 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

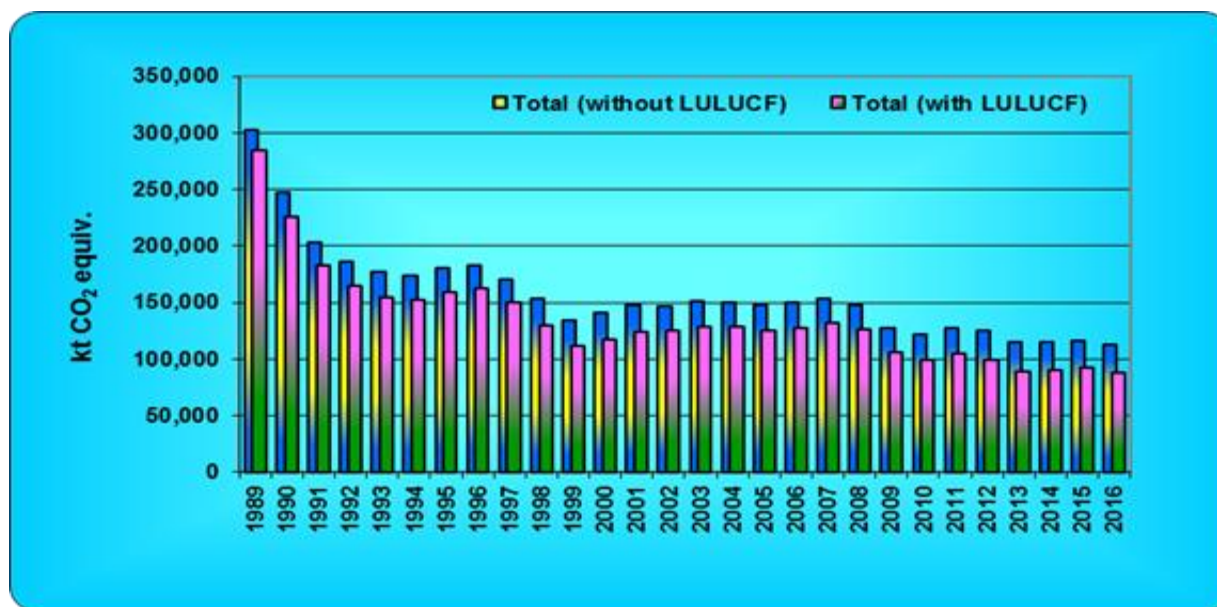
### 2.1 Description and interpretation of emissions trends for aggregated GHG emissions

The total GHG emissions in 2016, excluding removals by sinks, amounted to 112,542.36 CO<sub>2</sub> 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 62.81% in 2016 in comparison to 1989 while the net GHG emissions/ removals (taking into account the CO<sub>2</sub> removals) decreased with 68.93%. 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 period 2009-2016.

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<sub>6</sub>, 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<sub>2</sub>, followed by CH<sub>4</sub> and N<sub>2</sub>O. In the base year, the shares of GHG emissions were: 69.26% CO<sub>2</sub>, 23.19% CH<sub>4</sub>, 6.08% N<sub>2</sub>O, 1.47% PFCs. In 2016, the shares of GHG emissions were: 66.69% CO<sub>2</sub>, 25.37% CH<sub>4</sub>, 6.21% N<sub>2</sub>O, 0.00% PFCs. The F gases started to be used as substitutes for ODS in refrigerating and air conditioning systems since 1991. In 2016, the contribution of these gases to the total GHG emissions is negligible: 1.68% HFCs and 0.04% SF<sub>6</sub>. Next table presents the trend of the aggregated emissions, split by gas.

***Table 2.1 Trends by gas [kt CO<sub>2</sub> equivalent]***

<b>Year</b>	<b>CO<sub>2</sub> including LULUCF</b>	<b>CO<sub>2</sub> excluding LULUCF</b>	<b>CH<sub>4</sub> excluding LULUCF</b>	<b>N<sub>2</sub>O excluding LULUCF</b>	<b>HFCs</b>	<b>PFCs</b>	<b>SF<sub>6</sub></b>
<b>1989</b>	209,595.92	189,719.44	70,186.63	18,401.44	0.16	4,446.00	0.47
<b>1990</b>	171,231.79	149,308.97	57,229.56	15,477.43	0.18	2,808.43	0.47
<b>1995</b>	124,836.93	101,630.76	41,939.48	11,344.43	2.53	2,354.07	0.98



Year	CO <sub>2</sub> including LULUCF	CO <sub>2</sub> excluding LULUCF	CH <sub>4</sub> excluding LULUCF	N <sub>2</sub> O excluding LULUCF	HFCs	PFCs	SF <sub>6</sub>
2000	93,538.38	68,953.70	36,107.23	9,333.79	70.82	1,674.72	8.68
2005	100,966.62	76,328.76	36,059.30	10,322.16	368.91	95.28	15.67
2007	108,559.69	85,269.93	34,508.33	9,192.33	665.63	28.18	29.88
2008	105,365.40	81,625.71	33,724.54	7,989.77	946.95	17.87	33.83
2009	87,205.42	63,547.76	32,157.97	7,318.72	924.42	8.16	47.03
2010	83,551.26	58,696.10	30,042.19	7,536.50	982.46	9.13	60.71
2011	89,343.22	64,001.45	29,520.29	7,859.26	1,092.14	12.72	47.83
2012	86,320.93	59,244.98	30,123.95	7,146.74	1,197.29	7.43	50.76
2013	76,829.20	49,161.65	29,766.70	7,304.57	1,298.45	6.15	57.20
2014	77,160.49	49,831.58	29,742.20	7,037.30	1,373.10	6.34	51.78
2015	77,788.22	52,418.13	29,584.06	7,143.44	1,636.76	6.57	52.27
2016	75,051.66	48,740.60	28,551.60	6,989.67	1,894.11	5.44	49.88

**Carbon dioxide (CO<sub>2</sub>)** – the most significant anthropogenic greenhouse gas is the carbon dioxide. The decrease of CO<sub>2</sub> emissions (from 209,595.92 Gg in 1989 to 75,051.66 Gg in 2016) 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<sub>4</sub>)** – the methane emissions, related mainly to the Fugitive emissions from fossil fuels extraction and distribution and to the livestock, decreased in 2016 by 59.32% compared with the levels in 1989. The decrease of CH<sub>4</sub> emissions in Agriculture is due to the decrease of the livestock level.

**Nitrous oxide (N<sub>2</sub>O)** – the N<sub>2</sub>O 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<sub>2</sub>O emissions trend. The N<sub>2</sub>O emissions in 2016 decreased with 62.02% in comparison with the level in the base year.

**Fluorocarbons and SF<sub>6</sub> (HFCs, PFCs, SF<sub>6</sub>)** – The PFCs emissions generated in the production of the primary aluminium are reported for the entire analyzed period (1989-2016) and have decreased with 99.88% in 2016 comparing with the level in 1989.

### *2.1.2 Description and interpretation of emissions trends for indirect greenhouse gases and SO<sub>2</sub>*

The trends of the indirect GHGs are similar with the GHGs trends (Table 2.2). The CO, NO<sub>x</sub>, NMVOC and SO<sub>2</sub> emissions evolution follows the general direct GHG emissions trend. The SO<sub>2</sub> emissions decrease is caused by the decline of the fuels burnt for energy and the decrease of sulphur content in fuels.

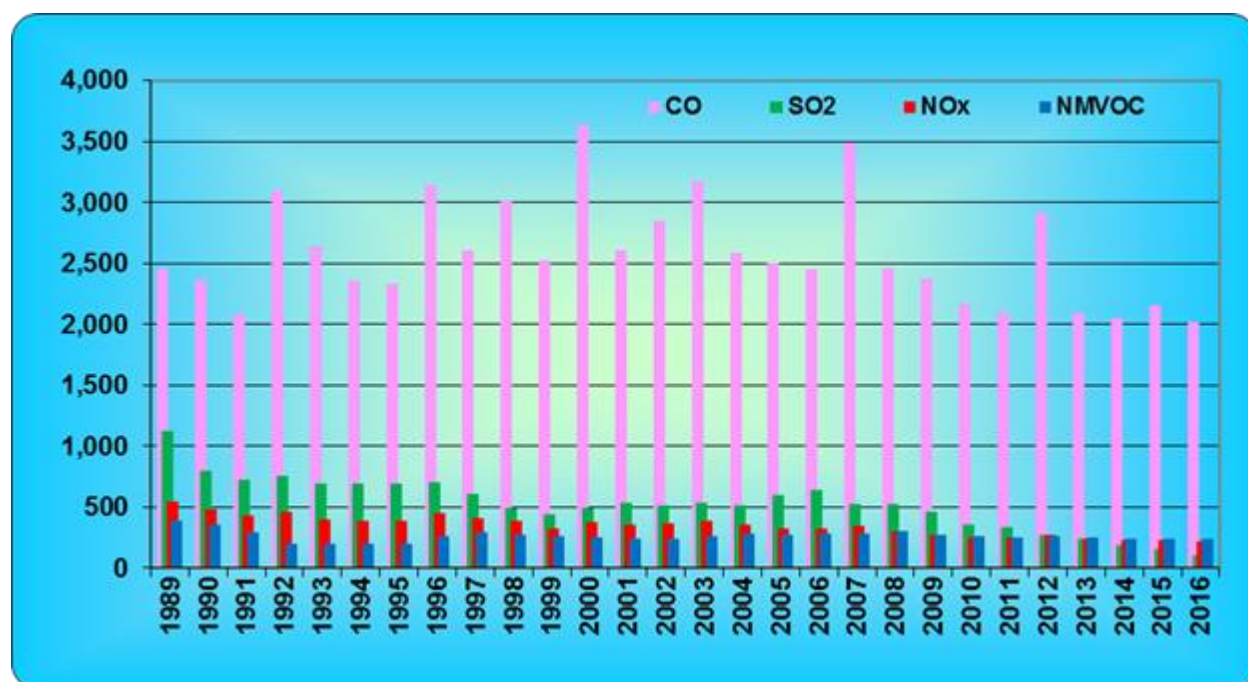
The indirect GHG emissions trends are presented in Figure 2.2.

**Table 2.2 Indirect GHG emissions levels [kt]**

Year	NO <sub>x</sub>	CO	NMVOC	SO <sub>2</sub>
1989	551.11	2457.01	388.02	1120.60
1990	485.02	2368.84	352.65	802.11
1995	390.20	2331.17	203.22	697.02
2000	375.86	3643.53	255.53	493.86
2005	320.51	2500.28	274.53	598.63
2007	345.62	3496.58	277.93	521.40
2008	303.28	2465.32	301.74	528.30
2009	273.54	2379.51	267.98	458.59
2010	247.94	2168.41	266.23	360.64
2011	252.94	2102.47	254.34	339.09
2012	274.52	2909.15	261.75	277.07

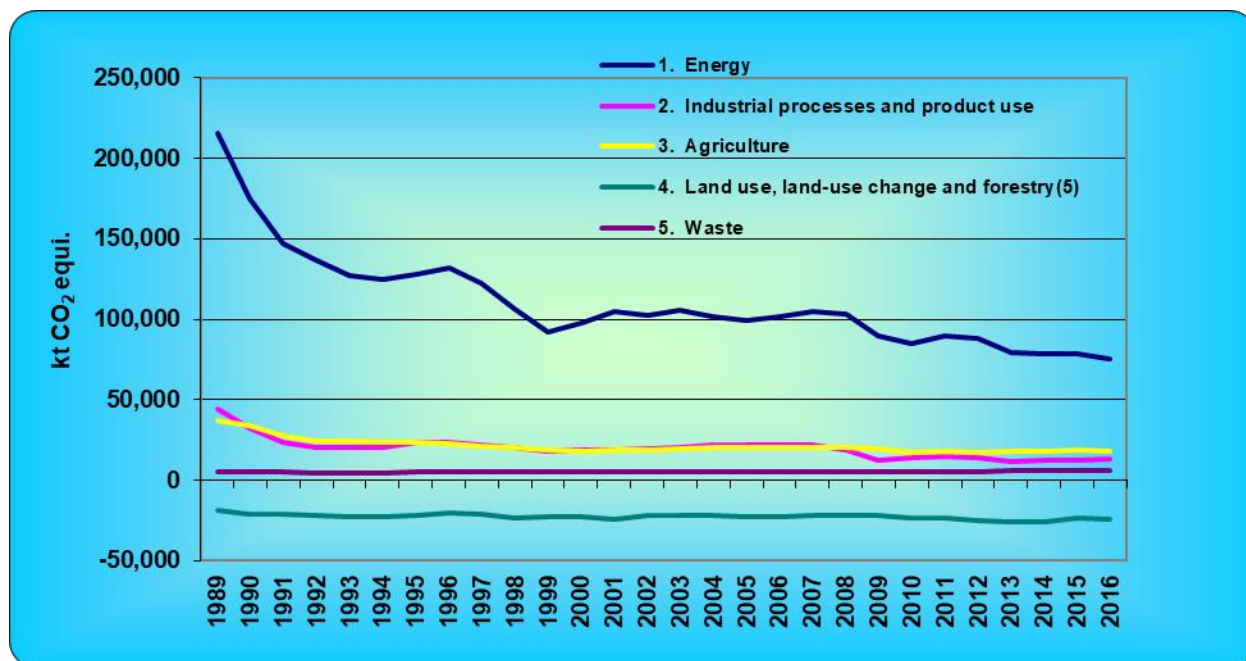
Year	NO <sub>x</sub>	CO	NMVOC	SO <sub>2</sub>
2013	237.42	2094.50	247.36	240.30
2014	226.21	2051.80	243.37	193.38
2015	225.21	2156.33	238.58	154.56
2016	215.32	2023.24	238.61	107.42

*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<sub>2</sub> equivalent.

*Figure 2.3 Trends by sector*

**Energy** - represents the most important sector in Romania. The Energy sector accounted for 67.03% of the total national GHG emissions in 2016. The GHG emissions resulted from the Energy sector decreased by 64.97% compared with the base year.

**Industrial processes and product use** - contributes to total GHG emissions with 11.50% in 2016. A significant decrease of GHG emissions was registered in this sector 71.03% decreases in 2016 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 2016 are 51.16% 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.

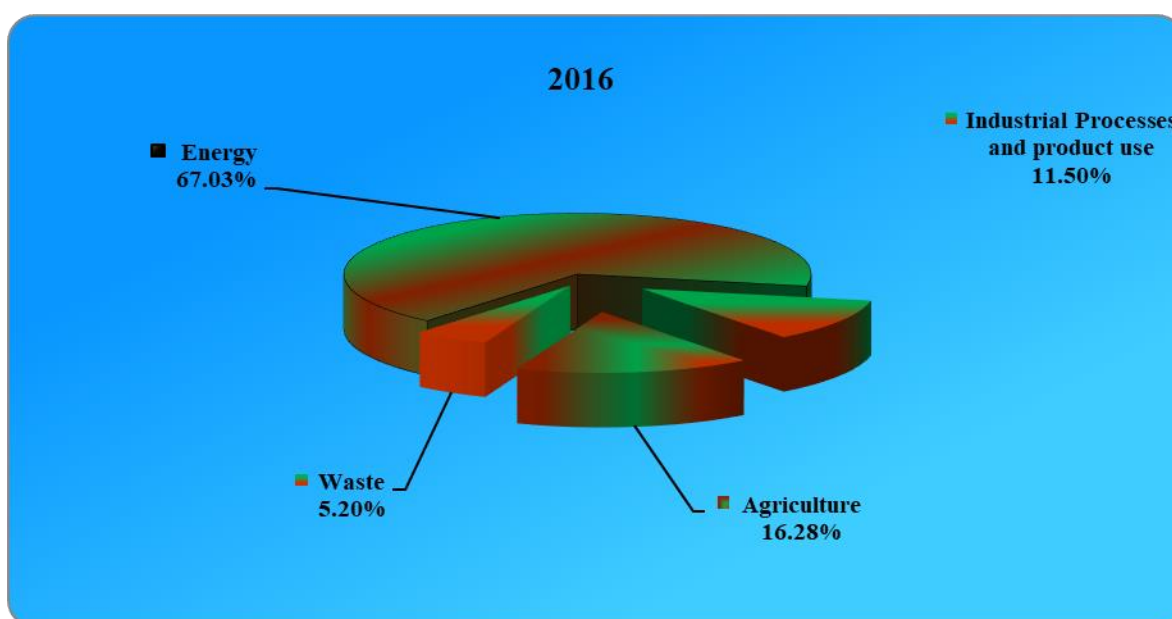
In 2016 year, 16.28 % of the total GHG emissions resulted from the agriculture sector.

**LULUCF** - The net GHG removals/emissions level is 30.35% higher in 2016 in comparison with the level in the base year.

**Waste** sector - emissions have increased in 2016 with 13.87% in comparison with the level in 1989. The contribution of the waste sector to the total GHG emissions in 2016 is 5.20%.

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

*Figure 2.4 Sectorial GHG emissions in 2016 [%]*



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

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

### 3 ENERGY (CRF Sector 1)

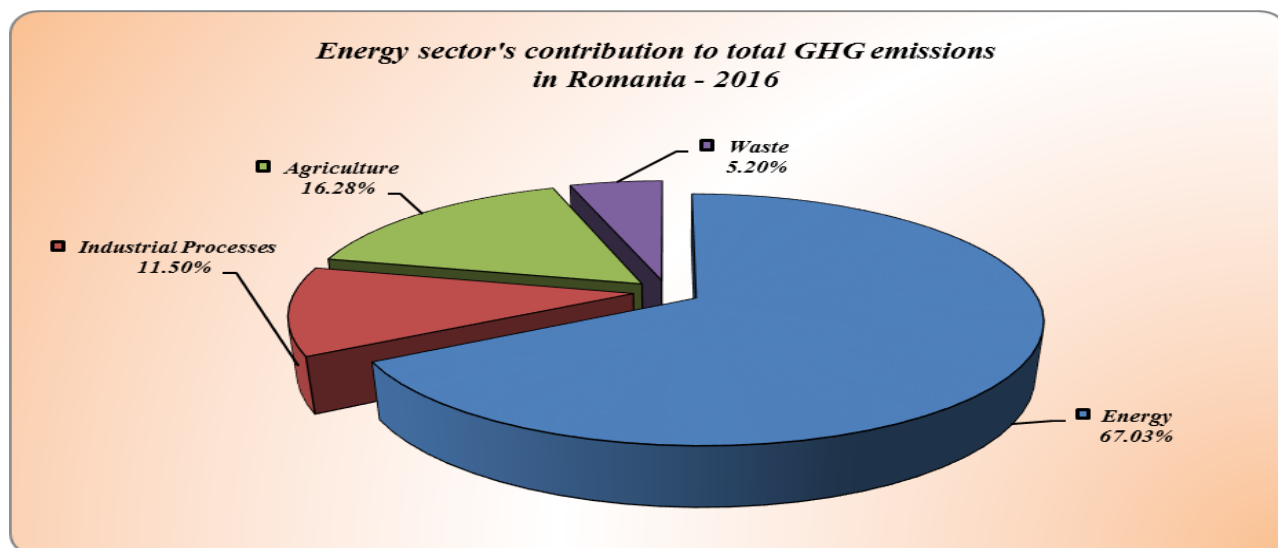
#### 3.1 Overview of the sector

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

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

Compared to the other GHG emissions sectors (Industrial Processes, Agriculture, LULUCF, Waste), the Energy sector represents the largest source of anthropogenic GHG emissions in Romania. In 2016, the Energy sector was responsible for about 67.03% of the total GHG emissions 112,542.36 kt CO<sub>2</sub> equivalent.

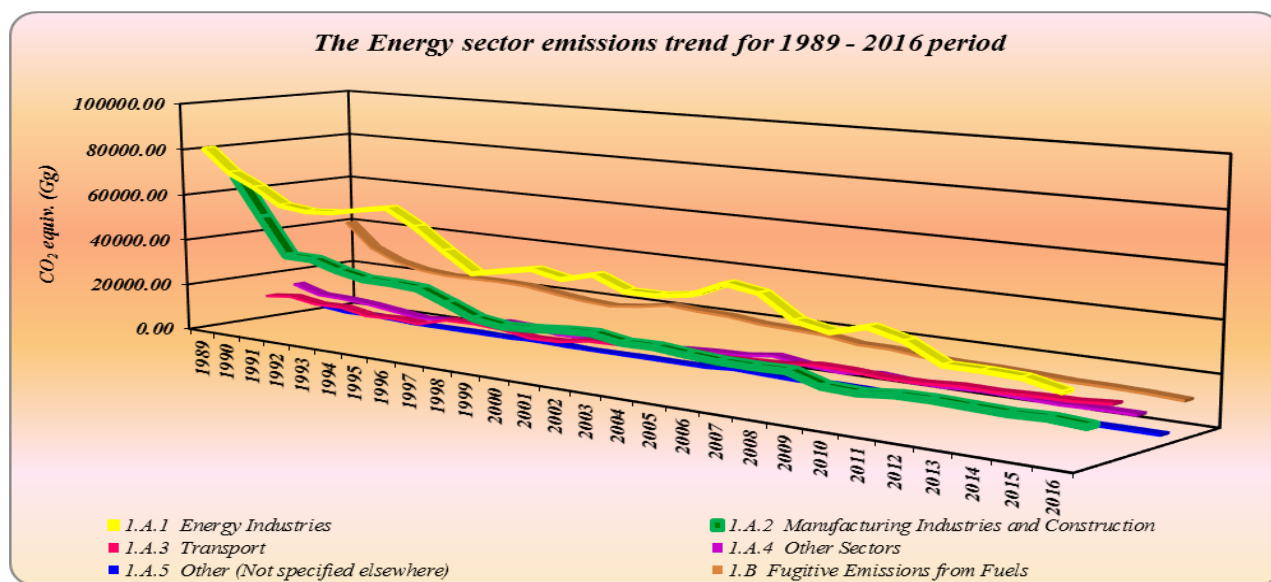
*Figure 3.1 The contribution of Energy Sector to the total GHG emissions in Romania, 2016*



### *Emission trends*

In 2016, emissions from the Energy sector have decreased by 64.97% (75,431.74 kt CO<sub>2</sub> equivalent compared to 215,313.14 kt CO<sub>2</sub> equivalent in 1989, base year).

**Figure 3.2 The energy sector emission trend for the period 1989-2016**



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

With the entire economy in transition, some energy intensive industries reduced their activities and more coal mines have diminished their activity and all these are reflected in the GHG emissions reduction.

The decline of economic activities and energy consumption in the period 1989-1992 had directly caused the decline in total emissions in that period.

Emissions have started to increase until 1994, because of economy revitalization. Considering the starting of the operation at the first reactor at the Cernavoda nuclear power plant (1996), the emissions started to decrease again. The decrease continued until 1999. The increased trend after 1999 reflects the economic development in the period 1999-2004. At the end of 2007, the second

unit of the Cernavoda nuclear plant was functioning, therefore the decrease in emission trend is not very noticeable; for 2008 it was noticed a slight tendency of decrease of emissions.

In 2015, the available energy resources of oil equivalent (toe), increasing by 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 (+ 31.4%); This, together with the oil resources (which grew by + 1.2%) had a share of about 36% in total primary energy resources; Significant declines were recorded at the natural gas resources usable -3.7%.

In 2016, emissions from the Energy sector have decreased by 55.06% (79,359.67 kt CO<sub>2</sub> equivalent to 2016 compared to 176,586.28 kt CO<sub>2</sub> equivalent in 1990).

In 2016, emissions from the Energy sector have decreased with 0.95% (79,359.67 kt CO<sub>2</sub> equivalent compared to 80,120.37 kt CO<sub>2</sub> equivalent in 2015).

According to the Energy Balance, the energy resources available in 2016 were the same as those in 2015, ie 42.2 million tonnes of oil equivalent (toe), the decrease in primary energy production being offset by the increase in imports of energy products.

Among the primary energy resources, crude oil had the highest growth (+746 thousand toe, + 6.5%); the natural gas increased with 43 thousand toe (+ 0.4%) and the imported coke recorded an increase with 6 thousand toe (+ 1.2%).

Primary energy production of 24798 thousand toe in 2016 decreased with 1589 thousand in comparison with 2015, and the most significant decrease was the production of natural gas (- 1012 thousand toe), representing -11.4%, compared to the previous year.

Imports of energy products increased by 15.7% compared to last year, mainly due to the increase in imports of natural gas (+1025 thousand toe) and crude oil (+872 thousand toe).

Imports of petroleum products and coal (including coke) decreased by 106 thousand toe and 19 thousand toe respectively.

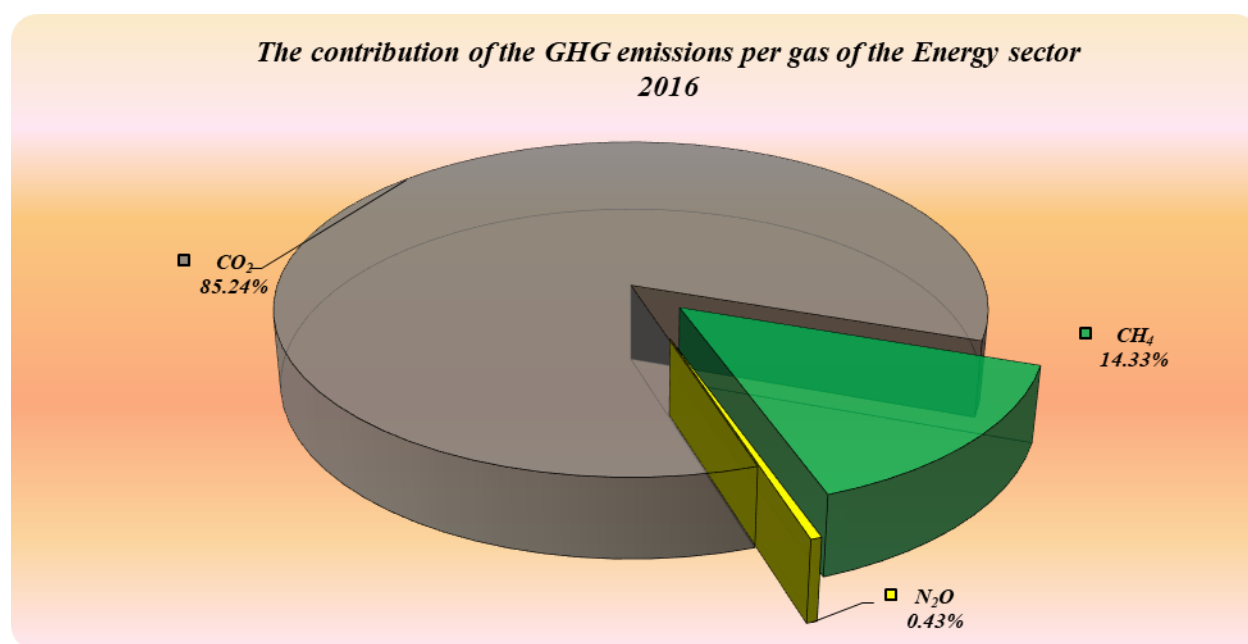
In 2016, the share of coal consumption in the total consumption for the thermoelectric power generation was 45.6% and 18.3% of gaseous hydrocarbons. (Source - Romanian National Institute for Statistics).



**Table 3.1 Shares of GHG emission categories within the Energy sector, in 2016**

Energy sector-categories	Percentages for 2016
<i>Energy industries</i>	34.22
<i>Manufacturing Industries and Construction</i>	15.01
<i>Transports</i>	22.31
<i>Other sectors</i>	13.75
<i>Other</i>	0.62
<i>Fugitive emissions</i>	14.10

The most important GHG in the sector is CO<sub>2</sub>; small amounts of CH<sub>4</sub> and N<sub>2</sub>O are also emitted.

**Figure 3.3 The different GHG's contribution to the 2016 Energy sector**

**Table 3.2 Status of emissions estimation within the Energy Sector for 2016**

IPCC category-Energy Sector	Emissions estimation status		
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
<b>1.AA Fuel Combustion – Sectorial Approach</b>			
<i>1.A.1. Energy Industries</i>			
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	✓	✓	✓
<i>1.A.2. Manufacturing Industries and Construction</i>	✓	✓	✓
1.A.2.a. Iron and steel	✓	✓	✓
1.A.2.b. Non ferrous metals	✓, NO, IE	✓, NO, IE	✓,NO, IE
1.A.2.c. Chemicals	✓	✓	✓
1.A.2.d. Pulp paper and print	✓	✓	✓
1.A.2.e. Food processing, beverages and tobacco	✓	✓	✓
1.A.2.f.	✓	✓	✓
1.A.2.g Other (as specified in table 1.A(a)s2)	✓	✓	✓
<i>1.A.3. Transport</i>			
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	✓	✓	✓
<i>1.A.4. Other Sectors</i>	✓	✓	✓
1.A.4.a. Commercial/institutional	✓	✓	✓
1.A.4.b. Residential	✓	✓	✓
1.A.4.c. Agriculture/Forestry/Fisheries	✓	✓	✓
<i>1.A.5. Other</i>	✓	✓	✓
1.A.5.a.Stationary	✓	✓	✓

IPCC category-Energy Sector	Emissions estimation status		
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
1.A.5.b.Mobile	✓	✓	✓
<b>1.B Fugitive Emissions from Fuels</b>			
<i>1.B.1.Solid Fuels</i>			
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
<i>1.B.2. Oil and Natural Gas</i>			
<i>1.B.2.a. Oil</i>	✓, 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
<i>1.B.2.b. Natural Gas</i>	✓	✓	✓
1.B.2.b.i. Venting gas	✓	✓	NA
1.B.2.b.ii. Flaring gas	✓	✓	✓
1.B.2.b.iii.1. Exploration	IE, NO	IE	NA
1.B.2.b.iii.2. Production	✓, NO	✓	NA
1.B.2.b.iii.3. Processing	✓	✓	NA
1.B.2.b.iii.4. Transmission an storage	✓	✓	NA

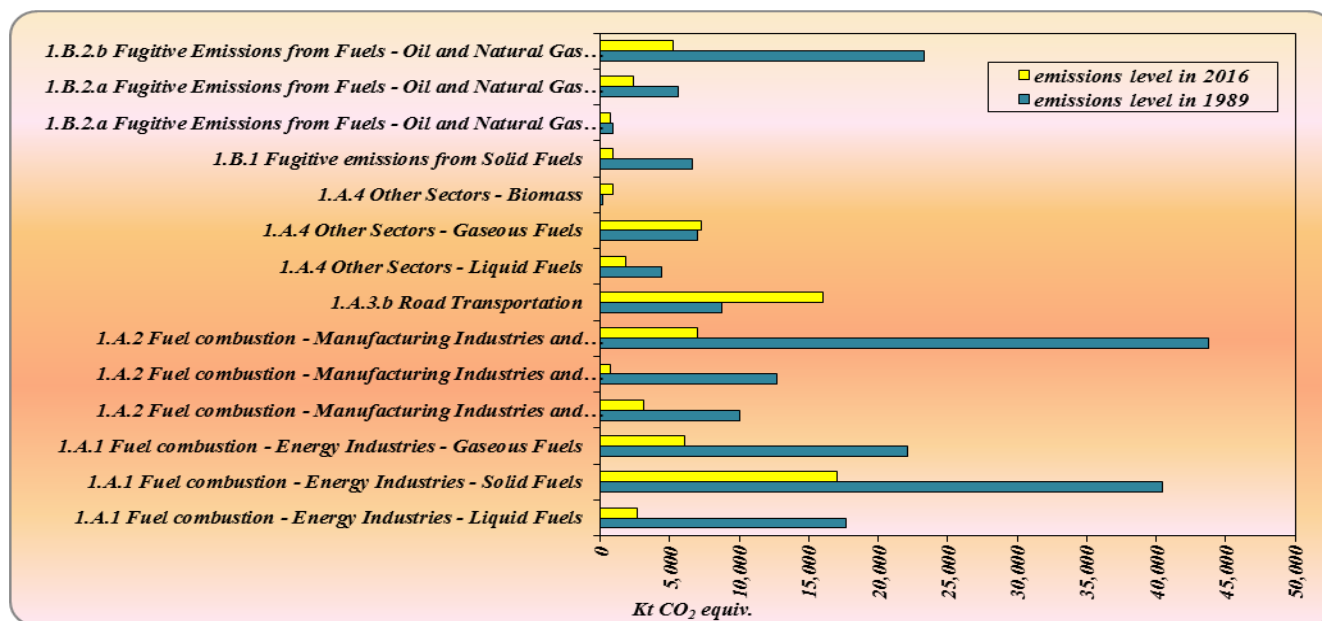
IPCC category-Energy Sector	Emissions estimation status		
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
1.B.2.b.iii.5. Distribution and storage	✓	✓	NA
1.B.2.b.iii.6. Other	NO	✓	NA
1.B.2.d.Other	NO	NO	NA
<i>1.D. Memo items</i>			
1.D.1. International Bunkers			
1.D.1.a. Aviation	✓	✓	✓
1.D.1.b. Marine	✓	✓	✓
1.C.2. Multilateral Operations	NO	NO	NO
1.C.3. CO <sub>2</sub> Emissions from Biomass	✓	NA	NA
1.A.B. Fuel Combustion – Reference Approach	✓		

### 3.1.1 Key sources

**Table 3.3 Key categories overview - Energy 2016**

Key categories	GHG	Criteria	Contribution in total GHG emissions [%]
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	2.33%
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	15.14%
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	5.38%
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	2.73%
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	0.63%

Key categories	GHG	Criteria	Contribution in total GHG emissions [%]
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	6.18%
1.A.3.b Road Transportation	CO <sub>2</sub>	L,T (excluding and including LULUCF)	14.23%
1.A.4 Other Sectors - Liquid Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	1.65%
1.A.4 Other Sectors - Gaseous Fuels	CO <sub>2</sub>	L,T (excluding and including LULUCF)	6.44%
1.A.4 Other Sectors - Biomass	CH <sub>4</sub>	L,T (excluding and including LULUCF)	0.83%
1.B.1 Fugitive emissions from Solid Fuels	CH <sub>4</sub>	L,T (excluding and including LULUCF)	0.81%
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO <sub>2</sub>	L,T (excluding and including LULUCF)	0.63%
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH <sub>4</sub>	L,T (excluding and including LULUCF)	2.10%
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH <sub>4</sub>	L,T (excluding and including LULUCF)	4.62%

**Figure 3.4 Key categories, both by level and trend criteria, overview – Energy Sector, 2016**

## 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<sub>2</sub> 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 corresponding NCVs were derived and used as averages, as follows: for the Romanian EU-ETS reporting period, 2007-2012 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.

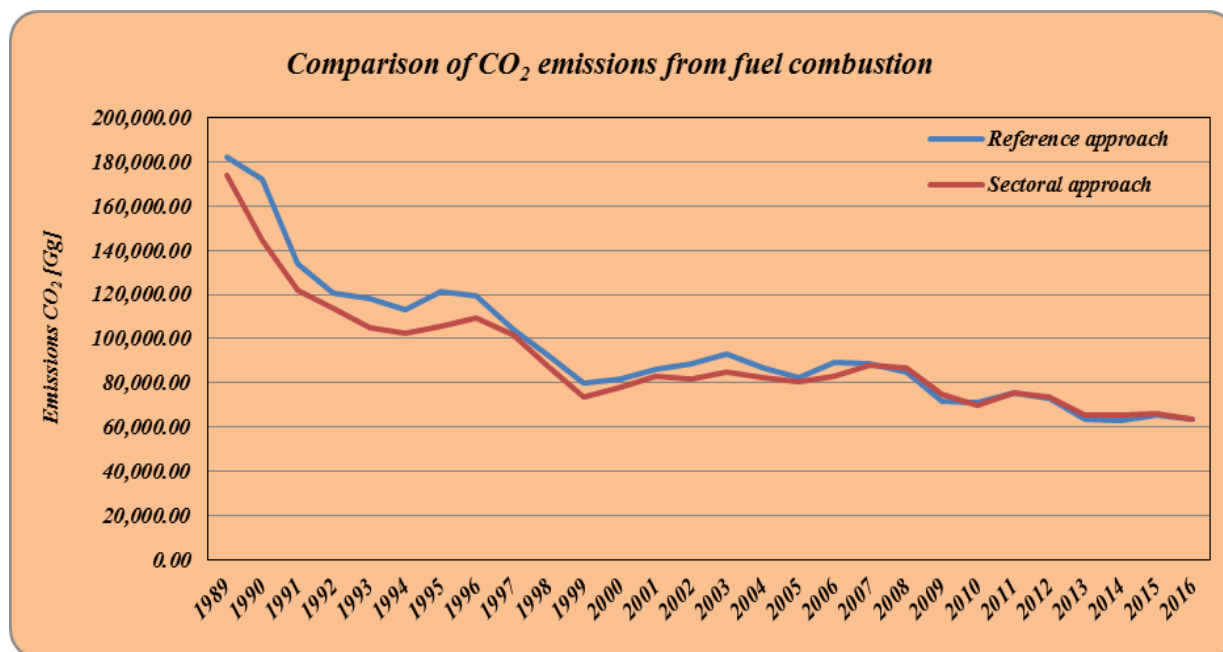
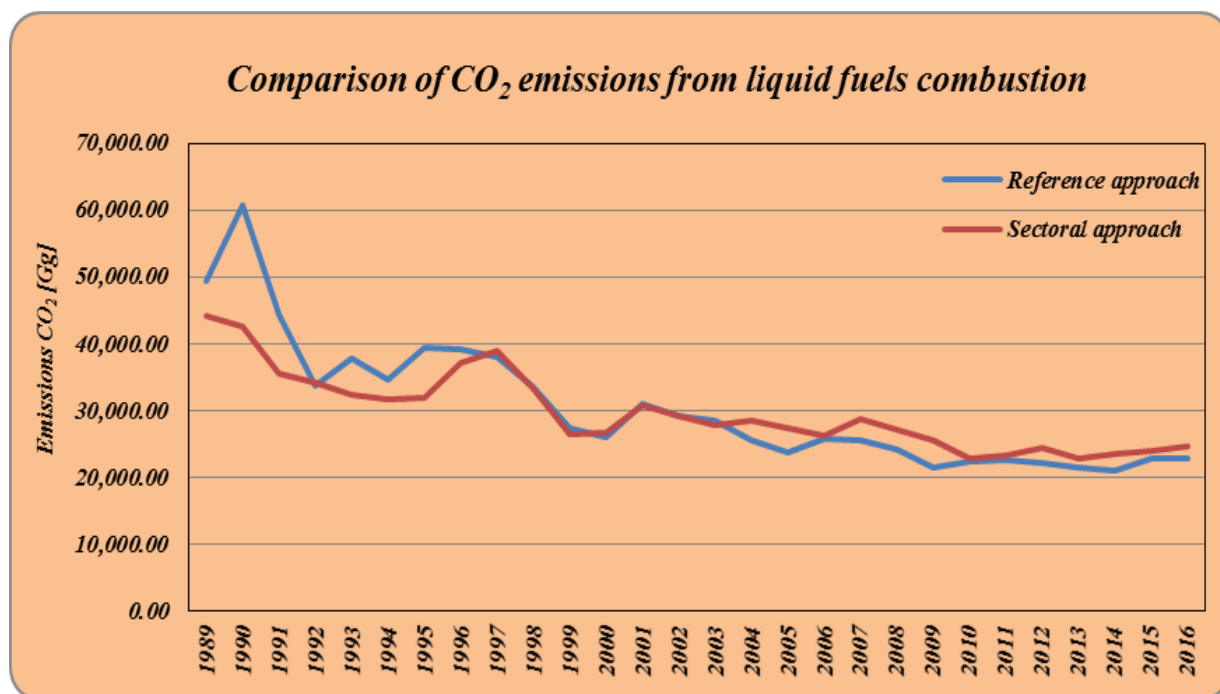
According to the information provided by the National Institute for Statistics, some operators, reporting under the EU ETS for the years 2007–2012, had reported quantities of industrial waste co-incinerated in cement installations as biomass and not as industrial waste. In order to avoid the potential underestimation of emissions in the inventory, from these emissions was subtracted the percentage representing real biomass, and the CO<sub>2</sub> 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<sub>2</sub> emissions were also added in the Reference Approach, as production of industrial wastes and corresponding emissions.

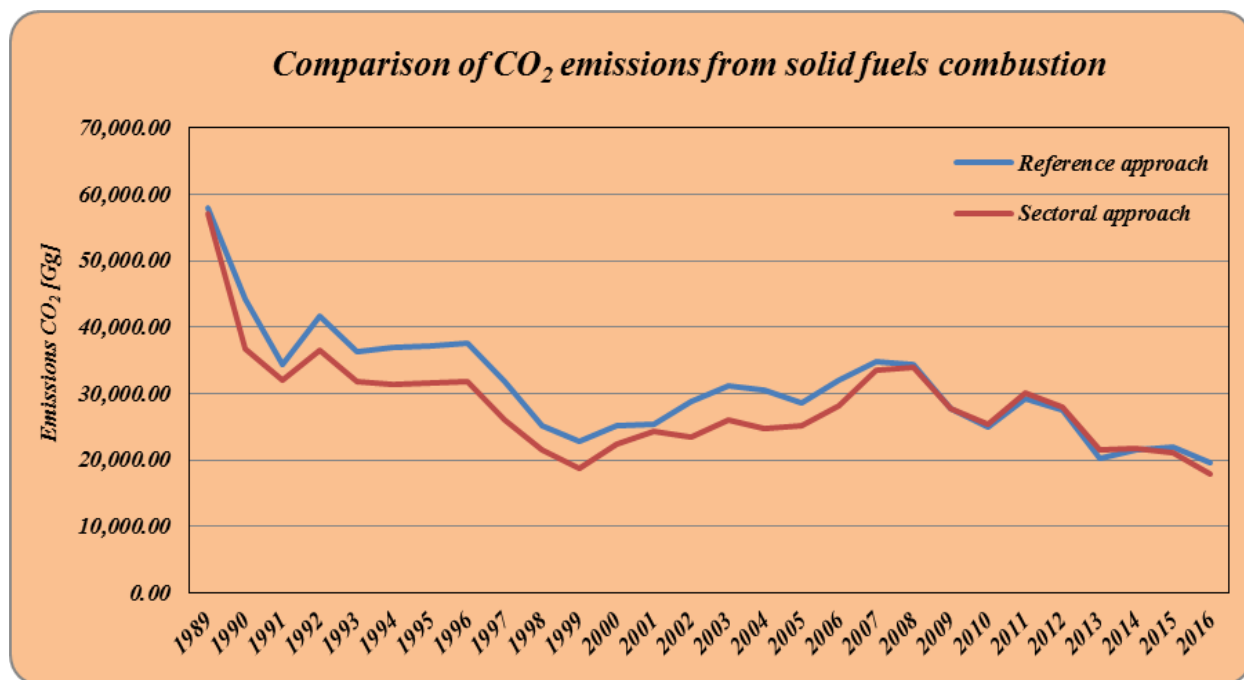
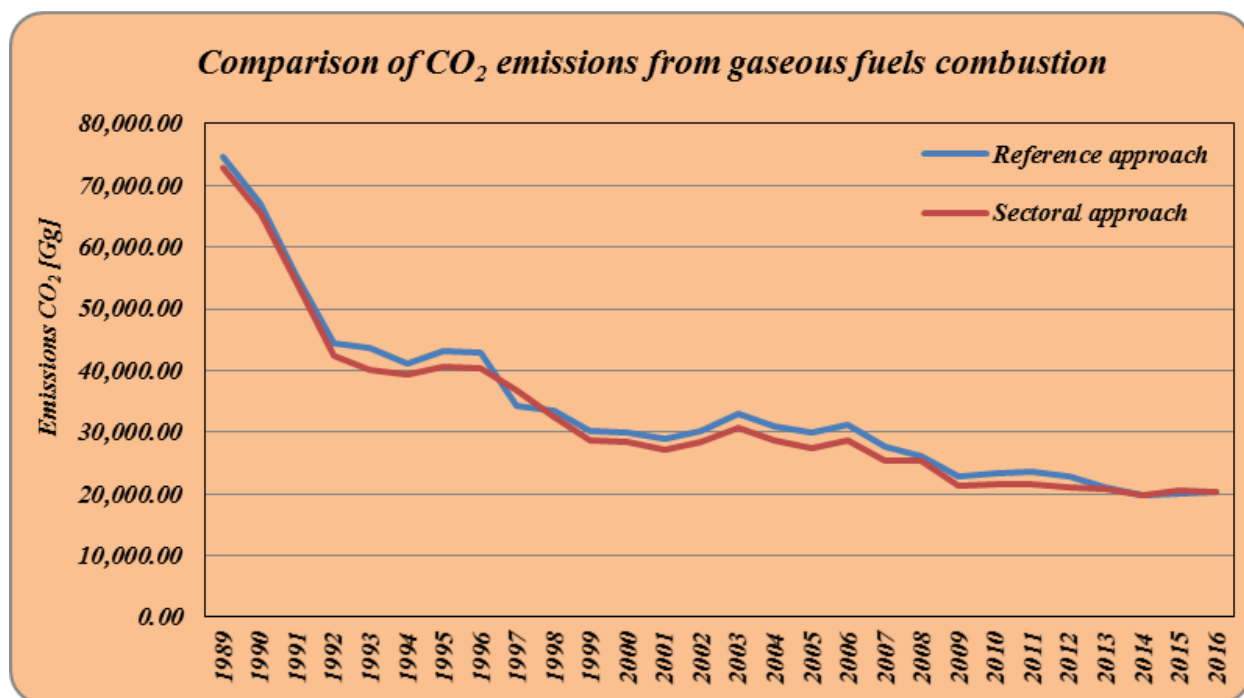
Regarding the previous ERT observation that the energy consumption values for several oil products are consistently higher in the IEA data than in the CRF tables (for lubricants, around 20 per cent higher; for bitumen, around 11 per cent; for residual fuel oil and gasoline around 1 to 2 per cent, respectively), Romania, as declared before, uses the National Statistics Institute activity data provided through the Energy Balance and reported also to EUROSTAT and IEA. Also, for the above type of fuels, as conversion factors, the NCVs reported through the Energy Balance-liquid fuels and assumed for the entire time series or national determined value, are used.

### ***Results of the Reference Approach***

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



**Figure 3.5 Comparison of the sectorial approach with the reference approach****Figure 3.6 Comparison of the sectorial approach with the reference approach – liquid fuels**

*Figure 3.7 Comparison of the sectorial approach with the reference approach – solid fuels**Figure 3.8 Comparison of the sectorial approach with the reference approach – gaseous fuels*

### *Explanation of Differences*

A comparison between the RA and the SA indicates differences in both the energy consumption data and CO<sub>2</sub> emissions, -0.33 % in terms of energy consumption and, 0.16 % in terms of CO<sub>2</sub> emissions for 2016.

One of the reasons for these differences refers to the fact that the Reference Approach deals with the non-energy uses of fuels as if they are combustion activities. A correction is done by subtracting the non-energy use from the aparent consumption of the fuels. Thus, the consumption reported through the Energy Balances as being non-energetic in the sectoral activities, were subtracted from the Reference Approach. In addition, the following processes consumption were subtracted from the Reference Approach:

- In 1.A.1.b, Petroleum refining category, the reported quantities of the petroleum coke, on the entire time-serie, were subtracted. Further to a dialog between energy sector experts and the operators from Refineries domain, it was concluded that the petroleum coke is reported in the Energy Balance as refinery fuel, in fact being the quantity of the "catalyst coke" deposited on the catalyst during refining processes and representing process emissions which are accounted as fugitive emissions. the RA-SA difference was affected in the sense of decreasing of this difference. The petroleum coke was subtracted from 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<sub>2</sub> emissions estimation in the Reference Approach in comparison with the Sectoral Approach.
- In 1.A.2.c, Chemicals category, the reported quantities of the natural gas consumption, used in energy goal, on the entire time-series were subtracted. These quantities are reported in the IPPU sector in 2.B.1, Ammonia Production category, in according to the 2006 IPCC methodology.

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 2007-2016. 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 losses 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: annually 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.

Country specific values NCVs and CO<sub>2</sub> EFs have determined and used for 2015 and 2016 years.

**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)

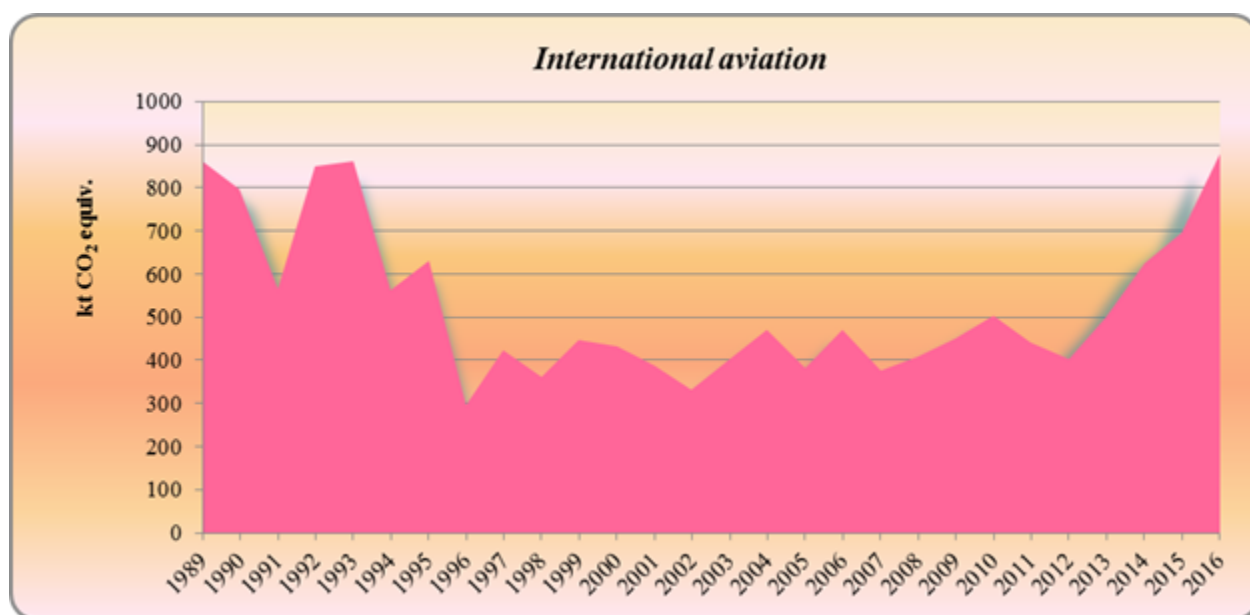
The International Bunkers category comprise data and information on the fuels and the emissions resulting from international air and marine transport of passengers and cargo. These GHG related data and information are also subject to the inventory and they are reported, but the GHG emissions are not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

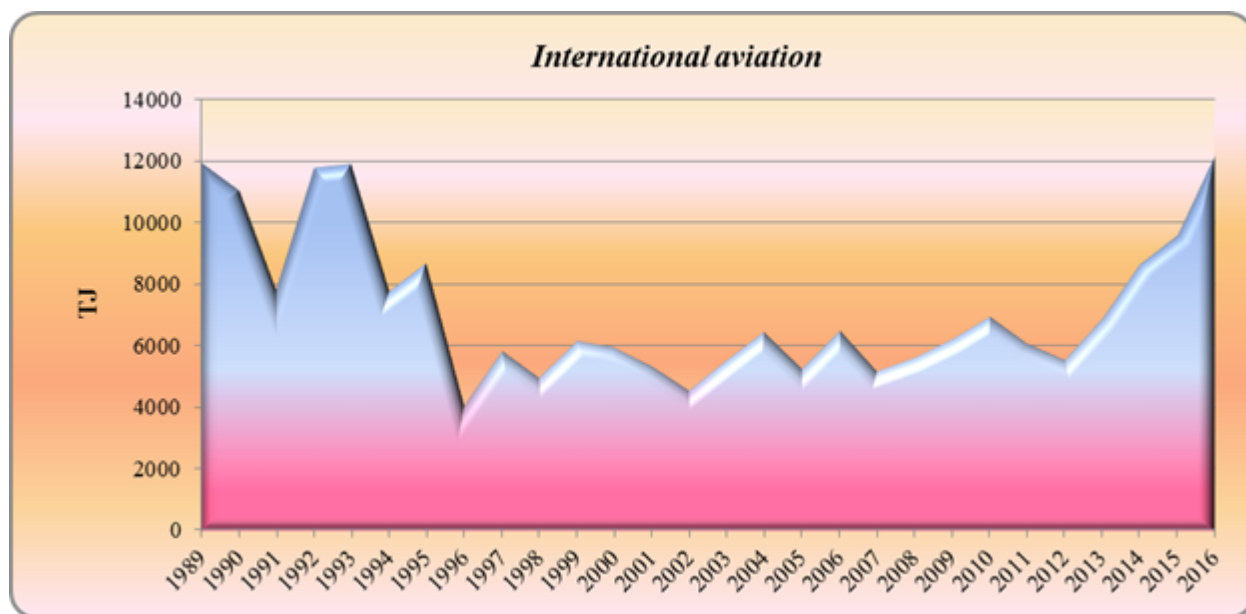
In 2016 the emissions from International Aviation Subsector represent 5.22 % of total emissions from the transport sector (16,828.17 ktCO<sub>2</sub> equivalent).

**Figure 3.9 GHG emissions from International Aviation Subsector**



In 2016 the emissions from the International Aviation subsector have increased by 1.92 % compared to the base year 1989 due to the fuel consumption has increased.

**Figure 3.10 Fuel consumption associated with the International Aviation Subsector, 1989-2016 period**



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

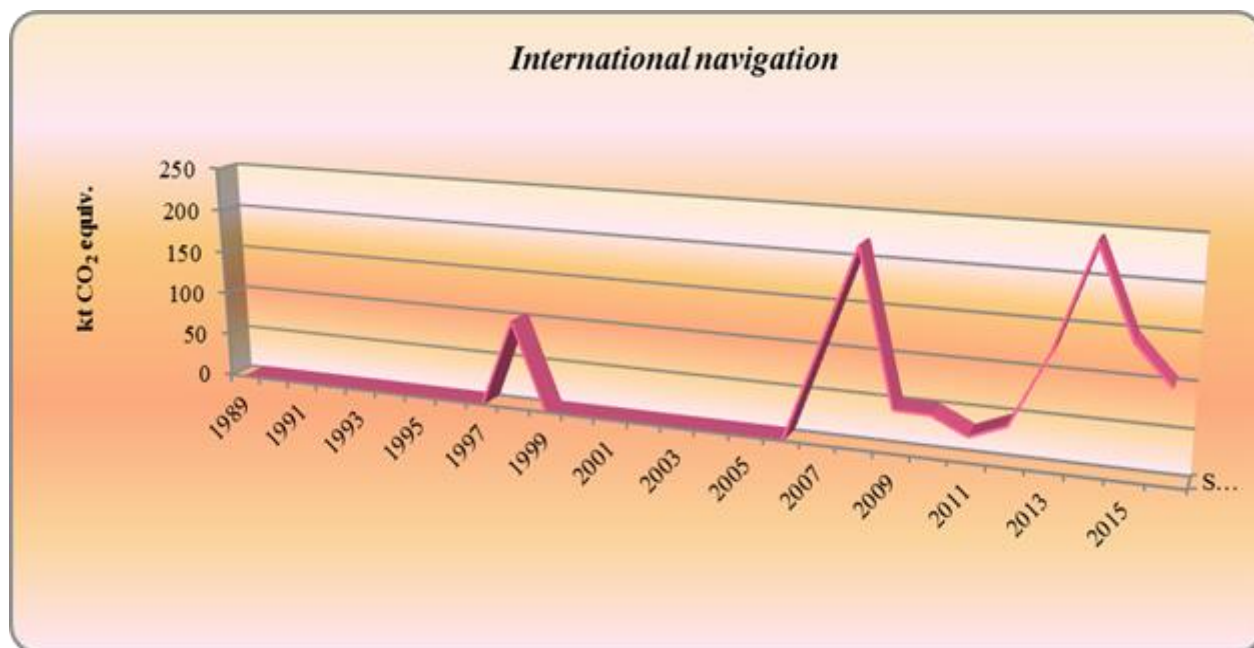
The values of CH<sub>4</sub> and N<sub>2</sub>O emissions for Domestic and International Aviation were calculated for each cycle type of aircraft flight (kg fuel/ LTO) using the IPCC 2006 methodology vol 2, chapter 3 Table 3.6.9, page 3.70 (see Annex 3.3).

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

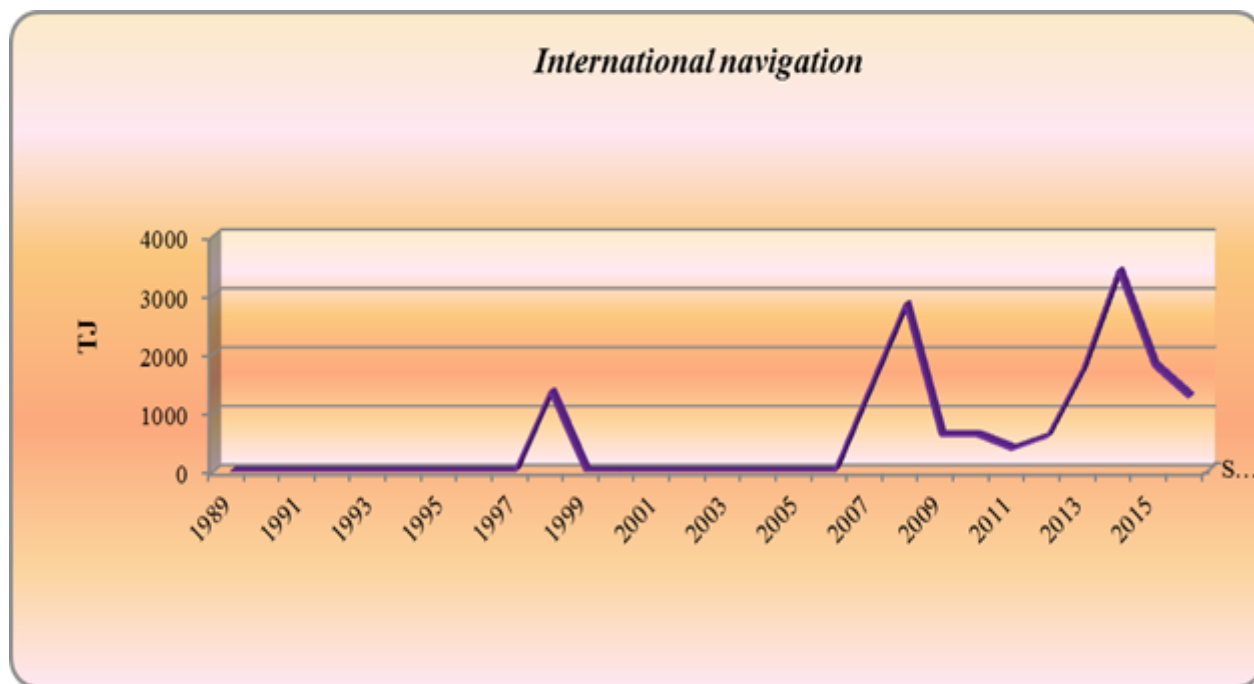
The activity data for international navigation are provided through the IEA/Eurostat Questionnaire; emission factors values used are both country specific and default, provided through the IPCC 2006.

In 2016 the emissions from International Navigation Sub-sector represent 0.60% of total emissions from the transport sector (16,828.17 kt CO<sub>2</sub> equivalent).

**Figure 3.11 The GHG emissions from International Navigation Subsector**



**Figure 3.12 Fuel consumption associated with the International Navigation Subsector, 1989-2016 period**



The lack of data provided by the National Statistics Institute for the consumption of diesel oil for the periods 1989-1997 and 1999-2006, as well as for the consumption of residual fuel oil for the period 1989-2007 are transposed in Fig. 3.12, where fuel consumption growth is reflected by the peaks of 1998 and 2006 -2008. Beginning with 2009, fuel consumption is starting to fall again.

In the 2016 year, the fuel consumption level associated with the International Navigation category decreased by 29.93% compared with 2015.

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: annually 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.

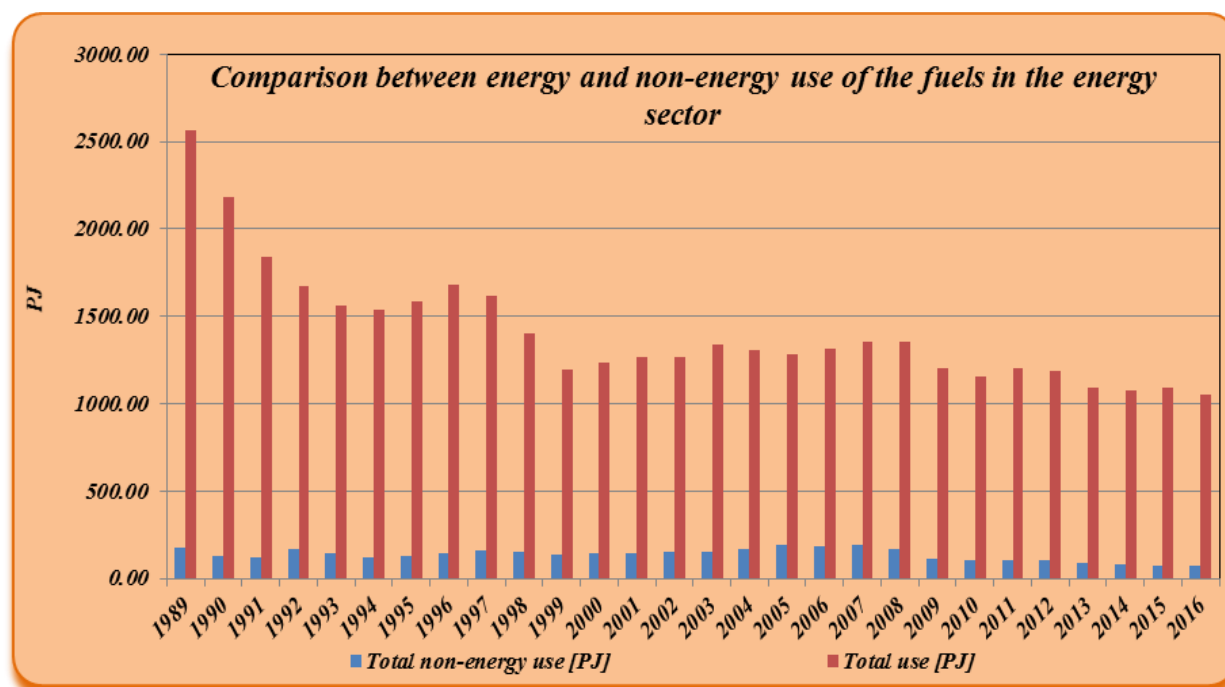
Country specific values NCVs and CO<sub>2</sub> EFs have determined and used for 2015 and 2016 years. The following type of fuels have been added to the Table 1.A(d), “Feedstocks, reductants and other non-energy use of fuels - Other fuels” category: Refinery gas, Paraffin waxes, White spirit. According 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**

<b>Year</b>	<b>Non-energy use [PJ]</b>	<b>Apparent energy consumption incl. non- energy use [PJ]</b>	<b>[%]</b>
<b>1989</b>	177.88	2567.48	7
<b>1990</b>	126.30	2184.50	6
<b>1995</b>	127.31	1585.58	8
<b>2000</b>	144.27	1233.02	12
<b>2005</b>	190.42	1281.67	15
<b>2007</b>	190.95	1355.24	14
<b>2008</b>	164.11	1356.13	12
<b>2009</b>	109.34	1200.72	9
<b>2010</b>	103.07	1154.64	9
<b>2011</b>	106.65	1205.94	9
<b>2012</b>	102.88	1190.84	9
<b>2013</b>	90.10	1088.68	8
<b>2014</b>	84.08	1078.01	8
<b>2015</b>	70.27	1087.50	6
<b>2016</b>	71.18	1054.99	7

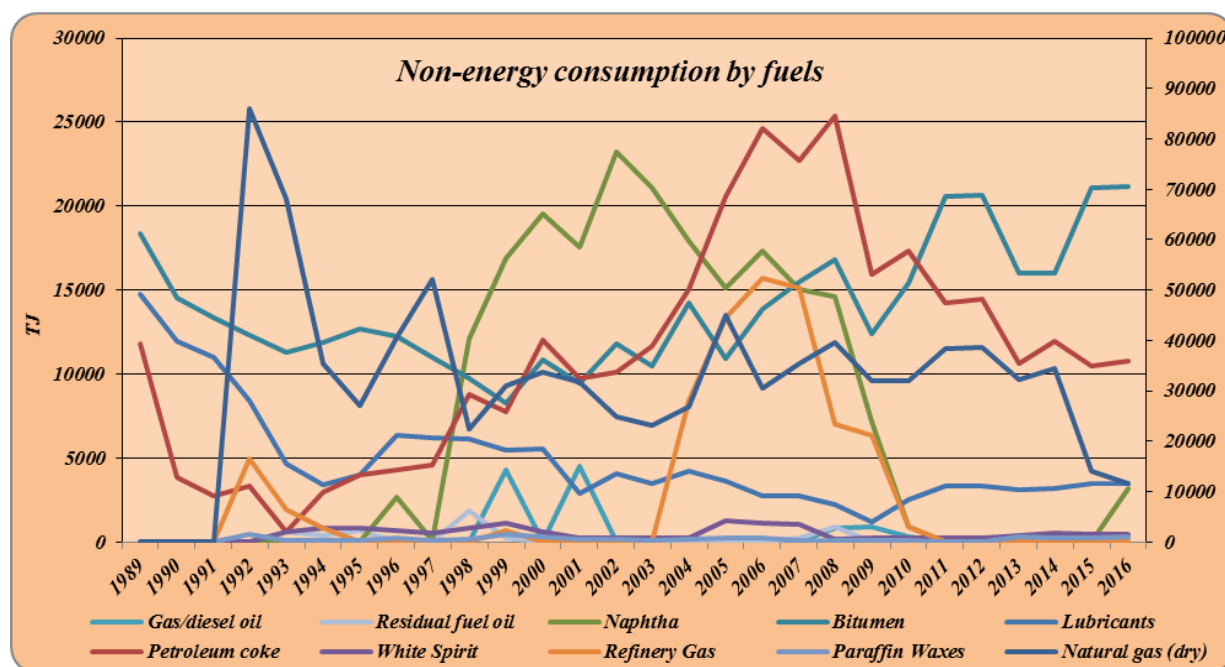
**Figure 3.13 Comparison between the energy and non-energy use of the fuels in the energy sector**



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 around 15% 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 6%. In 2016 the share of the non-energy use of the fuels in total consumption is about 7%.

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)****Solid Fuels**

- Activity data**

In 1990-2015 period are made the recalculations from 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<sub>2</sub> emissions from fuel combustion activities accounted for 64,798.60 Gg CO<sub>2</sub> equivalent in 2016.

Within the fuel combustion sector, 34.22% of the CO<sub>2</sub> equivalent emissions correspond to Energy Industries category, 15.01% of the CO<sub>2</sub> equivalent emissions correspond to 1.A.2 Manufacturing Industries and Construction, 22.31% of the CO<sub>2</sub> equivalent emissions correspond to 1.A.3 Transport, 13.75% of the CO<sub>2</sub> equivalent emissions correspond to 1.A.4 Other Sectors and less than 0.62% from the CO<sub>2</sub> 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 25,809.61 Gg CO<sub>2</sub> equivalent of the emissions in 2016. 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<sub>2</sub> equiv. decreased in 2013 in comparison with 2012, in the 1A1 Energy Industries, with 18,76%, the variation between 2014 and 2013 increased with 0.07%, the variation between 2015 and 2014 decreased with 1,71% and in 2016 year it observed a decrease with 10,40% in comparison with 2015.

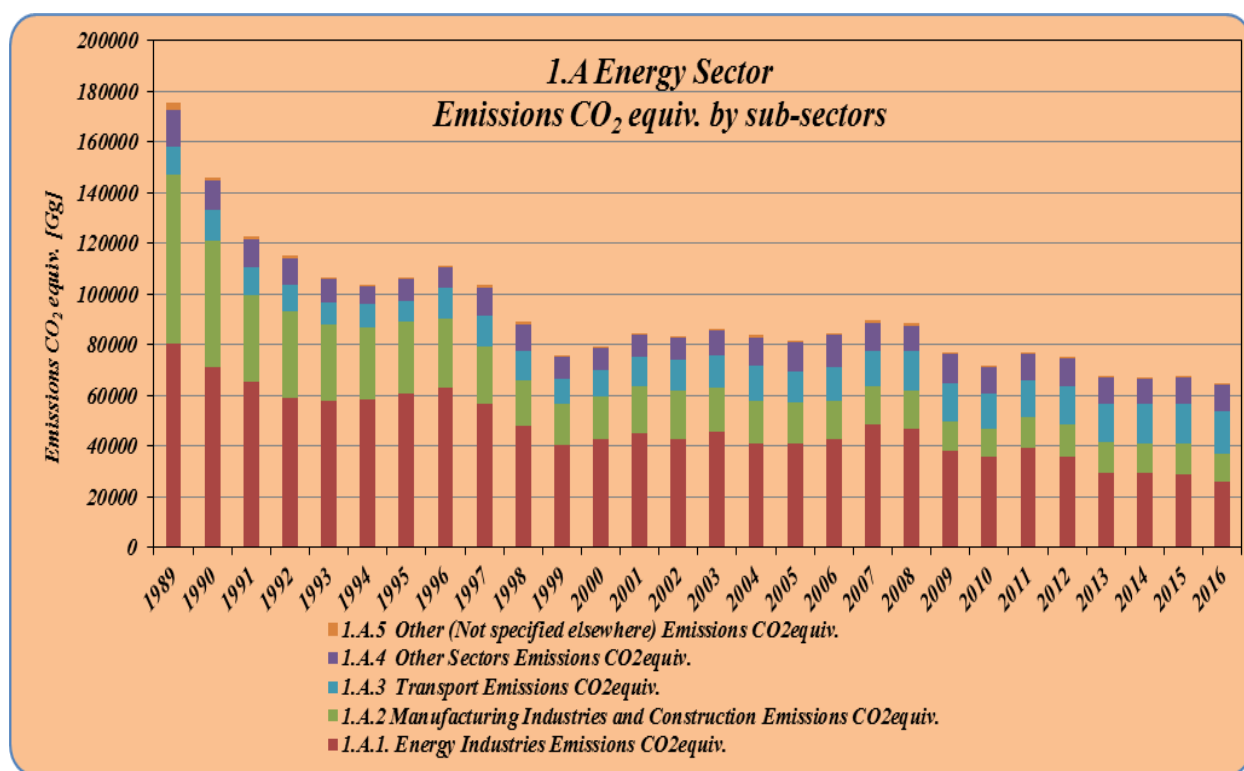
In 2013 year the 1A2 Manufacturing Industries and Construction category the GHG emissions of CO<sub>2</sub> equiv. encountered a decreased with 3,52% in comparison with 2012, the variation between 2014 and 2013 decreased with 3,20%, the variation between 2015 and 2014 increased with 4,49% and the variation between 2016 and 2015 decreased with 7,11%.

In 2013 year the 1A3 Transport category the GHG emissions of CO<sub>2</sub> equiv. encountered a decreased with 1,21% in comparison with 2012, the variation between 2014 and 2013 increased with 3,55%, the variation between 2015 and 2014 increased with 0,91% and the variation between 2016 and 2015 increased with 6,90%.

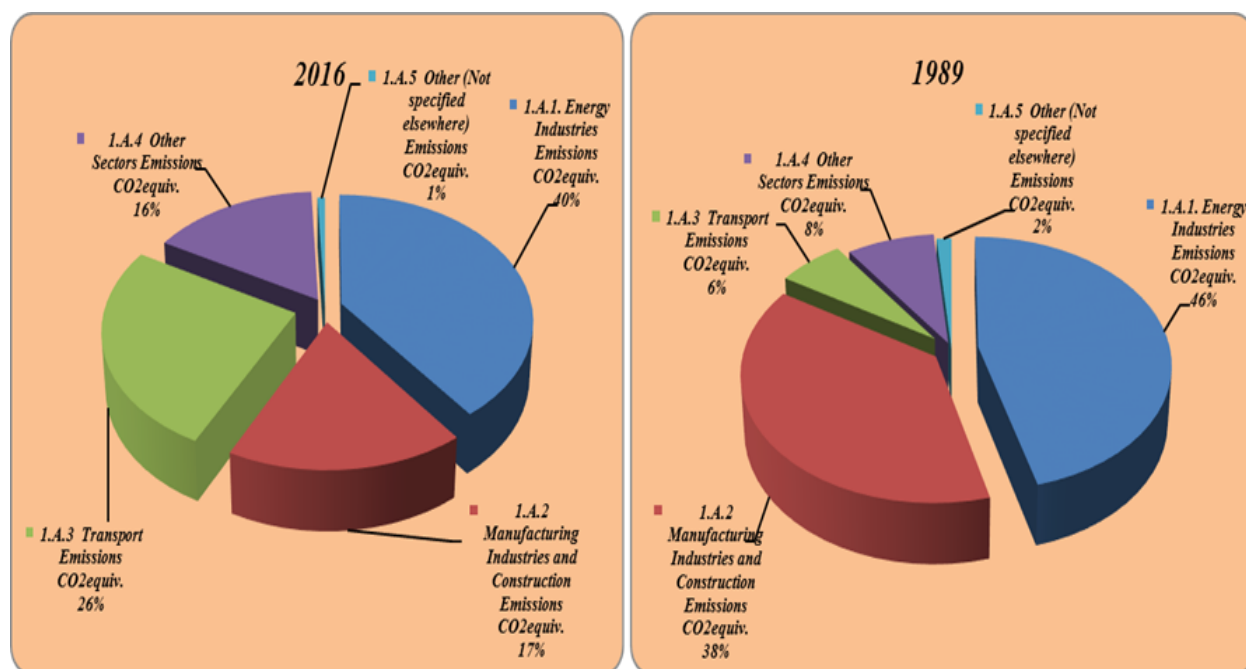
In 2013 year the 1.A.4 Other Sectors category the GHG emissions of CO<sub>2</sub> equiv. encountered a decreased with 3,76% in comparison with 2012, the variation between 2014 and 2013 decreased with 4,29%, the variation between 2015 and 2014 increased with 3,21% and the variation between 2016 and 2015 decreased with 0,14%.

In 2013 year the 1A5 Other category the GHG emissions of CO<sub>2</sub> equiv. encountered a decreased with 26,87% in comparison with 2012, the variation between 2014 and 2013 decreased with 5,30%, the variation between 2015 and 2014 increased with 22,08% and the variation between 2016 and 2015 decreased with 5,65%.

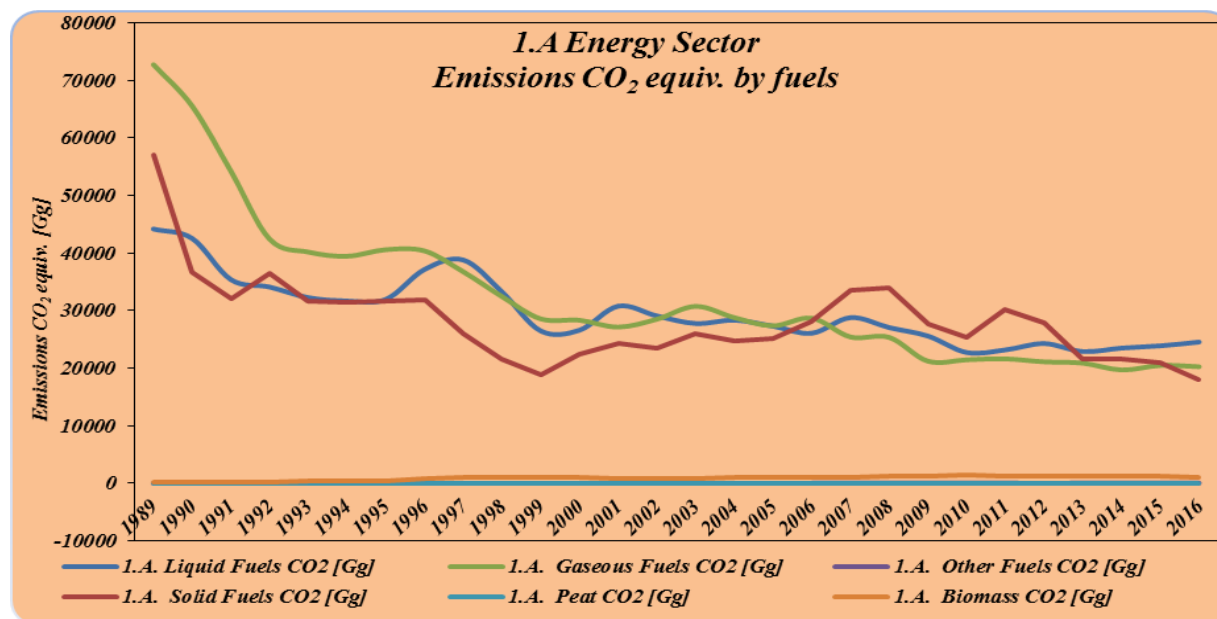
**Figure 3.15 Total GHG CO<sub>2</sub> equivalent. emissions associated with the Fuel Combustion**  
**Activities by categories**



**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**



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 2016 in comparison with 2015, with less than 1%.

**Figure 3.17 Total CO<sub>2</sub> emissions [kt] from Fuel combustion by fuel type**

In the period 2006-2012 the main contribution to CO<sub>2</sub> emissions was from solid fuels, having a pick in 2007-2008. In 2016 the contribution of the liquid fuel was about 38%, solid 28%, gaseous 32%.

It could be observed that, the three main fuels have, each of them, a significant contribution to the total of the Energy Industry CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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 years the country specific emission factors determined from the EU-ETS operator reports for the previous year, 2012, were used.

For 2015 and 2016 years the country specific emission factors determined from EU-ETS operator reports, were used.

### ***A) Tier 1 methodology***

The IPCC Tier 1 approach (IPCC 2006 Guidelines) is used to calculate the emissions from fuel combustion in the sectors CRF 1.A.1, CRF 1.A.2., CRF 1.A.4 and CRF 1.A.5.

For the gases CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub> 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 1990-2016. 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 analysed 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<sub>2</sub> emissions released from these processes are reported as an information item, as the CO<sub>2</sub> is naturally captured from the air. This is not applicable for the CH<sub>4</sub> and N<sub>2</sub>O 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, annually determination of the NCVs weighted averages values were used and, for the rest of the time series, the averages of the EU-ETS period were used. All the used NCVs for the liquids and solids 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<sub>2</sub> emission factors***

The default CO<sub>2</sub> 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<sub>2</sub> emission reports required under the EU ETS for the years 2007-2016.

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 country 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<sub>2</sub> 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.

Country specific values NCVs and CO<sub>2</sub> EFs have determined and used for 2015 and 2016 years.

**CH<sub>4</sub>, N<sub>2</sub>O** - EFs default are used.

**NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub>** – default **EMEP** EFs are used.

**SO<sub>2</sub>** – 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<sub>2</sub> emission factors for stationary combustion, without oxidation included, from ETS verified reports**

EF [t/TJ]	Years						
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	55.68	55.49	55.64	55.52	55.52	55.58
Refinery gas	54.32	54.69	58.11	57.93	56.38	57.42	56.90
Other bituminous coal	93.24	94.34	95.20	95.95	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

EF [t/TJ]	Years						
Type of Fuel	2007	2008	2009	2010	2007-2010 WA EFs	2011	2012
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	93.83	92.93	93.32	92.70	93.81

*Table 3.5 (continued) Country-Specific CO<sub>2</sub> emission factors for stationary combustion, without oxidation included, from ETS verified reports*

EF [t/TJ]	Years			
Type of Fuel	2013	2014	2015	2016
Lignite	95.86	97.95	98.10	98.11
Natural gas	55.59	55.59	55.54	55.74
Refinery gas	58.08	57.40	56.23	56.37
Other bituminous coal	92.18	93.14	92.61	93.16
Coke_Oven_Coke	95.34	108.28	106.24	104.25
Transport diesel	70.66	69.62	79.28	79.68
Residual fuel oil	78.50	79.23	79.52	79.06
Heating and other gasoil	76.11	73.63	76.03	74.08
Petroleum Coke	92.80	92.73	95.38	96.09
Industrial Wastes	89.53	92.34	92.45	95.00
Sub-bituminous coal	94.27	93.56	92.15	93.27

The EFs having the oxidation included are calculated as the total sum of the verified CO<sub>2</sub> 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<sub>2</sub> 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	95.87	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
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
Sub-bituminous coal	93.75	92.79	92.57	92.05	92.86	91.97	93.30

**Table 3.6 (continued) Country-Specific CO<sub>2</sub> emission factors for stationary combustion, oxidation included, from ETS verified reports**

EF [t/TJ]	Year			
Type of Fuel	2013	2014	2015	2016
Lignite	88.84	90.70	89.67	89.57
Natural gas	55.59	55.59	55.54	55.74
Refinery gas	57.90	57.40	56.23	56.37
Other bituminous coal	91.79	92.78	92.44	92.30
Coke_Oven_Coke	95.16	108.28	106.24	104.25
Transport diesel	70.66	69.62	79.28	79.68
Residual fuel oil	78.50	79.23	79.52	79.06

EF [t/TJ]	Year			
Type of Fuel	2013	2014	2015	2016
Heating and other gasoil	76.11	73.63	76.03	74.08
Petroleum Coke	92.80	92.34	94.93	95.55
Industrial Wastes	89.53	92.34	92.45	95.00
Sub-bituminous coal	93.52	92.54	91.11	92.58

### *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 <sub>2</sub> t/TJ (including oxidation factor)	EF CO <sub>2</sub> 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<sub>4</sub> emission factors for stationary sources***

The default CH<sub>4</sub> 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<sub>2</sub>O emission factors for stationary sources***

The default N<sub>2</sub>O 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<sub>2</sub> 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<sub>4</sub> 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<sub>2</sub>O 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<sub>2</sub> 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<sub>4</sub> 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<sub>2</sub>O 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.

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**

<b>CRF Category</b>	<b>Main activity</b>	<b>Share of the EU-ETS reporting to the EB [%]</b>	<b>Reporting Plants</b>
<b>1A1a</b>	<b><i>Electricity and heat production</i></b>	<b>90,25</b>	
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
<b>1A2</b>	<b><i>Manufacturing industry and Construction</i></b>	<b>60,60</b>	
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

<b>CRF Category</b>	<b>Main activity</b>	<b>Share of the EU-ETS reporting to the EB [%]</b>	<b>Reporting Plants</b>
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 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: <ul style="list-style-type: none"> <li>○ Installation for cement clinker production with capacity &gt; 500 tones/day;</li> <li>○ Installation for lime production with capacity &gt; 50 tones/day;</li> <li>○ Installation for glass production with capacity &gt;20 tones/day;</li> <li>○ Installation for ceramics production having a capacity &gt;75 tones/day,</li> <li>○ and having on sites nominal installed thermal power plant &gt; 20 MWt.</li> </ul>

### *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<sub>2</sub> CS EF 88.88 t/TJ, coke\_oven\_coke – CO<sub>2</sub> CS EF 95.2 t/TJ, lower than the limit of the range, Heating and other gasoil – CO<sub>2</sub> 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 as 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 as 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 another 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 losing the humidity, this having as consequences the decreasing of the calorific values and of the emission factors. Following the above activities the unconformities have 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<sub>2</sub> EFs - resulted from the ISPE Study and derived from the EU-ETS reports , SO<sub>2</sub> 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O were accounted. Also, there are accounted emissions resulted from indirect GHG gases, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>.

***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<sub>2</sub> Emission factors:***

- The CO<sub>2</sub> emission factor values for 2015 year have been updated because the Country Specific Emission Factor values for 2015 have been updated.

***2. Net calorific values:***

- The fuels which have determined or modified the CO<sub>2</sub> CS EF as above, the net calorific values were updated or determined, too.
- For the 2015 year, for the all fuels, the net calorific values were recalculated in accordance with the reporting on the EU-ETS reports.

***3. Activity data:***

- Because the activity data from Energy Balance provided from National Institute of Statistics were updated for 1995-2015 period from the 1.A.1 Energy Industry sub-sector, the CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions values for the 1995-2015 period were recalculated.

- In 1.A.2 Manufacturing Industries and Construction category – 1.A.2.c Chemicals sub-category, the reported quantities of the natural gas consumption used for energy purposes, was subtracted from in *Annex 4.1 Energy Balance 1989* (the column Natural Gas, line 63) for the 1989 year.

In 1.A.2 Manufacturing Industries and Construction category – 1.A.2.c Chemicals sub-category, the reported quantities of the natural gas consumption used for energy purposes, was subtracted from in *Annex 4.4 Energy Balance\_1990\_2016\_natural gas* (the sheet Table 2b\_TFC\_Energy use, the line 12) for the 1990-2016 period.

This quantities of the natural gas consumption, used in energy purposes, was subtracted as above, and are reported in the Industrial Processes and Product Use sector (IPPU), in the 2B1, Ammonia Production category, in according to the 2006 IPCC methodology. In this case the CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions values for the 1989-2015 period were updated.

- Because the activity data from Energy Balance provided from National Institute of Statistics were updated for the 1990,1992, 1993, 1994, 1995, 2014 and 2015 years from the 1.A.4 Other sub-sector, the CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions values for this years were recalculated.

<b>Share ETS-CO<sub>2</sub> on 1A1a</b>	<b>2014</b>	BE	15,414.22	13,327.24	86.5%
<b>Share ETS-CO<sub>2</sub> on 1A1a</b>	<b>2014</b>	GB	123,083.98	121,009.22	98.3%
<b>Share ETS-CO<sub>2</sub> on 1A1a</b>	<b>2014</b>	PL	152,593.99	145,144.52	95.1%
<b>Share ETS-CO<sub>2</sub> on 1A1a</b>	<b>2014</b>	SK	4,632.41	3,983.50	86.0%
<b>Share ETS-CO<sub>2</sub> on 1A1a</b>	<b>2014</b>	HU	11,354.44	11,031.62	97.2%
<b>Share ETS-CO<sub>2</sub> on 1A1a</b>	<b>2014</b>	AT	8,090.83	6,363.25	78.6%
<b>Share ETS-CO<sub>2</sub> on 1A1a</b>	<b>2014</b>	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	32,169	33,274	29,125	28,163	34,913	31,869	22,785	23,631	25,072
Sub- bituminous coal	ETS	2,313	3,020	2,243	1,860	2,400	2,062	2,013	1,831	1,290
	EB	2,314	3,021	2,243	1,860	2,400	2,062	2,013	1,831	1,290
Residual Fuel Oil	ETS	333	232	390	200	192	136	43	36	47
	EB	465	305	423	223	212	139	46	36	47
Natural gas [TJ]	ETS	139,090	122,442	106,475	87,758	107,942	102,174	100,379	93,218	101,366
	EB	182,051	161,286	128,005	123,522	128,938	112,268	90,341	83,896	91,229
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	-	-	-	-	63.00	123.00	111.00	114.00	103.00

**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 <sub>2</sub> [kt]		Diff [%]	Effects of changes on emission estimates for CH <sub>4</sub> [kt]		Diff [%]	Effects of changes on emission estimates for N <sub>2</sub> O [kt]		Diff [%]
	NGHGI 2017	NGHGI 2018	NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018	
1989	1,076,987.02	1,076,987.02	80,219.39	80,219.39	0.00	1.45	1.45	0.00	0.81	0.81	0.00
1990	980,766.30	980,766.30	70,723.31	70,723.31	0.00	1.53	1.53	0.00	0.61	0.61	0.00
1995	809,008.87	809,385.79	60,641.14	60,676.47	0.06	1.20	1.20	0.09	0.61	0.61	0.04
2000	564,578.35	570,923.17	41,946.55	42,541.27	1.42	0.79	0.81	2.41	0.41	0.41	0.93
2005	537,803.35	546,472.51	40,072.74	40,885.33	2.03	0.70	0.72	3.73	0.41	0.42	1.26
2007	601,399.64	617,150.13	47,213.47	48,605.38	2.95	0.70	0.75	6.74	0.51	0.52	1.86
2008	576,443.91	591,235.20	45,212.57	46,558.64	2.98	0.67	0.71	6.65	0.53	0.54	1.67
2009	476,149.46	486,493.86	37,146.50	38,077.74	2.51	0.56	0.59	5.55	0.45	0.46	1.37
2010	457,312.88	467,199.07	34,651.05	35,567.41	2.64	0.55	0.57	5.44	0.42	0.43	1.41
2011	506,563.42	513,048.68	38,592.21	39,215.47	1.62	0.62	0.64	3.16	0.51	0.51	0.76
2012	460,623.64	466,371.73	35,343.05	35,897.56	1.57	0.55	0.57	3.11	0.46	0.47	0.74
2013	393,811.85	382,024.45	29,631.73	29,165.59	-1.58	0.52	0.51	-1.11	0.36	0.36	0.09
2014	388,953.53	379,121.35	29,584.11	29,182.20	-1.36	0.57	0.57	-0.35	0.37	0.37	0.26

Year	Changes at AD level [TJ]		Effects of changes on emission estimates for CO <sub>2</sub> [kt]		Diff [%]	Effects of changes on emission estimates for CH <sub>4</sub> [kt]		Diff [%]	Effects of changes on emission estimates for N <sub>2</sub> O [kt]		Diff [%]
	NGHGI 2017	NGHGI 2018	NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018	
2015	388,723.31	375,368.64	29,596.35	28,681.10	-3.09	0.56	0.55	-1.20	0.37	0.37	-0.70

*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 <sub>2</sub> [kt]		Diff [%]	Effects of changes on emission estimates for CH <sub>4</sub> [kt]		Diff [%]	Effects of changes on emission estimates for N <sub>2</sub> O [kt]		Diff [%]
	NGHGI 2017	NGHGI 2018	NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018	
1989	1,100,073.55	1,071,650.65	67,975.07	66,403.34	-2.31	2.49	2.46	-1.14	0.35	0.35	-0.81
1990	853,114.05	830,992.38	51,118.35	49,892.75	-2.40	1.64	1.62	-1.38	0.22	0.22	-1.05
1995	501,615.61	481,221.45	29,156.58	28,028.83	-3.87	1.38	1.35	-1.48	0.19	0.18	-1.09
2000	300,040.96	286,244.69	17,893.10	17,130.20	-4.26	0.94	0.93	-1.47	0.13	0.13	-1.03
2005	272,300.38	258,359.43	16,742.88	15,939.08	-4.80	1.02	1.01	-1.37	0.14	0.14	-0.97



Year	Changes at AD level [TJ]		Effects of changes on emission estimates for CO <sub>2</sub> [kt]		Diff [%]	Effects of changes on emission estimates for CH <sub>4</sub> [kt]		Diff [%]	Effects of changes on emission estimates for N <sub>2</sub> O [kt]		Diff [%]
	NGHGI 2017	NGHGI 2018	NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018	
2007	258,118.09	246,881.68	15,583.86	14,946.91	-4.09	1.11	1.10	-1.02	0.16	0.15	-0.72
2008	260,738.32	246,652.11	16,067.79	15,271.53	-4.96	0.96	0.95	-1.46	0.13	0.13	-1.05
2009	197,421.00	187,121.77	11,915.26	11,338.65	-4.84	0.79	0.78	-1.30	0.11	0.11	-0.93
2010	198,598.18	182,703.80	11,750.61	10,868.79	-7.50	0.89	0.87	-1.79	0.12	0.12	-1.31
2011	217,129.31	198,898.40	13,227.07	12,215.06	-7.65	0.96	0.95	-1.89	0.13	0.13	-1.37
2012	217,481.69	202,204.21	13,274.35	12,425.55	-6.39	1.03	1.02	-1.48	0.14	0.14	-1.07
2013	211,494.06	200,401.37	12,607.90	11,991.90	-4.89	0.97	0.93	-3.93	0.13	0.13	-3.56
2014	208,152.98	196,666.06	12,272.26	11,605.85	-5.43	0.97	0.94	-3.83	0.13	0.13	-3.48
2015	211,603.21	205,403.33	12,394.24	12,131.30	-2.12	0.94	0.92	-2.08	0.13	0.13	-2.08

**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 <sub>2</sub> [kt]		Diff [%]	Effects of changes on emission estimates for CH <sub>4</sub> [kt]		Diff [%]	Effects of changes on emission estimates for N <sub>2</sub> O [kt]		Diff [%]
	NGHGI 2017	NGHGI 2018	NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018	
<b>1989</b>	242,917.87	242,917.87	14,177.80	14,177.81	0.00	17.74	17.74	0.00	0.19	0.19	0.00
<b>1990</b>	196,653.21	196,603.93	10,851.71	10,847.11	-0.04	16.69	16.67	-0.09	0.16	0.16	-0.05
<b>1995</b>	173,342.78	173,337.42	7,879.09	7,878.60	-0.01	14.28	14.28	-0.01	0.20	0.20	-0.00
<b>2000</b>	241,617.08	241,617.08	8,218.01	8,218.01	0.00	32.17	32.17	0.00	0.44	0.44	0.00
<b>2005</b>	289,259.25	289,258.65	10,213.43	10,213.38	0.00	35.51	35.51	0.00	0.48	0.48	0.00
<b>2007</b>	287,450.56	287,450.56	10,068.37	10,068.37	0.00	35.29	35.29	0.00	0.48	0.48	0.00
<b>2008</b>	296,642.64	296,642.64	8,882.99	8,882.99	0.00	44.67	44.67	0.00	0.60	0.60	0.00
<b>2009</b>	314,638.76	314,638.76	10,106.24	10,106.24	0.00	44.02	44.02	0.00	0.60	0.60	0.00
<b>2010</b>	305,619.60	305,619.60	9,058.74	9,058.74	0.00	45.44	45.44	0.00	0.61	0.61	0.00
<b>2011</b>	290,372.93	290,372.93	9,182.68	9,182.68	0.00	40.79	40.79	0.00	0.55	0.55	0.00
<b>2012</b>	305,172.62	305,172.62	9,690.41	9,690.41	0.00	42.53	42.53	0.00	0.58	0.58	0.00
<b>2013</b>	293,719.38	293,719.38	9,330.06	9,330.15	0.00	40.78	40.78	0.00	0.55	0.55	0.00
<b>2014</b>	283,306.27	283,306.27	8,872.13	8,872.70	0.01	41.04	41.04	0.00	0.55	0.55	0.00
<b>2015</b>	281,938.10	280,878.90	9,242.57	9,253.24	0.12	39.18	39.05	-0.35	0.52	0.52	-0.20

**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 <sub>2</sub> [kt]		Diff [%]	Effects of changes on emission estimates for CH <sub>4</sub> [kt]		Diff [%]	Effects of changes on emission estimates for N <sub>2</sub> O [kt]		Diff [%]
	NGHGI 2017	NGHGI 2018	NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018		NGHGI 2017	NGHGI 2018	
<b>1989</b>	30,015.39	30,015.39	2,464.90	2,464.90	0.00	0.17	0.17	0.00	0.03	0.03	0.00
<b>1990</b>	12,799.28	12,799.28	1,211.76	1,211.76	0.00	0.12	0.12	0.00	0.02	0.02	0.00
<b>1995</b>	8,877.38	8,877.38	554.28	554.28	0.00	0.84	0.84	0.00	0.01	0.01	0.00
<b>2000</b>	3,824.39	3,824.39	238.11	238.11	0.00	0.45	0.45	0.00	0.01	0.01	0.00
<b>2005</b>	18,969.26	18,969.26	831.51	831.51	0.00	2.39	2.39	0.00	0.04	0.04	0.00
<b>2007</b>	18,880.95	18,880.95	950.81	950.81	0.00	1.85	1.85	0.00	0.03	0.03	0.00
<b>2008</b>	16,614.04	16,614.04	811.68	811.68	0.00	1.70	1.70	0.00	0.03	0.03	0.00
<b>2009</b>	8,582.60	8,582.60	270.73	270.73	0.00	1.49	1.49	0.00	0.02	0.02	0.00
<b>2010</b>	8,828.91	8,828.91	267.81	267.81	0.00	1.56	1.56	0.00	0.02	0.02	0.00
<b>2011</b>	10,022.13	10,022.13	538.48	538.48	0.00	0.81	0.81	0.00	0.01	0.01	0.00
<b>2012</b>	10,249.28	10,249.28	558.37	558.37	0.00	0.82	0.82	0.00	0.02	0.02	0.00
<b>2013</b>	7,921.33	7,921.33	406.31	406.31	0.00	0.67	0.67	0.00	0.01	0.01	0.00
<b>2014</b>	7,531.18	7,531.18	385.25	385.25	0.00	0.62	0.62	0.00	0.01	0.01	0.00
<b>2015</b>	10,438.92	10,108.80	421.36	453.63	7.66	1.33	1.33	-0.07	0.02	0.02	-0.94

#### *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. Annually analysis on the EU-ETS reporting in comparison with Large Combustion Plants reporting, in order to check the consistency 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<sub>2</sub> 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 I.A.1.)*

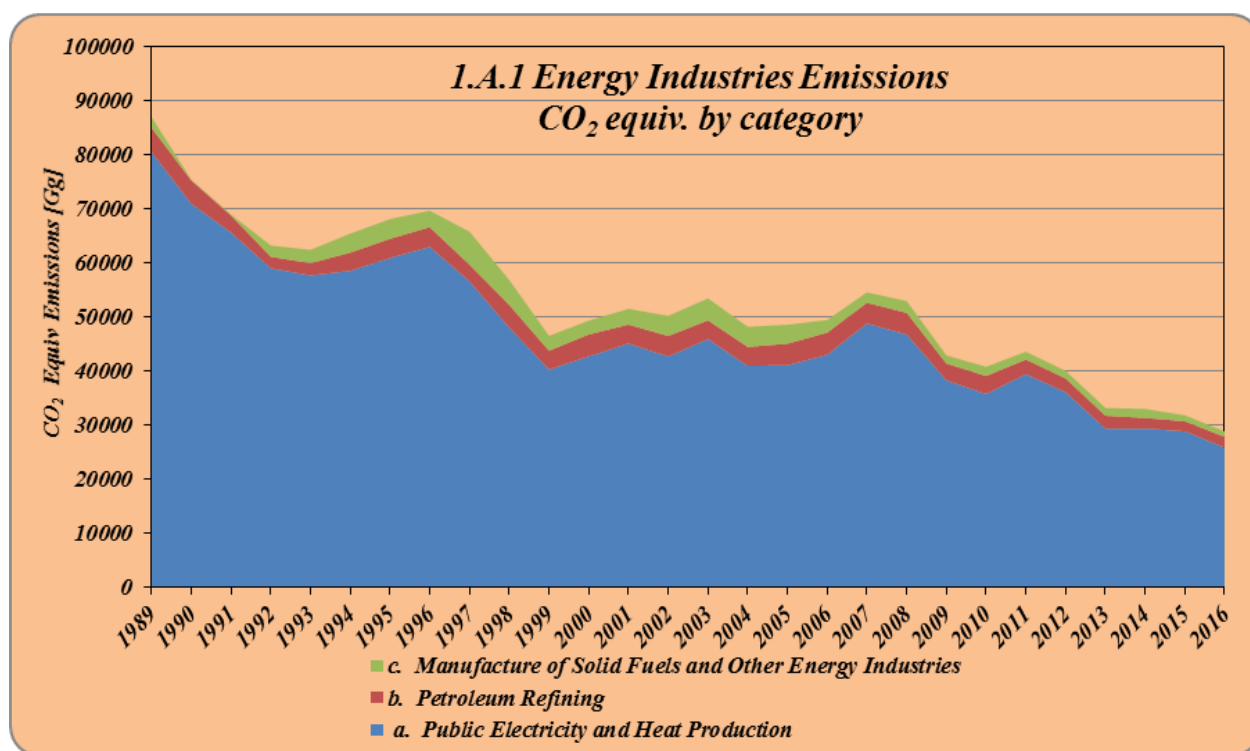
The following activity categories are included in this sub-sector:

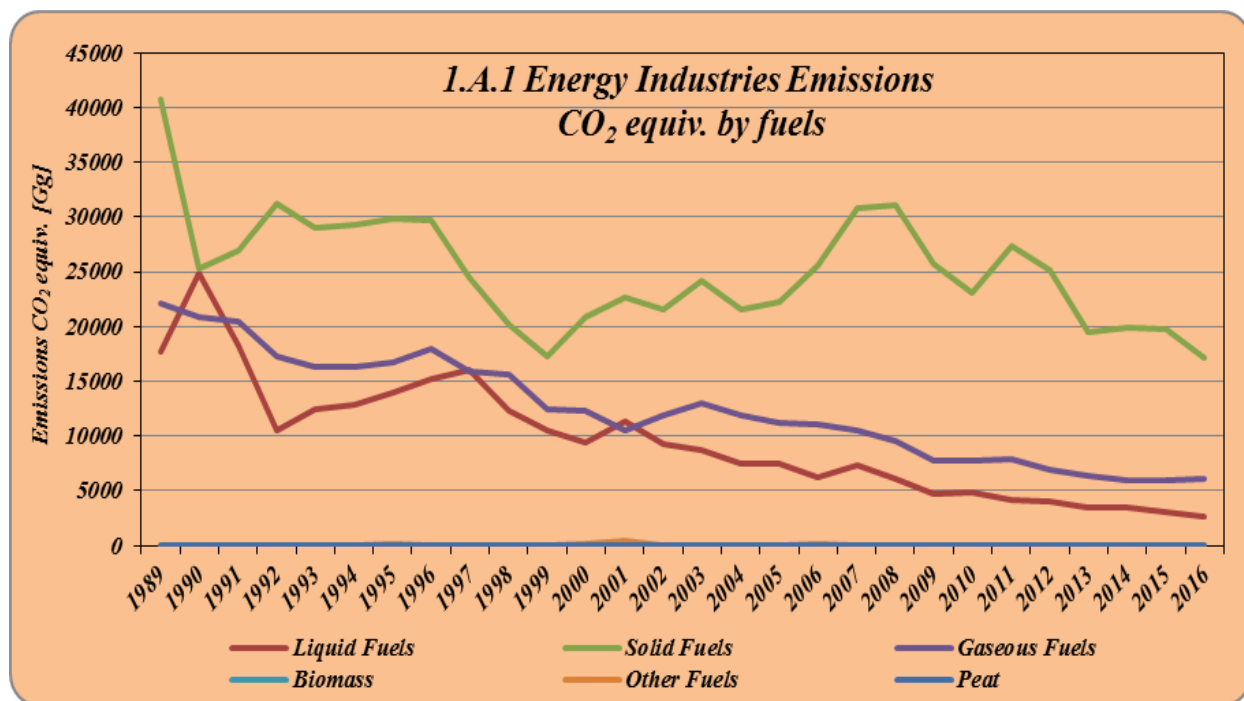
- ❖ Conventional electricity, CHP and heat producer plants;

- ❖ 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<sub>2</sub> 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**

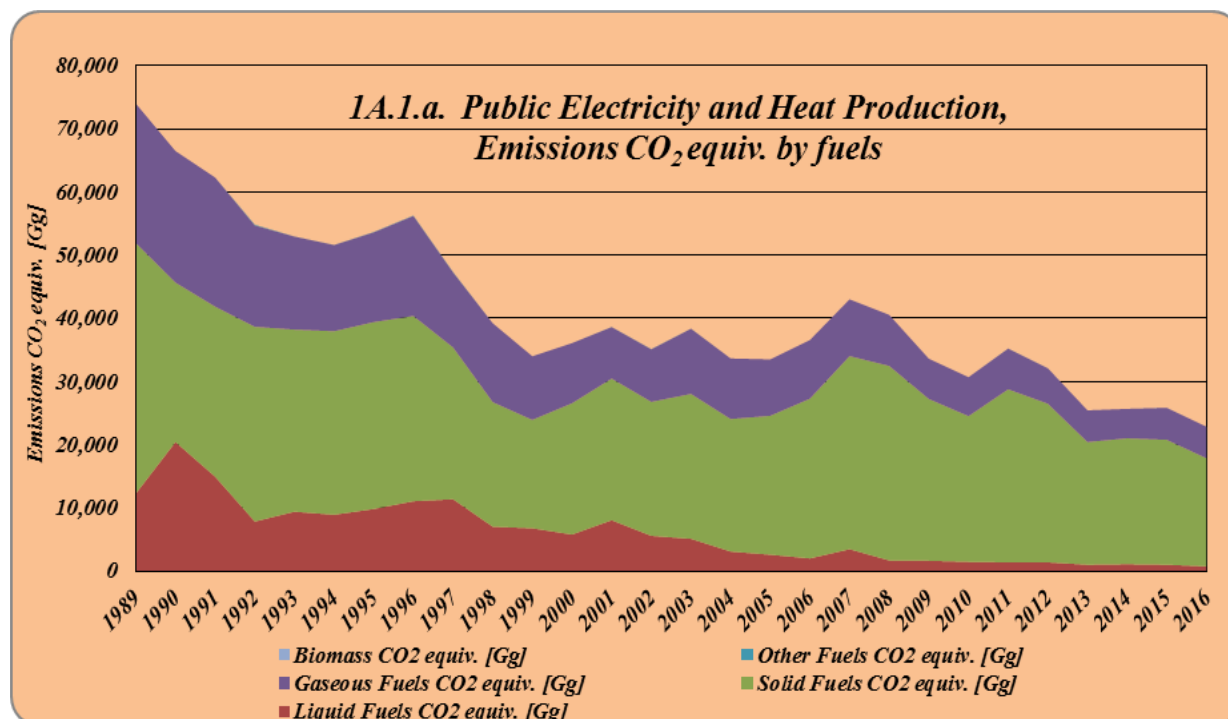
The general trend in CRF category 1.A.1 is a decrease in the emissions, but having a constant contribution to the total of 1A Fuel combustion emissions: 49.51% in the base year and a 39.83.% in 2016. For the last years of the time-series, 2014 and 2015, the share of the Energy Industries in the total Energy sector encountered a increasing, having a share of 43.72% 2014 year and 42.60% in 2015 year.

The contribution of this sub-sector to the 1.A. – Fuel combustion is, for the year 2016, about 64,798.60 kt CO<sub>2</sub> equiv. having the main contributor the activity category 1.A.1.a – Electricity and Heat Production with 22,743.08 kt CO<sub>2</sub> 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.).

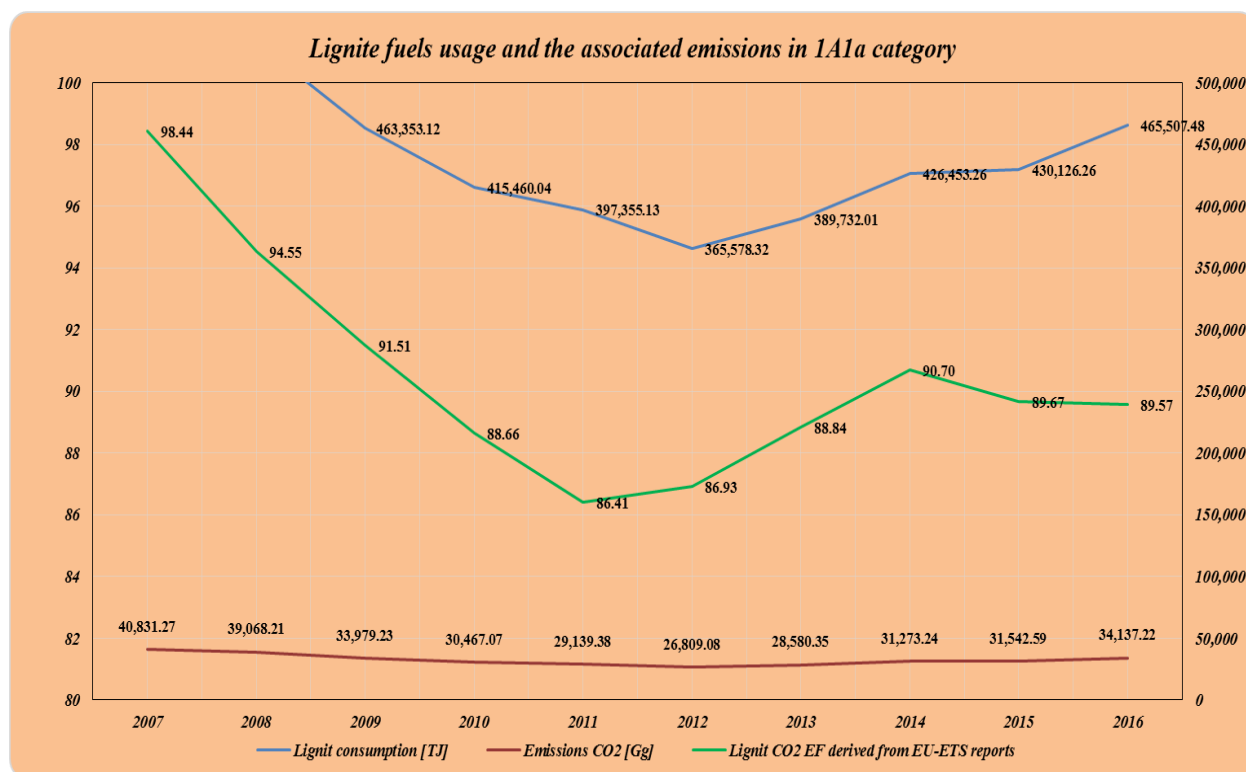
**Figure 3.20 GHG emissions from 1.A.1.a Public Electricity and Heat Production**

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 42.21% in the base year and 35.25% for the year 2016. The share of this activity category to the 1.A.1. - Energy Industry is 45.91% for the base year and 39.83% for the year 2016 (about 25,809.61 kt CO<sub>2</sub> 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 (3.88 CO<sub>2</sub> 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 2012 and for the fact that the supply from non fossil resources has an ascendant trend (hydro, wind, solar and nuclear resources). Particularly, the case of the lignite usage in the 1.A.1.a category, the descent trend of the country specific CO<sub>2</sub> 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<sub>2</sub> emissions, the main cause being the variation of the consumption - see the bellow figure.

**Figure 3.21 CO<sub>2</sub> 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*

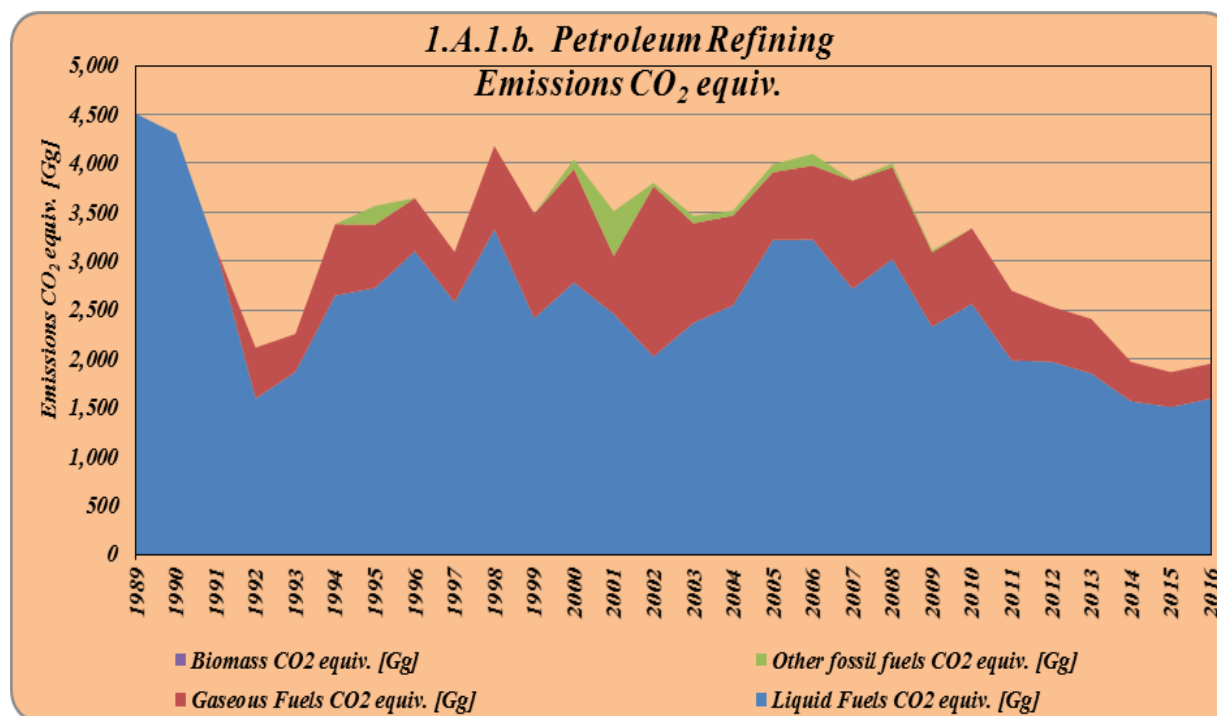
It is planned to take into consideration the emissions from the operators reporting on EU-ETS (having their reports verified by accredited verifiers) in order to achieve a hire tier approach in the estimation of the CO<sub>2</sub> emissions. See the Chapter 3.2.4.6 for more details.

### *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 2.57% for the year 1989 and 3.01% for the year 2016. The main fuels reported are liquids which are: Refinery gas, Transport diesel and Residual fuel oil, together with natural gas having a contribution about 1,948.68 kt CO<sub>2</sub> equiv. in 2016.

### 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*

For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

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

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<sub>2</sub> emissions. See the Chapter 3.2.4.6 for more details.

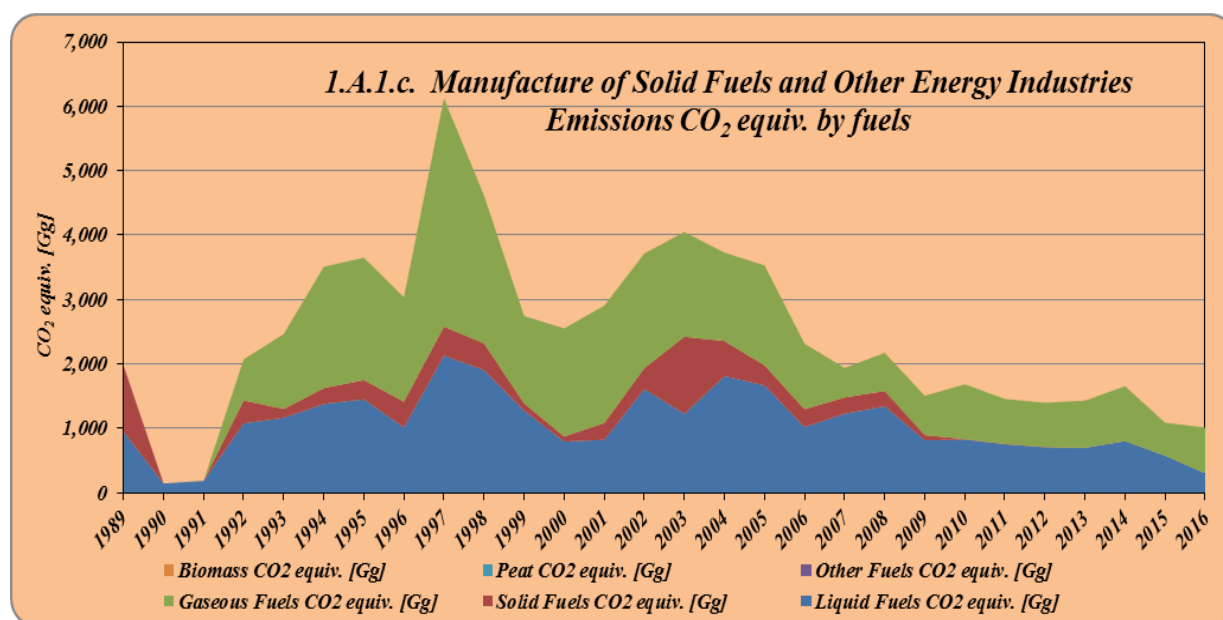
## *3.2.5.3 Manufacture of Solid Fuels and Other Energy Industries (CRF 1.A.1.c.)*

### *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 2016, starting to a share of 1.13% in the base year, 1989. The emissions from this activity decreased by 48.72% 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 preferred. 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.

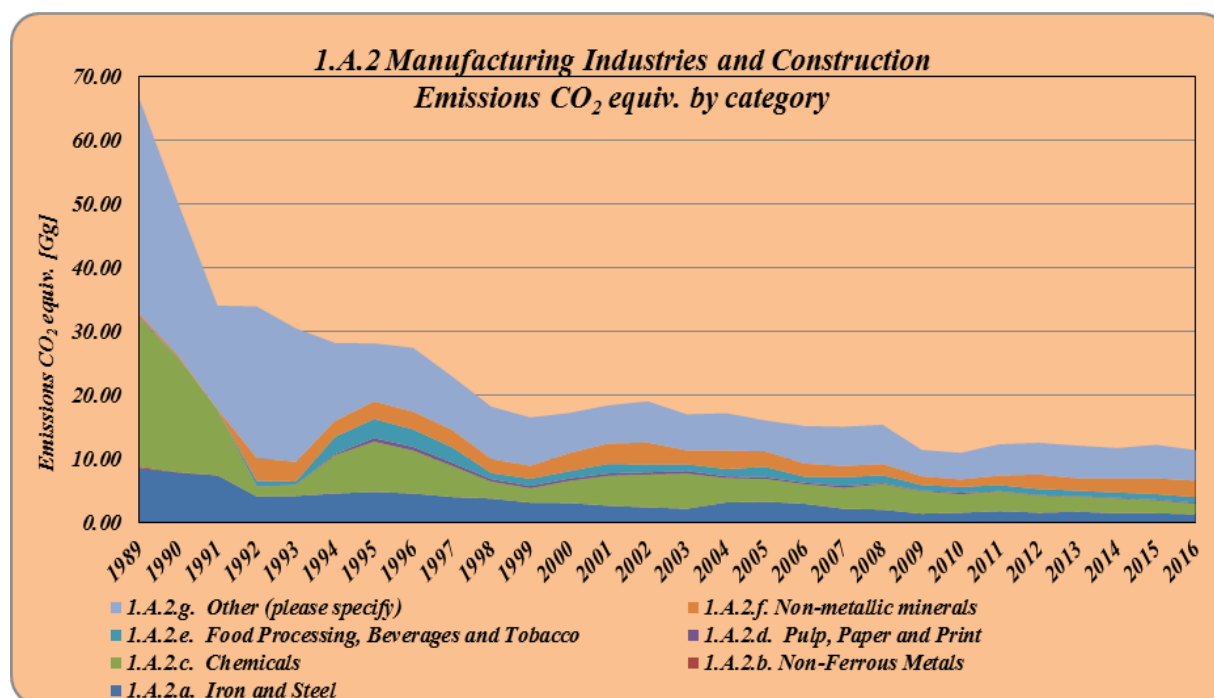
### 3.2.5.3.6 Category-specific planned improvements, if applicable including tracking of those identified in the review process

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<sub>2</sub> emissions. See the chapter 3.2.4.6 for more details.

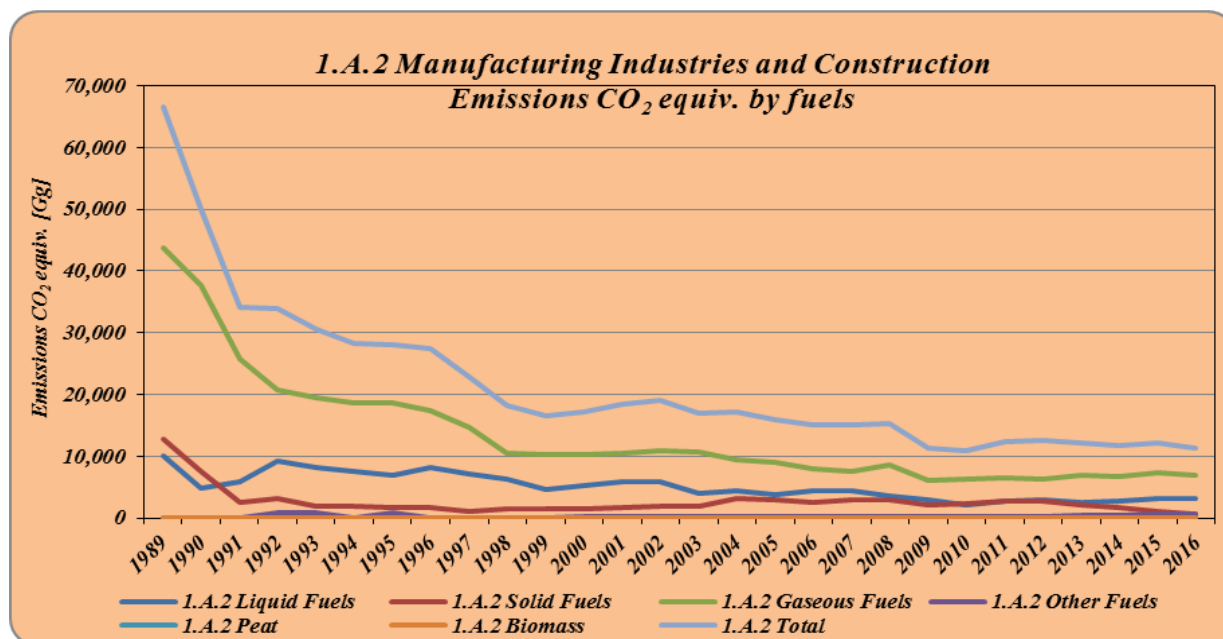
### 3.2.6 Fuel combustion, Manufacturing Industries and Construction (CRF 1.A.2.)

CRF 1.A.2. Manufacturing Industries and Construction is a CO<sub>2</sub> key category by, liquid, solid, gaseous fuels, level and trend, excluding and including LULUCF and other fossil, 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 2016 for 17.48% of the total Energy Sector GHG emissions (about 11,324.63 kt CO<sub>2</sub> equivalents).

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

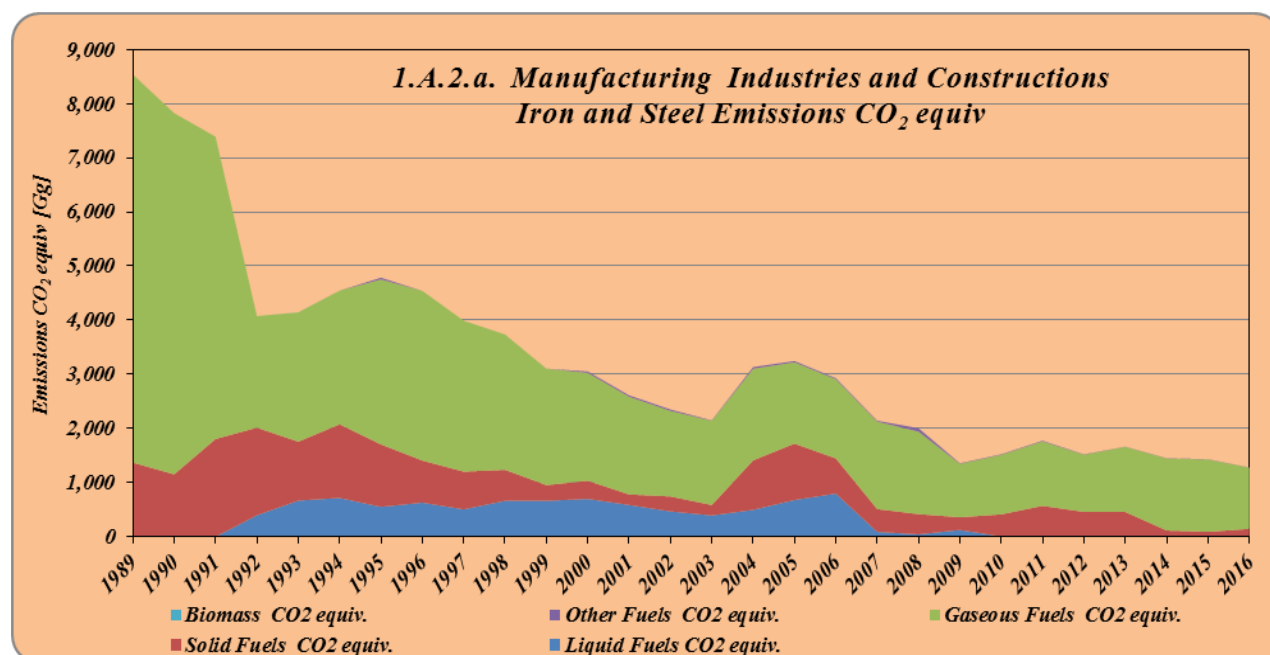
- ❖ **Energy Use in the Petrochemical Sector**
- ❖ **Energy Use in Transformation Sector, autoproducers:**
  - Auto producer Electricity Plants
  - Auto producer CHP Plants
  - Auto producer Heat Plants.
- ❖ **Energy Sector - Blast Furnaces (Energy)**
- ❖ **Industry Sector:**
  - Iron and Steel;
  - 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<sub>2</sub> equiv. emissions of the 1.A.2.a category to the 1.A.2 sub-sector, is 12.83% from the base year, to 11.30% - current year, 2016.



The contribution of this category is about 1,279.55 kt CO<sub>2</sub> equiv., in 2016.

#### *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*

For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

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

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<sub>2</sub> emissions. See the Chapter 3.2.4.6 for more details.

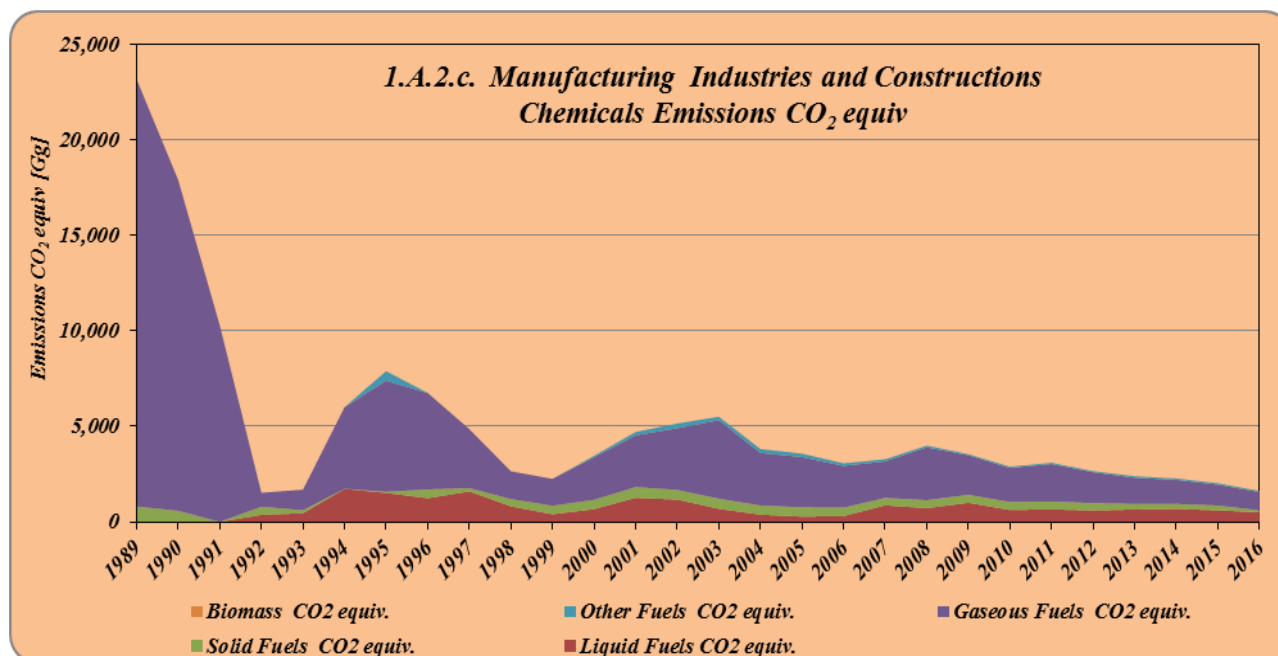
*3.2.6.2 Fuel combustion, Manufacturing Industries and Construction, Non-Ferrous metals (CRF 1.A.2.b)*

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*

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 – 34.80% to 14.34% - current year, 2016. The contribution of this category is about 1,623.90 kt CO<sub>2</sub> equiv., in 2016.

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

### 3.2.6.3.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels 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*

The recalculations for the specific activity data change are 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.

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

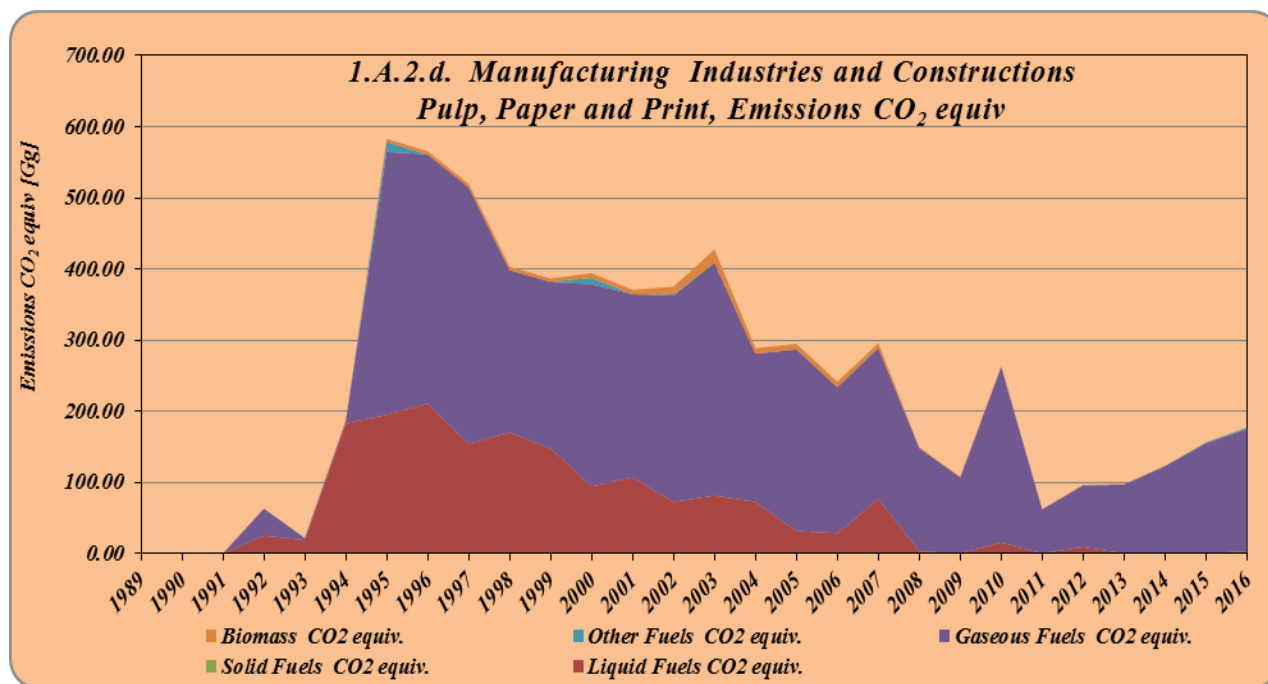
It is planned to take into consideration the emissions from the operators reporting on EU-ETS (having their reports verified by accredited verifiers) in order to achieve a higher tier approach in the estimation of the CO<sub>2</sub> emissions. See the Chapter 3.2.4.6 for more details.

#### *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*

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 1.56% - in the current year, 2016. The contribution of this category is about 177.05 kt CO<sub>2</sub> equiv., in 2016.

See more details about trends in the Chapters 3.1 – Overview of the sector and 3.2.4 Source category - Fuel combustion (CRF sector 1.A.).

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

#### 3.2.6.4.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels which are not reported under EU-ETS, are used.

For the fuels reported in this activity category having determined Country Specific Emission Factors, Tier 2 methodology is used.

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.

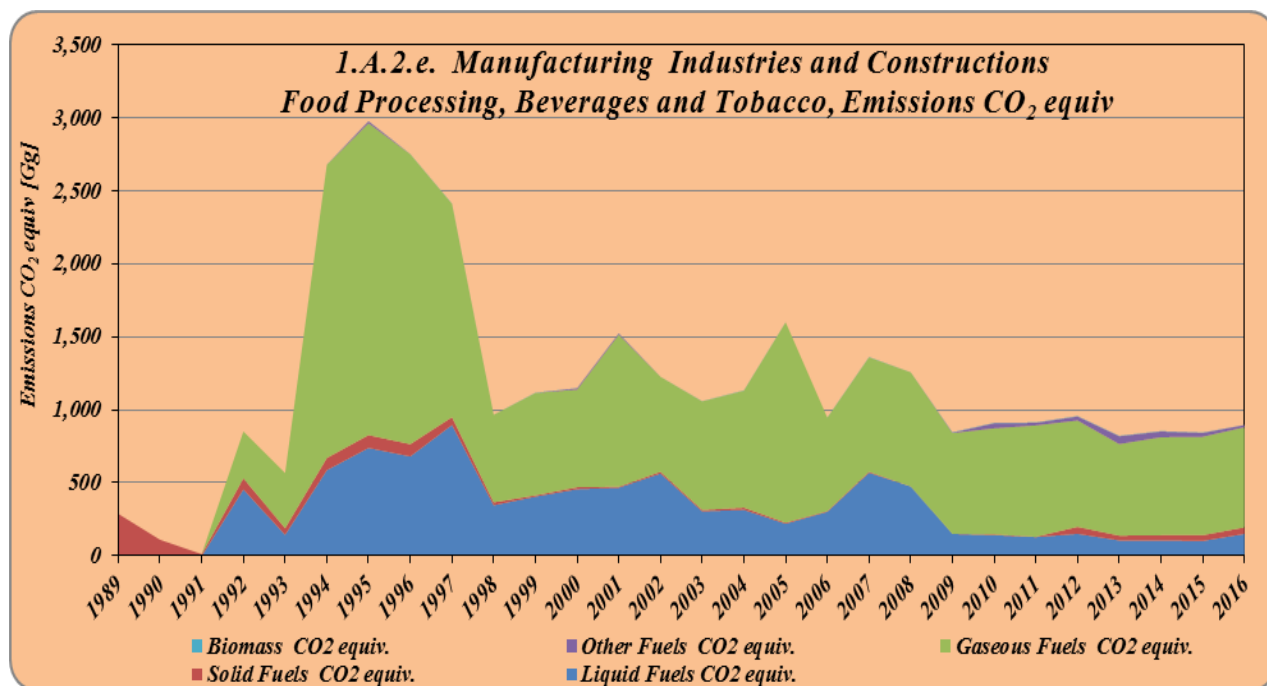
#### *3.2.6.4.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process*

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<sub>2</sub> 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*

The share of the total GHG emissions of the 1.A.2.e category to 1.A.2 sub-sector is about 0.43% - base year to the 7.91%, current year, 2016. The contribution of this category is about 896 kt CO<sub>2</sub> equiv., in 2016. 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.

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

#### 3.2.6.5.2 Methodological issues

Tier 1 Methodology and Default emission factors for the fuels 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*

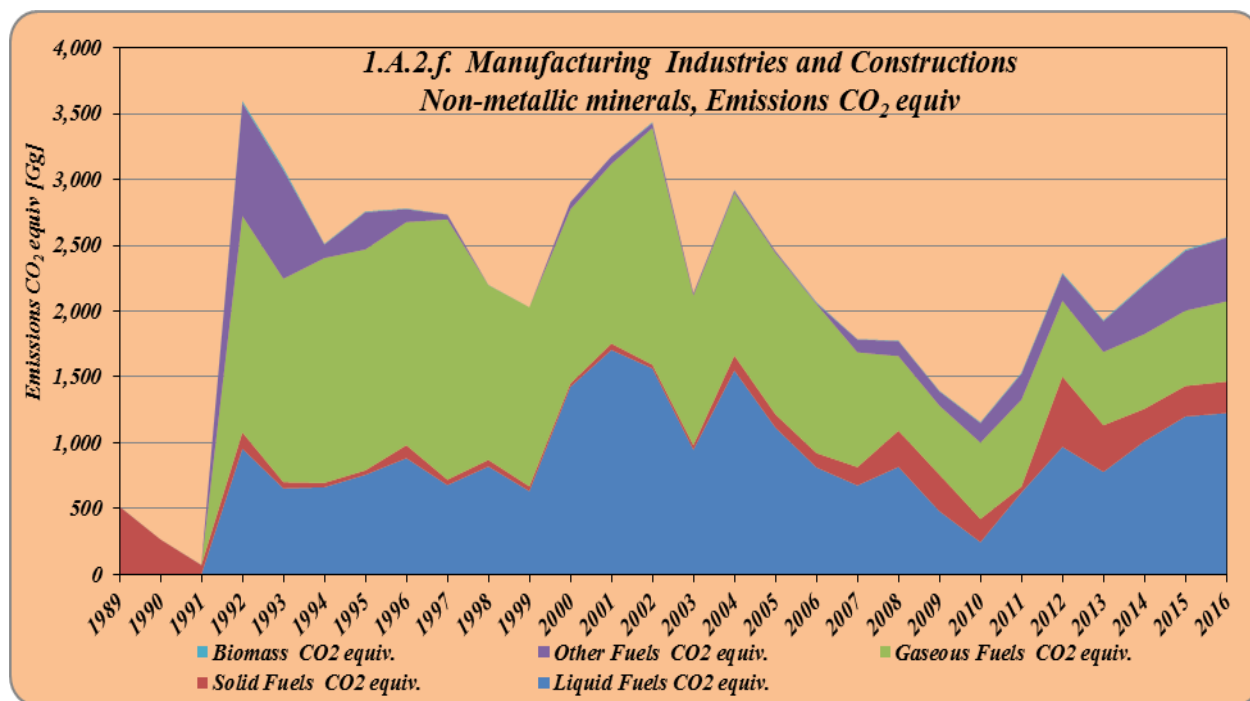
It is planned to take into consideration the emissions from the operators reporting on EU-ETS (having their reports verified by accredited verifiers) in order to achieve a hire tier approach in the estimation of the CO<sub>2</sub> emissions. See the Chapter 3.2.4.6 for more details.

#### *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 22.62%, current year, 2016. The contribution of this category is about 2,561.90 kt CO<sub>2</sub> equiv., in 2016.



*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.

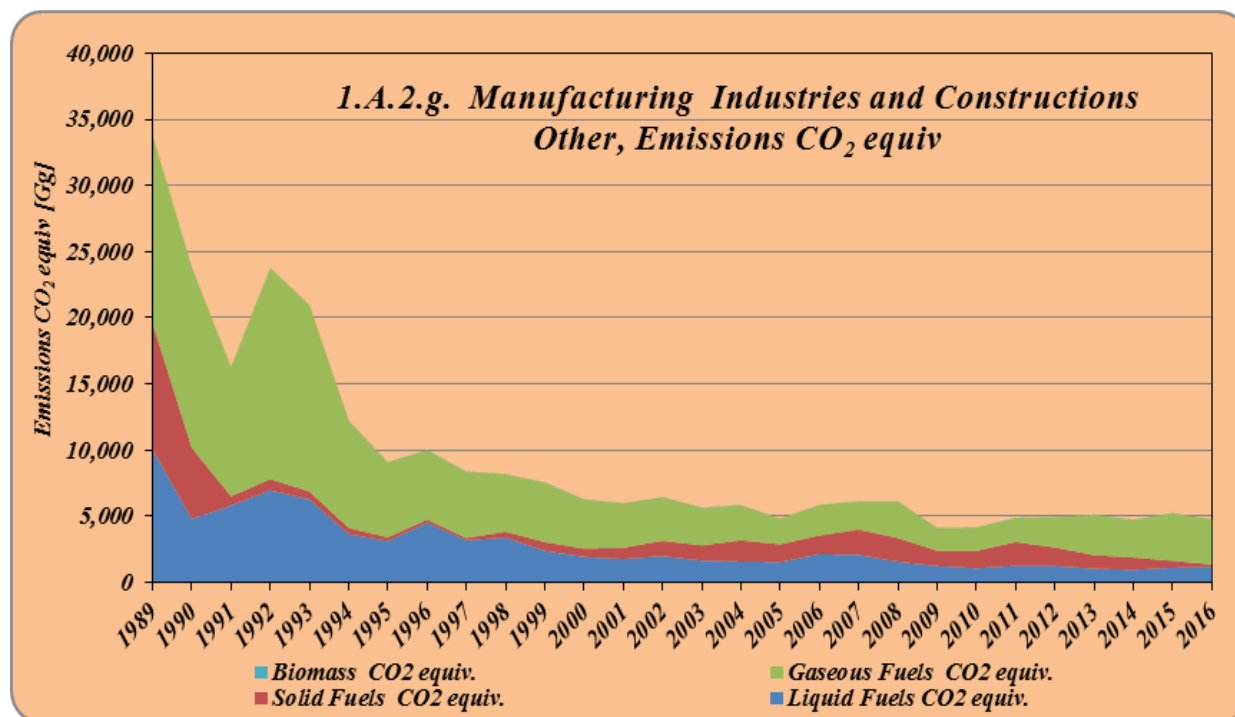
#### *3.2.6.6.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process*

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<sub>2</sub> 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 42.26%, in 2016, the contribution of this category being about 4,786.23 kt CO<sub>2</sub> 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.

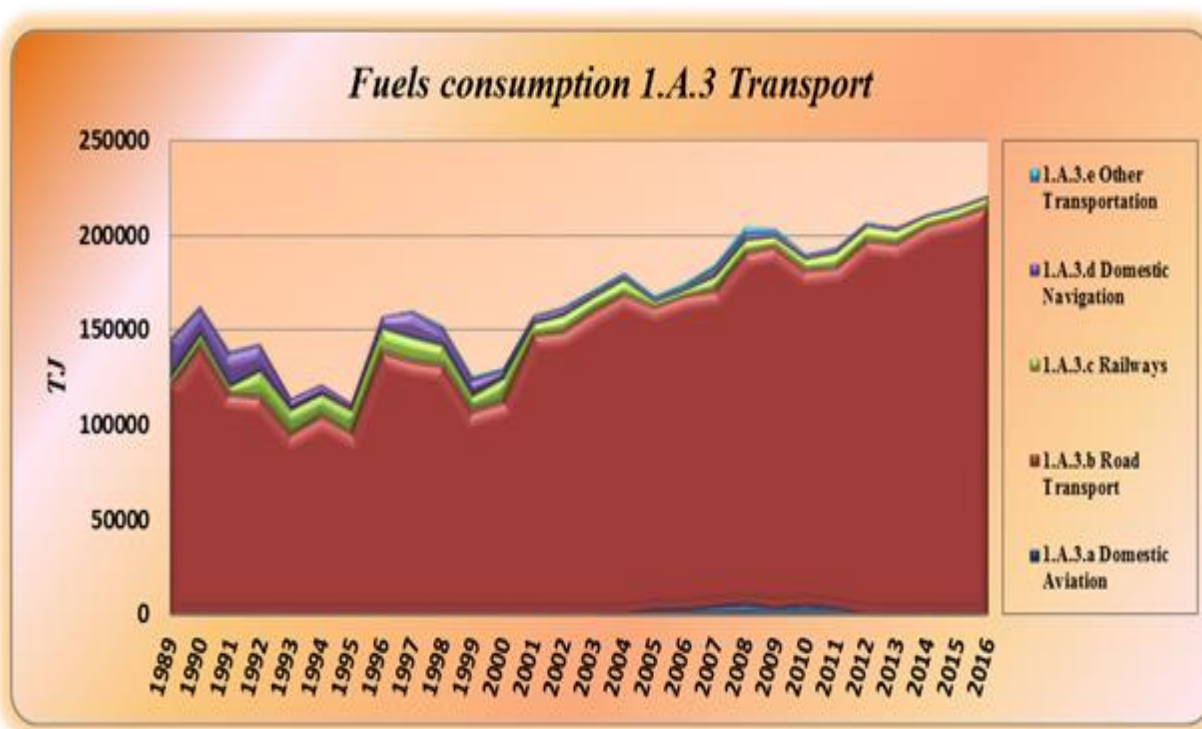
#### *3.2.6.7.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process*

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<sub>2</sub> 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**

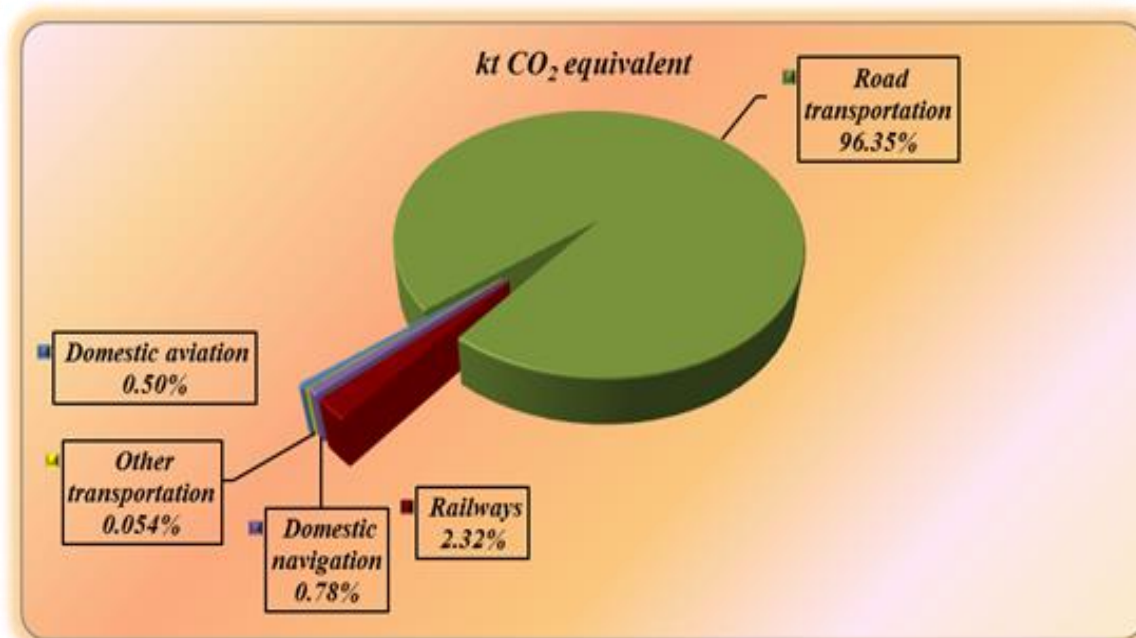
In 2016 year, the emissions from transport categories accounted for 16,828.17 kt CO<sub>2</sub> equivalent.

The GHG characterized are: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub>, NMVOC, CO and SO<sub>2</sub>.

Within the Energy Sector total emissions, 22.31% 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 2016**



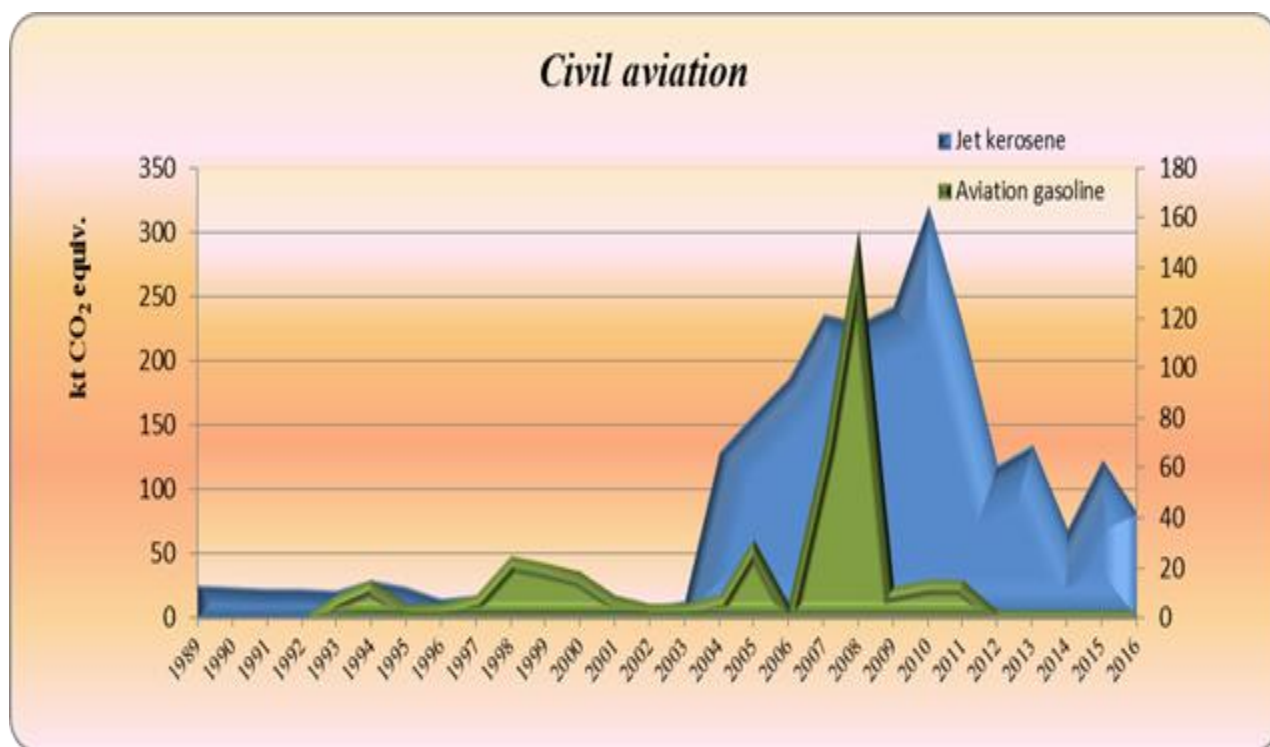
### 3.2.7.2 Civil Aviation (CRF I.A.3.a)

#### 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 2016 year, the civil aviation related emissions represents 0.50% of total emissions from the transport sector (16,828.17 kt CO<sub>2</sub> equivalent).

**Figure 3.34 GHG emissions Trend from 1A3a – Civil Aviation**

In the period 1989-2003 emissions remain 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 2005-2016 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 2004-2016, 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<sub>2</sub> 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.

<b>CO<sub>2</sub> emission factor</b>	
<b>Fuel</b>	<b>Default (kg/TJ)</b>
Aviation Gasoline	70,000
Jet Kerosene	71,500

For Tier 1 the values of CH<sub>4</sub>, N<sub>2</sub>O emissions factor for domestic and international aviation are default according to 2006 IPCC methodology, Table 3.6.5, page 3.6.4, chapter 3, vol 2.



Default emission factor (kg/TJ) for all fuels	
CH <sub>4</sub>	N <sub>2</sub> O
0.5	2

For Tier 2 the values of CH<sub>4</sub>, N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O 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<sub>x</sub> 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<sub>2</sub> emissions were used the values of the Sulphur content provided by the site EMEP/EEA Air Pollutant Emission Inventory Guidebook — 2016 and in according to 1996 IPCC Guidelines. Determination of values emission factors and emissions were in according to 1996 IPCC Guidelines.

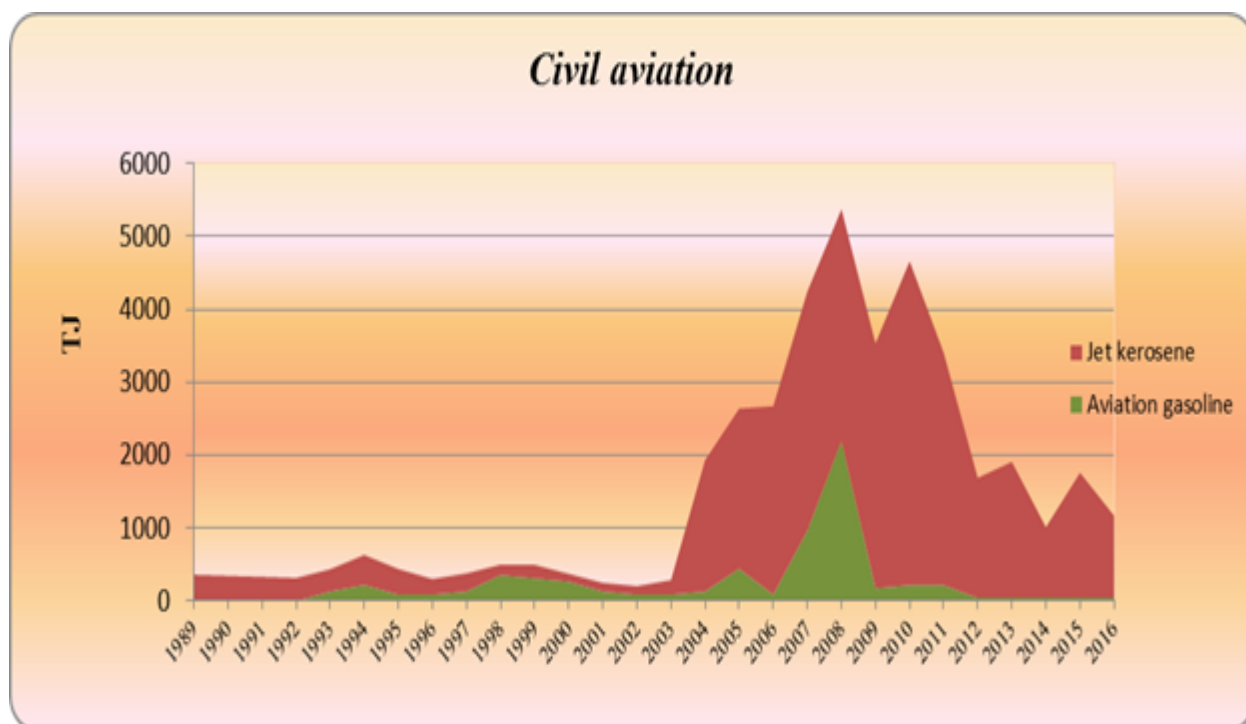
### ***Activity Data***

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 1989-2016 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; 2007-2016 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 3.35 Fuel consumption(Aviation gasoline) for Civil Aviation -I.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<sub>2</sub>*

##### ❖ **activity data:**

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

##### ❖ **emission 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<sub>4</sub>***❖ ***activity data:***

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

❖ ***emission 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<sub>2</sub>O***❖ ***activity data:***

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

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

*3.2.7.2.5 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.

*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)

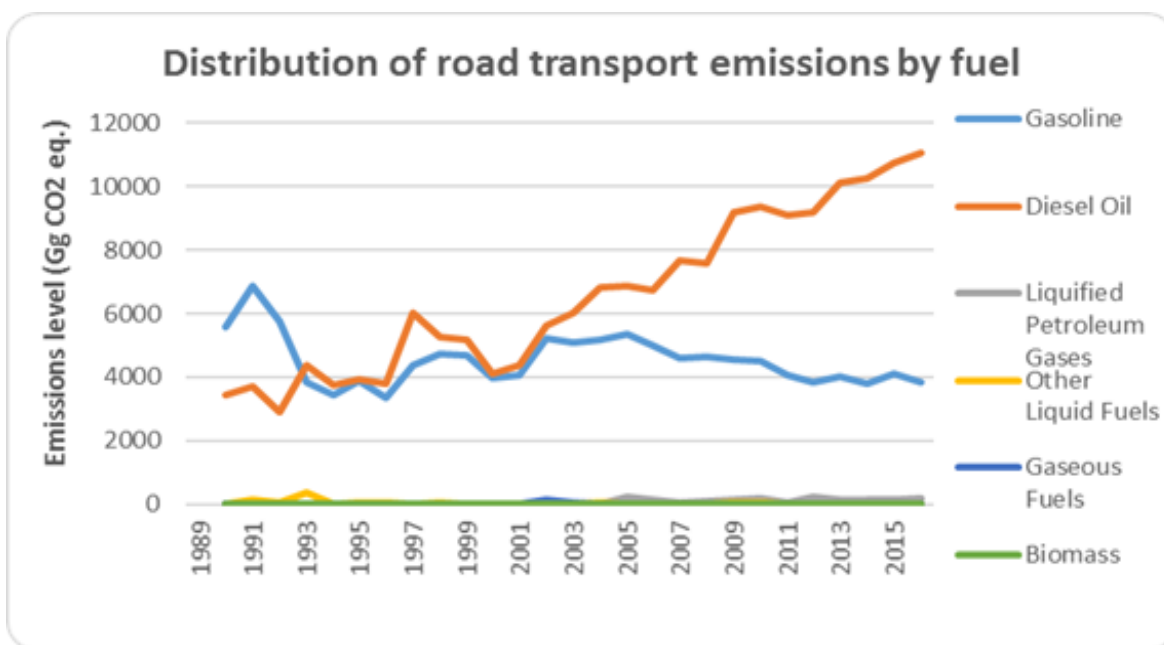
#### 3.2.7.3.1 Category description

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<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) 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<sub>2</sub>), particulate matter (PM) and oxides of nitrate (NO<sub>x</sub>), which cause or contribute to local or regional air pollution.

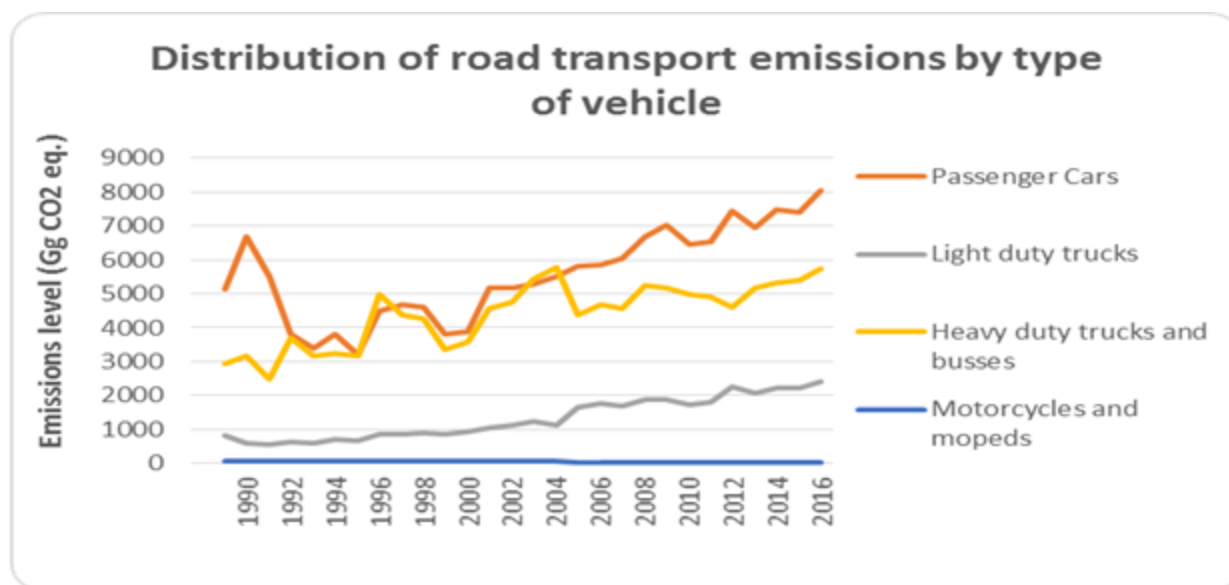
Exhaust emissions from road transport arise from the engines internal combustion of fuels such as gasoline, diesel, liquefied petroleum gas, other kerosene and natural gas.

**Figure 3.36 Distribution of Road transportation emissions by fuel (Gg CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions grew constantly to 2016.

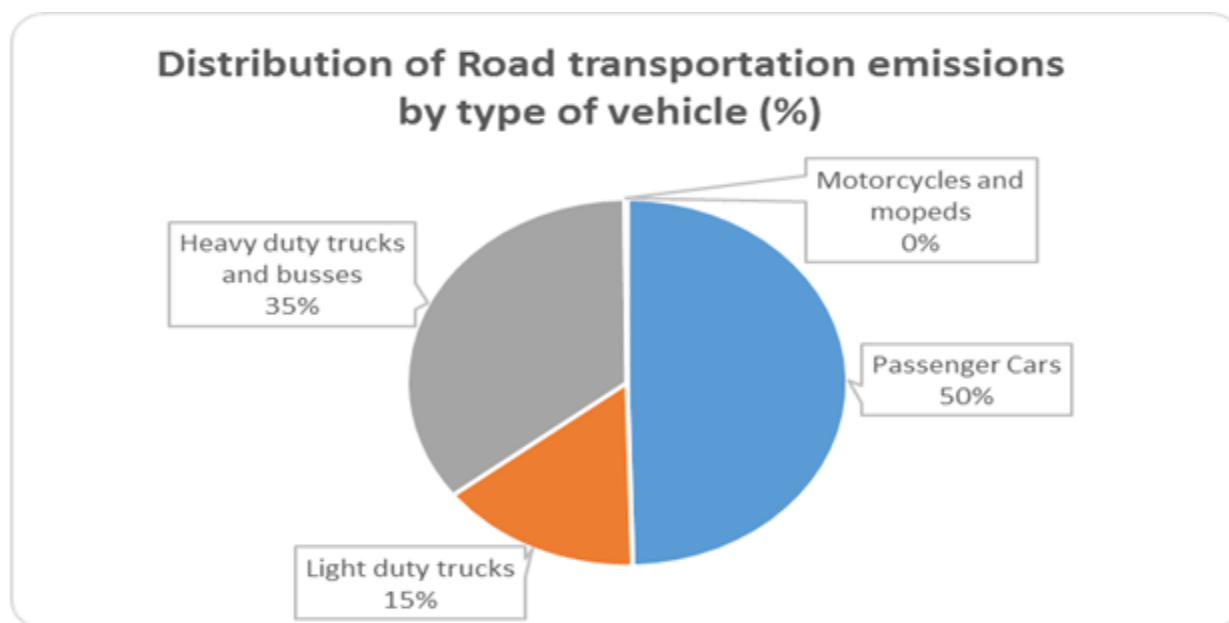
**Figure 3.37 Distribution of Road transportation emissions by type of vehicle (Gg CO<sub>2</sub> eq.)**



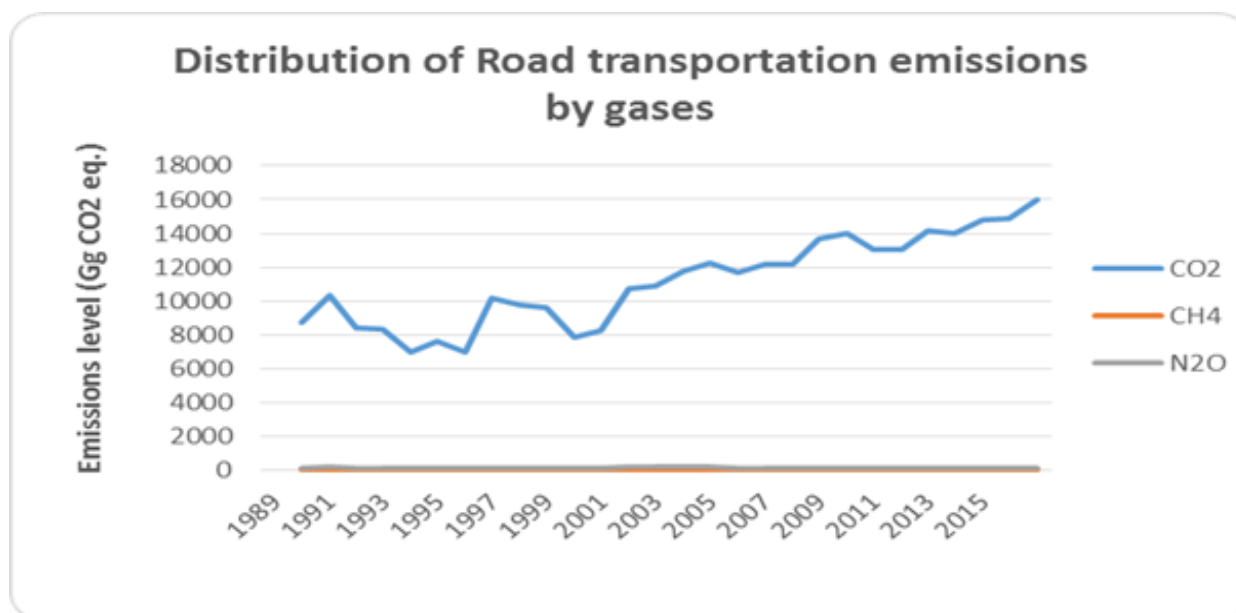
Overall, the GHG emissions from road transport increased by 80.19% compared to base year levels being 8998,90 kt CO<sub>2</sub>equiv in 1989 and reached levels of 16,214.83 kt CO<sub>2</sub>equiv in 2016. The most important contributor to GHG emissions is represented by passenger cars, followed by heavy duty trucks and buses, light duty trucks and motorcycles and mopeds; in 2016, emissions

from passenger cars contributed to 49.55% in total Road transportation emissions and heavy duty trucks and buses with 35.3%.

**Figure 3.38 Distribution of Road transportation emissions by type of vehicle (%)**



**Figure 3.39 Distribution of Road transportation emissions by gases (Gg CO<sub>2</sub> equivalent)**



Whereas CO<sub>2</sub> emissions are closely linked to fuel consumption, CH<sub>4</sub> and N<sub>2</sub>O emissions are impacted also by the technology. N<sub>2</sub>O emissions have a higher warming potential compared to CH<sub>4</sub>, hence, a slight increase in their release in the environment leads to a greater impact.

As it can be observed, CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> 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<sub>2</sub>. It accounts for 98.76% of the total greenhouse gas emissions of the sector, in 2016.

CH<sub>4</sub> emissions contributed with 0.21% 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 2016, N<sub>2</sub>O emissions contributed with 1.02% to the total emissions of the this sector. The changes in N<sub>2</sub>O 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<sub>2</sub>O as undesirable by-product in the exhaust gases, leading to an increase of N<sub>2</sub>O 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<sub>2</sub>O emissions.

CH<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O thereby leading to low levels of methane and nitrous oxide. As the technology improves over time, there is a noticeable decrease in the passage from Euro 1 to Euro 3, which could be detected clearly after 2005.

#### *3.2.7.3.2 Methodological issues*

##### ***Methodology***

In the development of estimates, it was primarily utilized default EFs available in the IPCC 2006 and, in some cases (where the previous documents do not comprise values) from EMEP/EEA air



pollutant emission inventory guidebook 2013. Model Copert 4, Tier 1 was used in the absence of more detailed fleet data (for the period 1989-2004).

For the 1989–2004 period

### ***A) Tier 1 methodology***

Tier 1 methods apply simple linear relation between activity data and emission factors. The activity data is derived from readily available statistical information (consumption energy statistics, fleet data, data on traffic counts etc).

The most common estimation approach is to combine information on the extent to which a activity takes place (called activity data or AD) with coefficients that quantify the emissions or removals per unit activity, called emission factors (EF), the default Tier 1 emission factors are chosen in way that they represent 'typical' or 'averaged' process conditions - they tend to be technology independent.

For this time period 1989-2004, was used default emission factors of EMEP/EEA emission inventory guidebook 2013, Tier 1. Emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are calculated based on the amount and type of fuel combusted and its carbon content (for CO<sub>2</sub> 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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O 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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, NO<sub>x</sub> 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<sub>2</sub> ch. Road transport GB 2013, table 3-11 pag.27; CH<sub>4</sub> ch. Road transport GB 2013, table 3-70 pag.82; N<sub>2</sub>O ch. Road transport GB 2013, table 3-7 pag.26; CO, NO<sub>x</sub>, 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<sub>2</sub> 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 1990-2016 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<sub>2</sub> emissions released from these processes are reported as an information item, as the CO<sub>2</sub> is naturally captured from the air. That is not applicable for the CH<sub>4</sub> and N<sub>2</sub>O 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 2005-2016 period

### ***Methodology***

Model Copert 4, Tier 3 was used for the period 2005-2016, detailed statistics necessary to use higher level methods have allowed.

For the period 2005-2016 the emission calculations of road transport have been performed with the use of the version 11 of the European COPERT 4 software, model methodology corresponding to Tier 3, according to the IPCC 2006. In the Tier 3 method, exhaust emissions are calculated using a combination of firm technical data (emission factors) and activity data (total vehicle km). In the model emissions were calculated through the input of detailed data on average daily trip distance, the relative humidity per month, minimum and maximum temperatures per month, consumption and fuel specifications, vehicle fleet categorized in sectors, subsectors and technology (standard), vehicle stock and annual mileage, speed and driving shares.

### ***Emission Factors***

For period 2005-2016 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 2005-2016 in the 41 regions of Romania. These data used in Copert are calculated as an arithmetic average of the 41 regions of the country.

***Fuel specifications***

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

**Table 3.13 Country specific characteristics for gasoline and diesel oil according Decision no 689/ 2004, update by Decision no. 15/2006**

	Sulfur (% m/m)		Hidrocarbons		Benzene (% v/v)	E100 (% v/v)	E150 (% v/v)	Oxygen Content (%m/m)
			aromatics (% v/v)	olefins (% v/v)				
< 1 january 2005								
Leaded gasoline	-	0.08	42	-	3	-	-	-
Unleaded gasoline	Sulfur (mg/kg)							
	min	max						
	-	150	42	-	3	-	-	-
Unleaded Gasoline								
≥ 1 january 2005	-	150	42	18	1	46	75	2.7
≥ 1 january 2007	-	50	35	18	1	46	75	2.7
≥ 1 january 2009	-	10	35	18	1	46	75	2.7
Diesel oil								
	Sulfur (mg/kg)		PAH (% m/m)		Density (kg/m³)	T95% C <sup>0</sup>	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 (DDLVR) 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 3.14 Uncertainties for road transport**

Road Transport 1.A.3.b.	Uncertainty				Combined uncertainty		
	Activity Data	EF CO <sub>2</sub>	EF N <sub>2</sub> O	EF CH <sub>4</sub>	EF CO <sub>2</sub>	EF N <sub>2</sub> O	EF CH <sub>4</sub>
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 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-bituminous Coal, Other bituminous Coal, Coking Coal, Other Kerosene.

In the 2016 year the emissions from Railways category represents 2.32% of total emissions from the transport sector (16,828.17 Gg CO<sub>2</sub> equivalent).

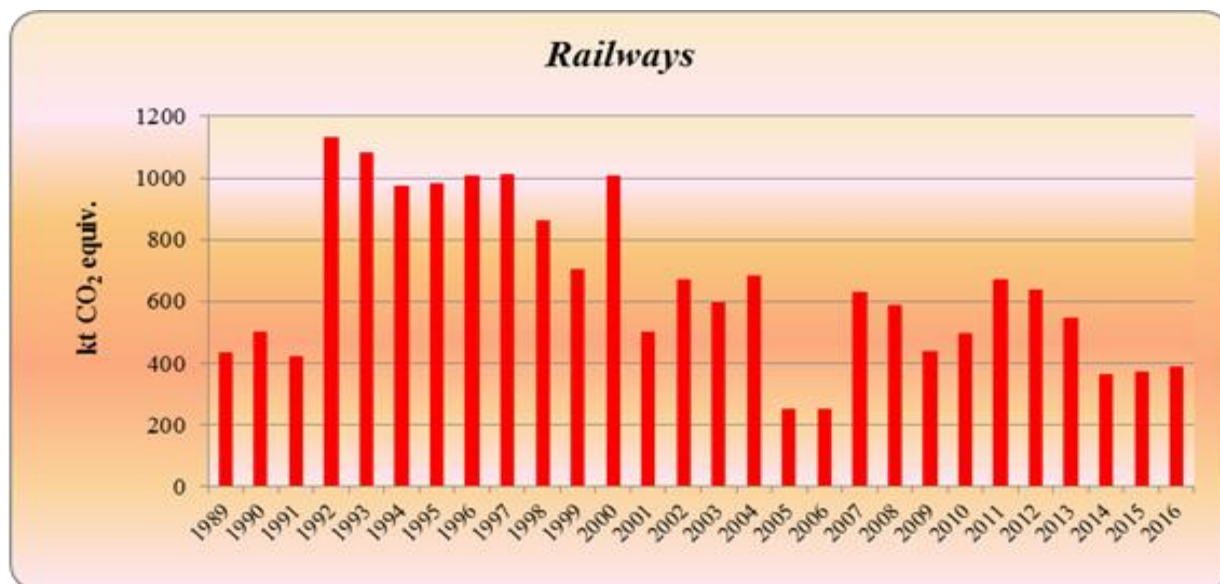
In Railways Subsector, the emissions trend reflects the changes in this period characterized by a process of transition to a market economy.

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

For 2016 an increase compared to 2015 has been observed, due to the domestic trips number increased.

**Figure 3.40 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 — 2016.

### ***Tier 2 method***

The CO<sub>2</sub> emissions, 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<sub>2</sub> emissions from fuel combustion in the sectors.

The CO<sub>2</sub> emissions, are calculated according to 2006 IPCC Guidelines vol.2 (pag.3.33, section 3.3.1.1)

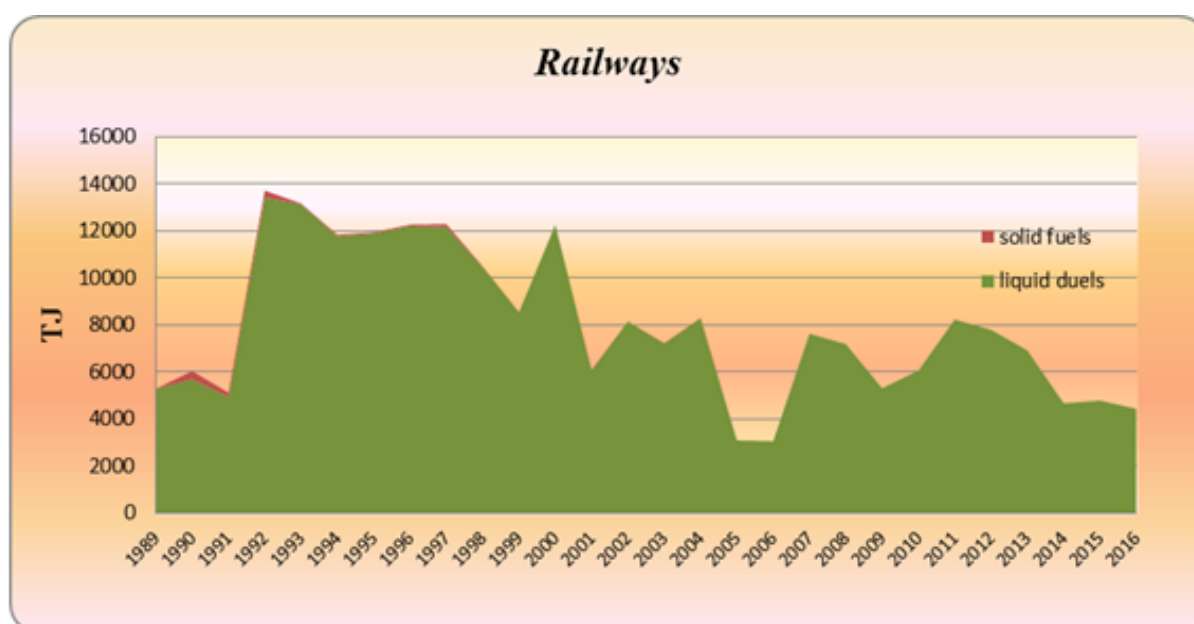
### ***Emission factors***

The values of CO<sub>2</sub> Emissions Factor is country specific. The values of CH<sub>4</sub> and N<sub>2</sub>O 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 3.41 Fuel consumption for Railways -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<sub>2</sub>*

❖ *activity data:*

- Liquid: 5%
- Solid: 3%

❖ *emission 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<sub>4</sub>*

❖ *activity data:*

- Liquid: 5%
- Solid: 3%

❖ *emission 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<sub>2</sub>O*****❖ *activity data:***

- Liquid: 5%
- Solid: 3%

**❖ *emission 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 nonconformities 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 nonconformities noted were solved of the 2012 NGHGI; they are described in the Chapter

3.2.7.4.5 – Source-specific recalculations, including changes made in response to the review process and at the Chapter 10 - Recalculations and improvements levels; the quantitative effects of their solving are described at the Chapter 3.2.7.4.5 – Source-specific recalculations, including changes made in response to the review process.

The activity data series were also compared to those on Eurostat, the data being reported at the same level of aggregation and the figures comparable; additionally, national emission factors values were compared with national emission factors values specific to Bulgaria, considering that similar energy activities are implemented. Further elements are presented within Annex 6.3.

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

No recalculations were performed for this submission.

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

No source-specific planned improvements are envisaged.

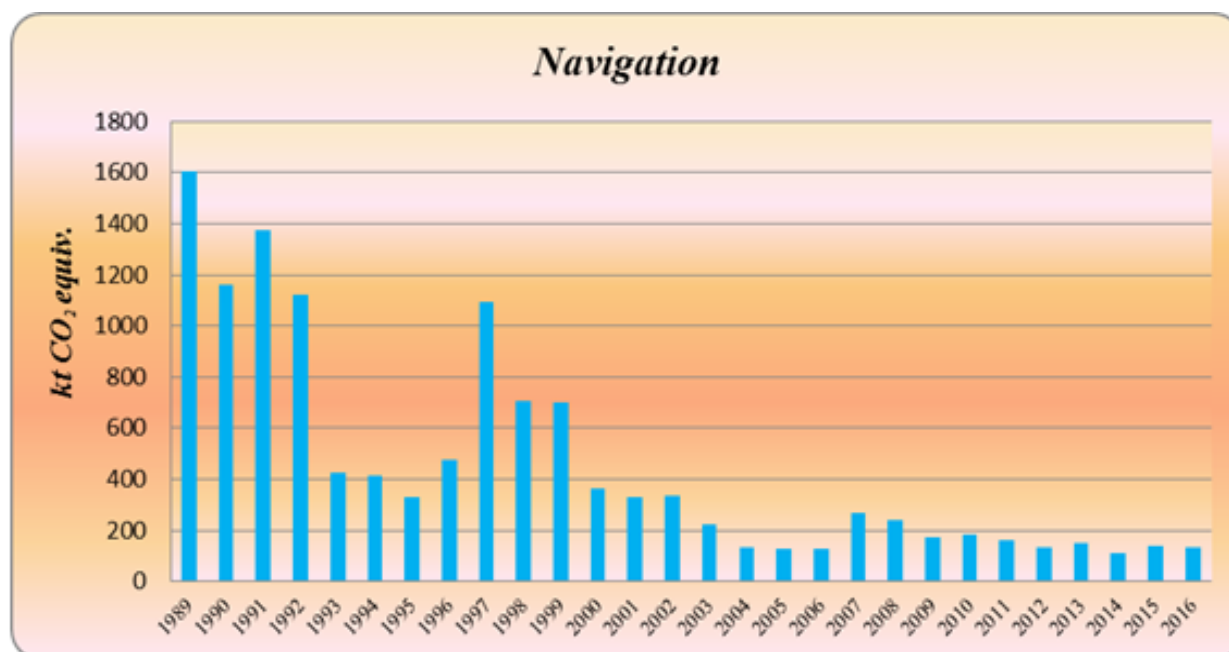
*3.2.7.5 Navigation(CRF 1.A.3.d)*

*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 2016 year the emissions from Navigation category represents 0.78% of total emissions from the transport sector (16,828.17 kt CO<sub>2</sub> equivalent).

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 3.42 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.

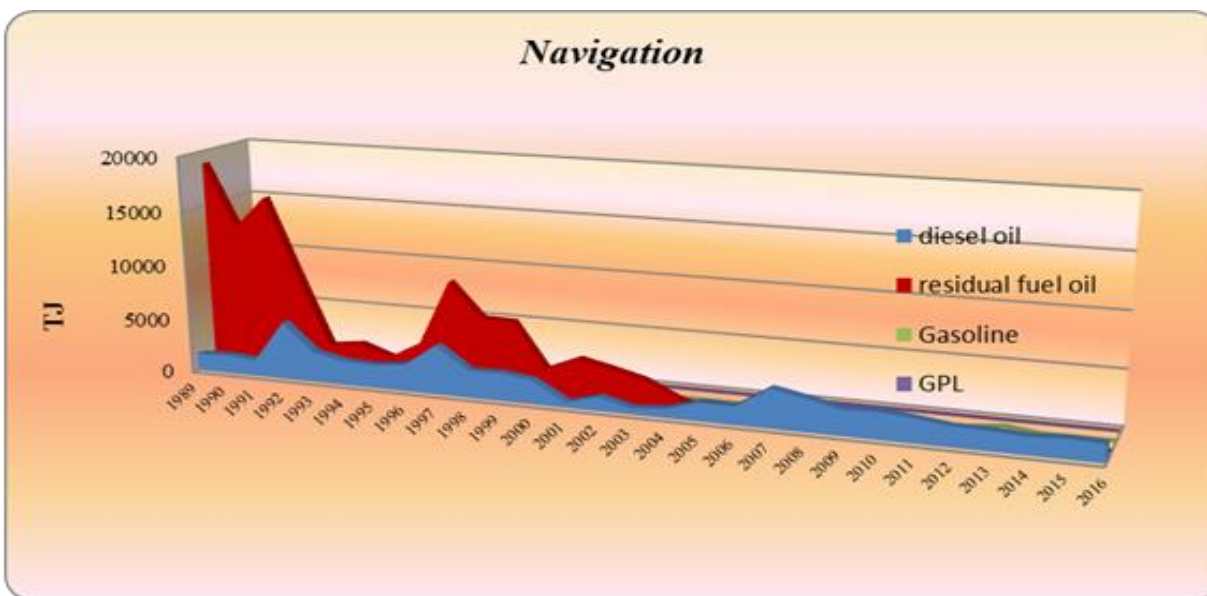
### **Emission Factors**

The values of CO<sub>2</sub> Emissions Factor is country specific.

The values of CH<sub>4</sub> and N<sub>2</sub>O 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 3.43 Fuel consumption 1.A.3.d Navigation 1989-2016 period**

### 3.2.7.5.3 Uncertainties and time-series consistency

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

#### *CO<sub>2</sub>*

##### ❖ *activity data:*

- Residual Fuel Oil: 5.0 %
- Diesel oil: 5.0%
- Gasoline: 3.0%

##### ❖ *emission 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<sub>4</sub>*****❖ *activity data:***

- Residual Fuel Oil:5.0 %
- Diesel oil: 5.0%
- Gasoline:3.0%

**❖ *emission 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<sub>2</sub>O*****• *activity data:***

- Residual Fuel Oil:5.0 %
- Diesel oil: 5.0%
- Gasoline:3%

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

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

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

❖ **activity data:**

- ✓ Domestic Navigation (1.A.3.d.) category: the emission values for 2015 have been updated because the activity data of Fuel Consumption have been updated;
- ❖ *emissions:*
  - ✓ Domestic Navigation (1.A.3.d.) category: the CO<sub>2</sub> emission value for 2015 has been updated because the Country Specific Emission Factor value and the activity data value of fuel consumption for 2015 has been updated; the CH<sub>4</sub> and N<sub>2</sub>O emission values for 2015 have been updated due to updated of the activity data value of fuel consumption for 2015.

*Table 3.15 Effects of data changes on CO<sub>2</sub> emissions level*

Year	Effects of changes on CO <sub>2</sub> emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	
1989	1587.6113	1587.6113	0.00
1990	1151.3370	1151.3370	0.00
1995	325.7423	325.7423	0.00
2000	358.0031	358.0031	0.00
2005	128.3844	128.3844	0.00
2007	264.5882	264.5882	0.00
2008	236.6164	236.6164	0.00
2009	171.1164	171.1164	0.00
2010	182.6449	182.6449	0.00
2011	158.0096	158.0096	0.00
2012	133.6694	133.6694	0.00
2013	149.2042	149.2042	0.00
2014	110.2649	110.2649	0.00
2015	128.1086	139.7790	9.11

*Table 3.16 Effects of data changes on CH<sub>4</sub> emissions level*

Year	Effects of changes on CH <sub>4</sub> emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	
1989	0.14305	0.14305	0.00
1990	0.10395	0.10395	0.00
1995	0.03004	0.03004	0.00
2000	0.03268	0.03268	0.00
2005	0.01217	0.01217	0.00
2007	0.02477	0.02477	0.00
2008	0.02091	0.02091	0.00
2009	0.01614	0.01614	0.00
2010	0.01745	0.01745	0.00
2011	0.01517	0.01517	0.00
2012	0.01272	0.01272	0.00
2013	0.01475	0.01475	0.00
2014	0.01109	0.01109	0.00
2015	0.01288	0.01235	-4.14

*Table 3.17 Effects of data changes on N<sub>2</sub>O emissions level*

Year	Effects of changes on N <sub>2</sub> O emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	
1989	0.04087	0.04087	0.00
1990	0.02970	0.02970	0.00
1995	0.00858	0.00858	0.00
2000	0.00932	0.00932	0.00
2005	0.00348	0.00348	0.00
2007	0.00708	0.00708	0.00

Year	Effects of changes on $N_2O$ emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	
2008	0.00598	0.00598	0.00
2009	0.00461	0.00461	0.00
2010	0.00499	0.00499	0.00
2011	0.00433	0.00433	0.00
2012	0.00364	0.00364	0.00
2013	0.00421	0.00421	0.00
2014	0.00317	0.00317	0.00
2015	0.00368	0.00353	-4.14

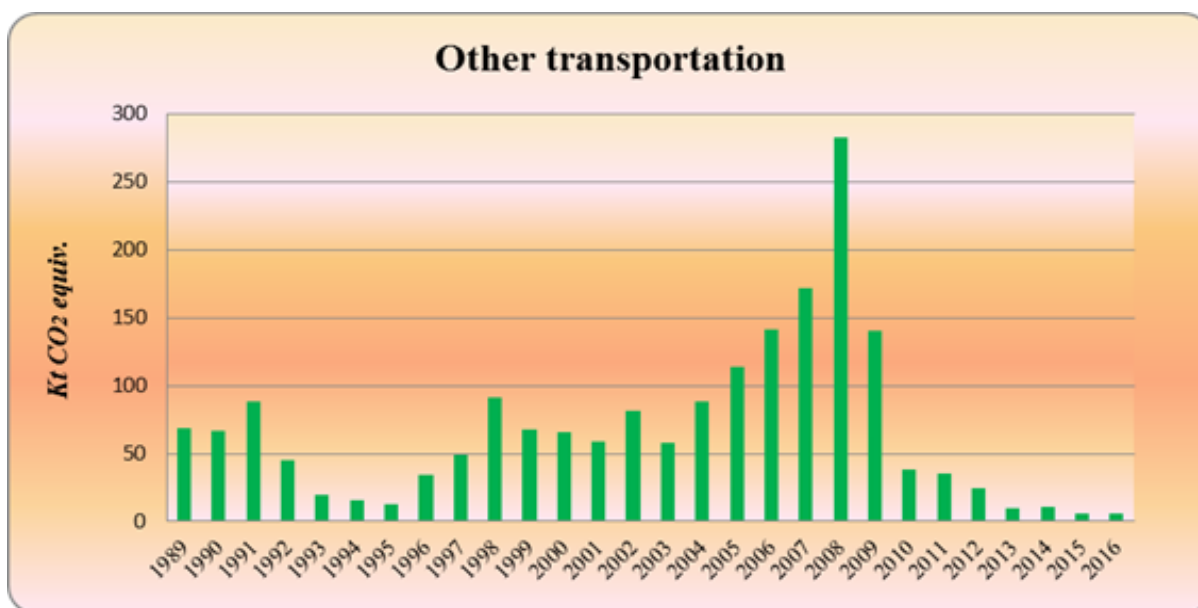
*3.2.7.5.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process*

No source-specific planned improvements are envisaged.

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

*3.2.7.6.1 Category description*

This category includes Pipeline Transport (1A.3.e.i) and 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 2016 year the emissions from sub-sector Other Transportation represents 0.035 % of total emissions from the transport sector (16,828.17 kt CO<sub>2</sub> equivalent).

**Figure 3.44 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.

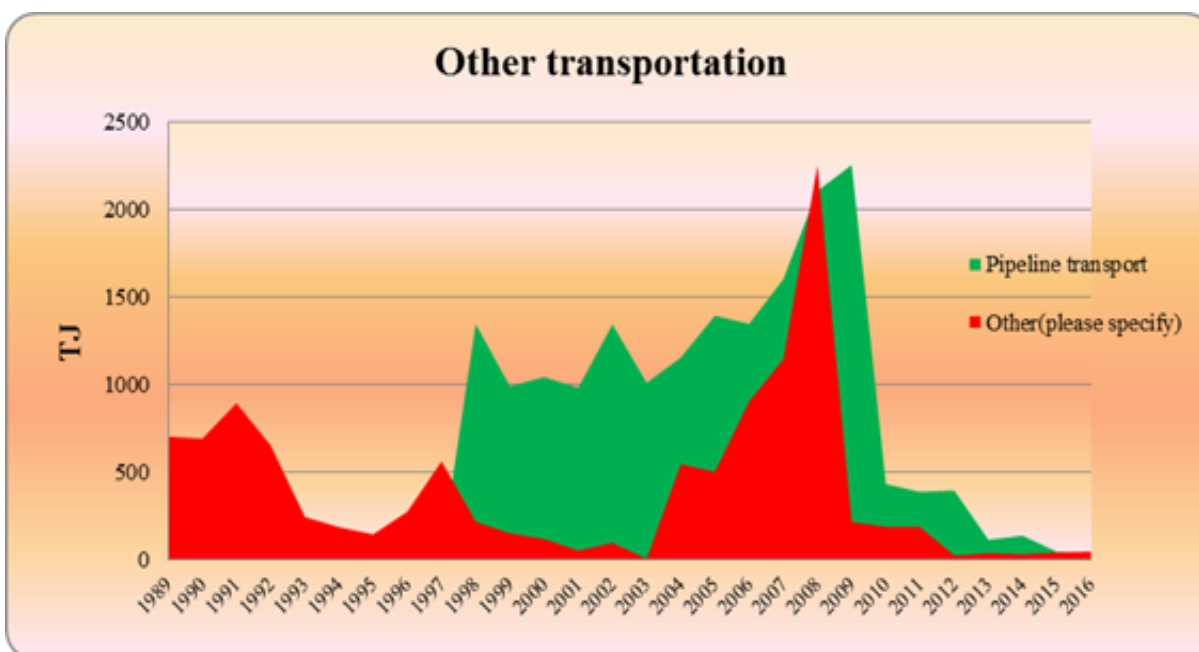
The Tier1 and Tier 2 method was used and are presented in the section 3.2.7.4.2.

### **Emission Factors**

The CO<sub>2</sub> emission factor is country specific and is presented in section 3.2.7.4.2. The values of CH<sub>4</sub>, N<sub>2</sub>O NO<sub>x</sub>, emission factors are default and in according to 2006 IPCC Guidelines. The values of CO, NMVOC, SO<sub>2</sub> emission factors are default and in according to 2006 IPCC Guidelines, IPCC 1996 Guidelines and EMEP/EEA Air Pollutant Emission Inventory Guidebook — 2016.

### **Activity Data**

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

**Figure 3.45 Fuel consumption 1.A.3.c Other transportation 1989 -2016**

### 3.2.7.6.3 Uncertainties and time-series consistency

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

#### *CO<sub>2</sub>*

- **activity data:**
  - Liquid: 3.0%
  - Solid: 3.0%
  - Gaseous: 3.0%
  - Biomass: 3.0%
- **emission 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<sub>4</sub>***

- ***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<sub>2</sub>O***

- ***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 with national emission factors values specific to Bulgaria, considering that similar

energy activities are implemented. Further elements are presented within Annex 6.3.

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

No recalculations were performed due to the activity data changes.

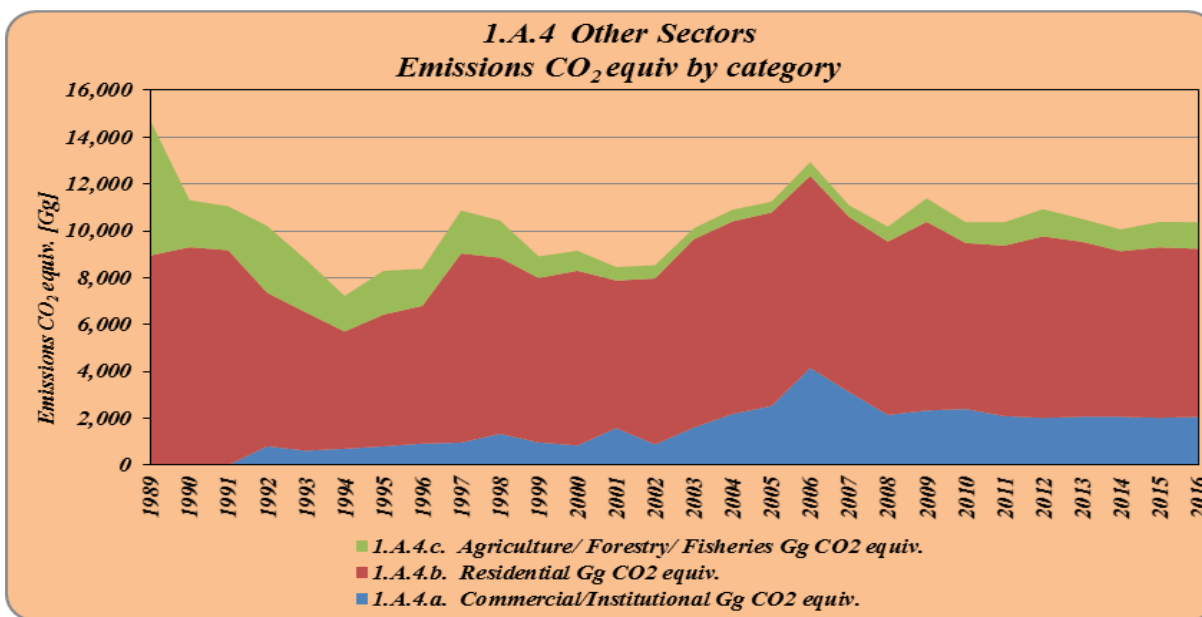
*3.2.7.6.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process*

No source-specific planned improvements are envisaged.

*3.2.8 Fuel combustion, Other Sectors (CRF 1.A.4.)*

*3.2.8.1 Category description*

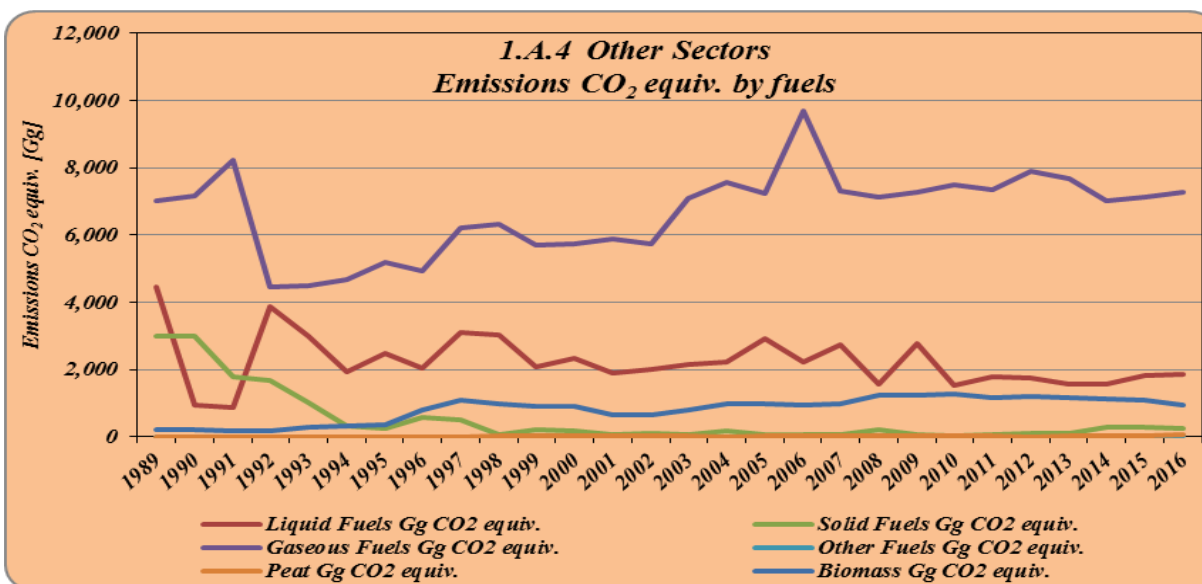
CRF category 1.A.4. Other sectors, as result of T1 approach is a CO<sub>2</sub> key category by gaseous fuel – level and trend, excluding and including LULUCF, CO<sub>2</sub> key category by solid fuel - trend, excluding and including LULUCF, CO<sub>2</sub> key category by liquid fuels – level and trend, excluding and including LULUCF and is a CH<sub>4</sub> key category by biomass – level and trend, excluding and including LULUCF.

**Figure 3.46 GHG emissions from 1.A.4. – Other, by category**

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

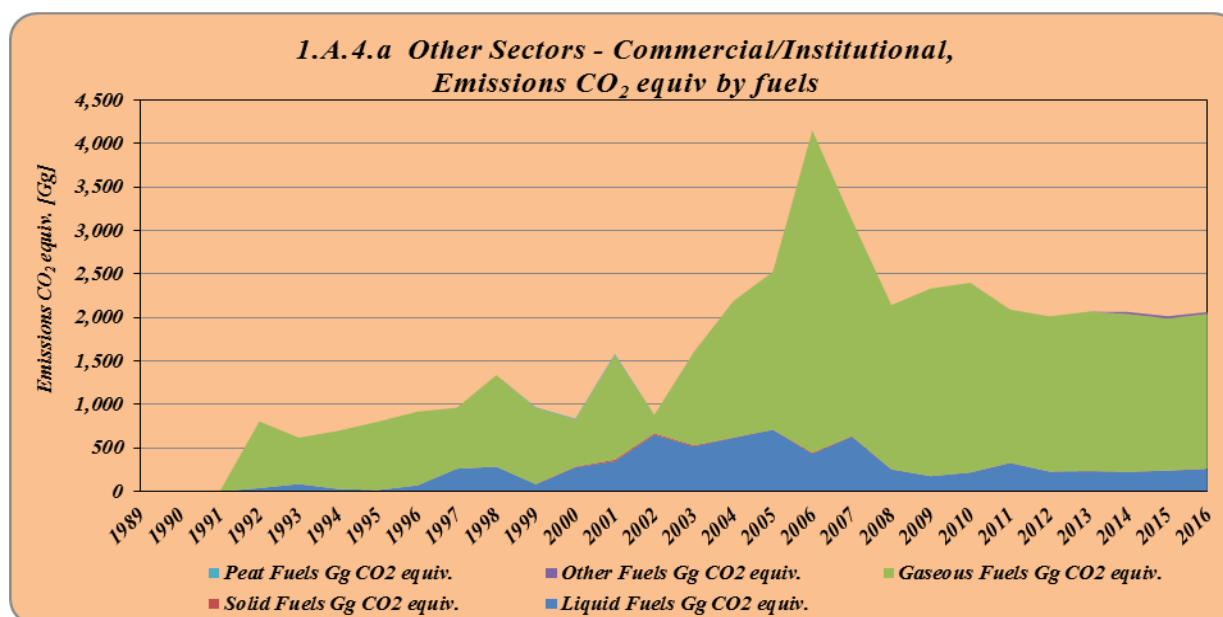
- ❖ Commercial/Institutional;
- ❖ Residential;
- ❖ Agriculture/ Forestry/ Fisheries.

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 3.47 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 3.48 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 19.88%, current year, 2016. The reporting of combustion on this category started with the 1992 year. The contribution of this category is about 2,061.65 kt CO<sub>2</sub> equiv., in 2016. 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*

For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

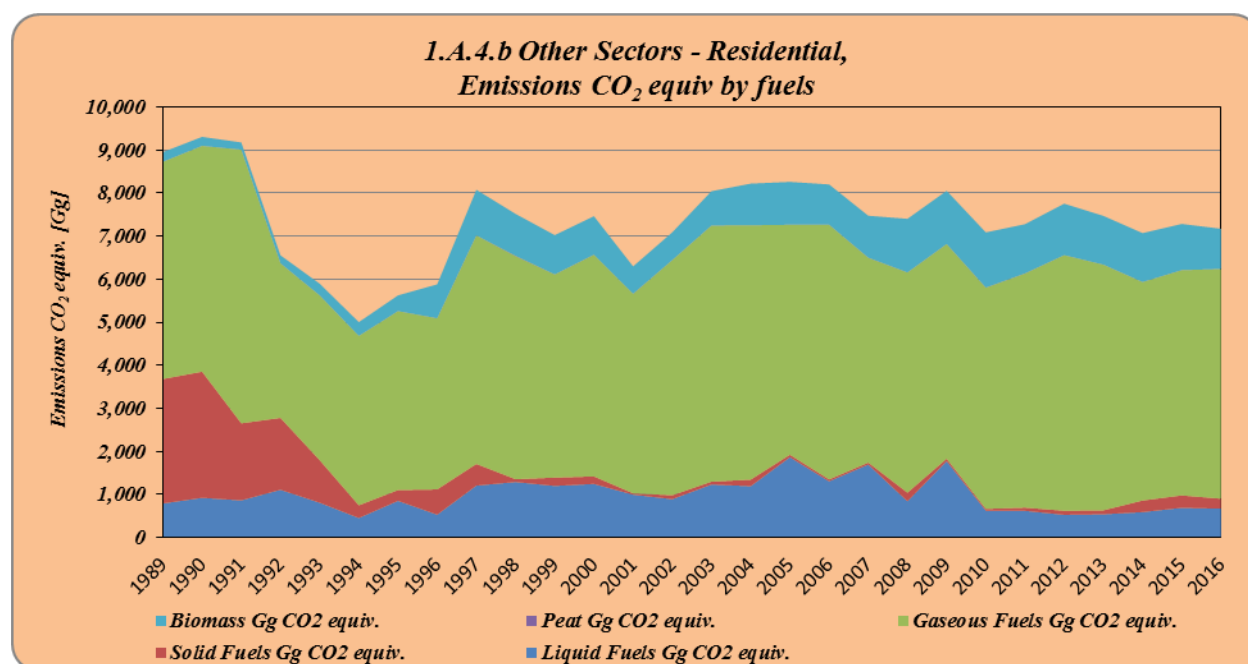
#### *3.2.8.2.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process*

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 3.49 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 69.16%, current year, 2016. The contribution of this category is about 7,172.19 kt CO<sub>2</sub> equiv., in 2016. 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<sub>4</sub> and N<sub>2</sub>O 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*

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.

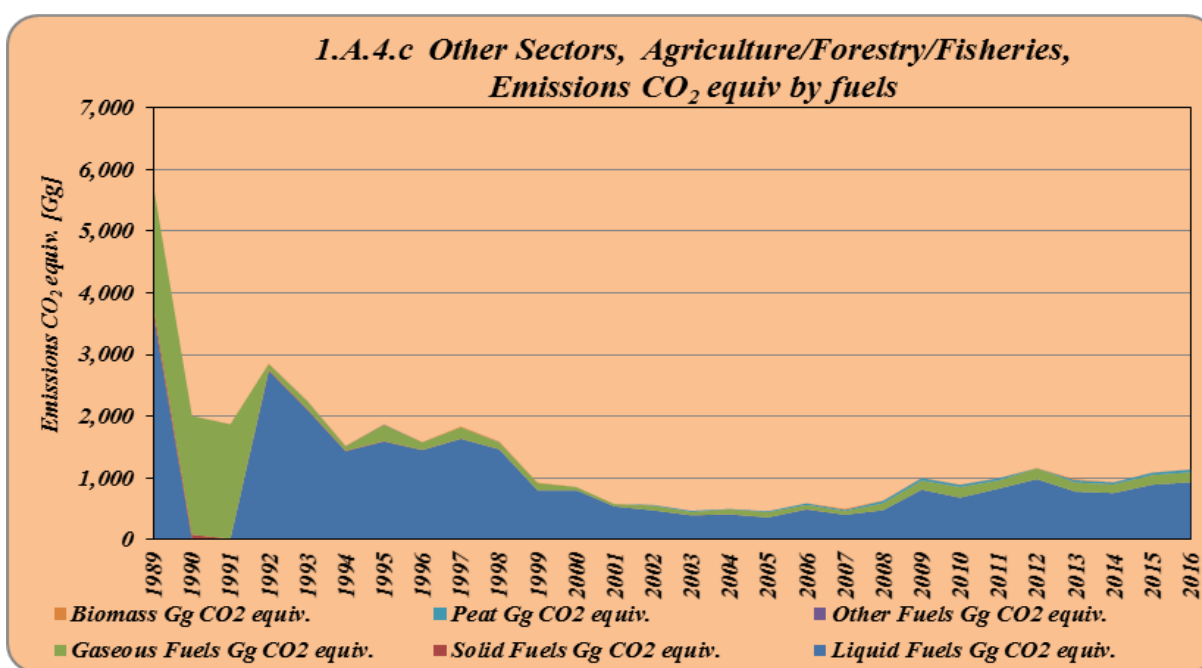


### 3.2.8.4 Fuel combustion, Other Sectors – Agriculture/ Forestry/ Fisheries (CRF 1.A.4.c)

#### 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 3.50 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 10.96%, current year, 2016. The contribution of this category is about 1,137.02 kt CO<sub>2</sub> equiv., in 2016. 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*

For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

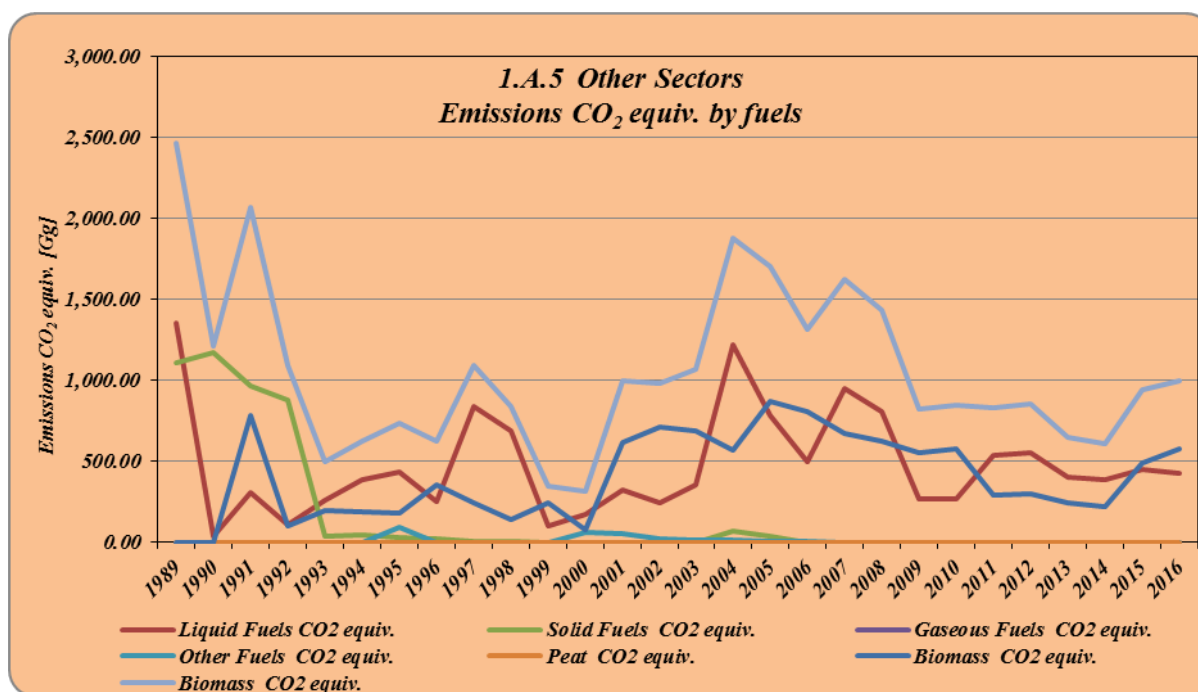
### 3.2.8.4.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process

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

**Figure 3.51 GHG emissions from 1.A.5 – Other Sectors, by fuels**



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 affairs 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*

For more details and effect of the activity data changes on the emissions estimation, see the Chapter 3.2.4.5.

### **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:

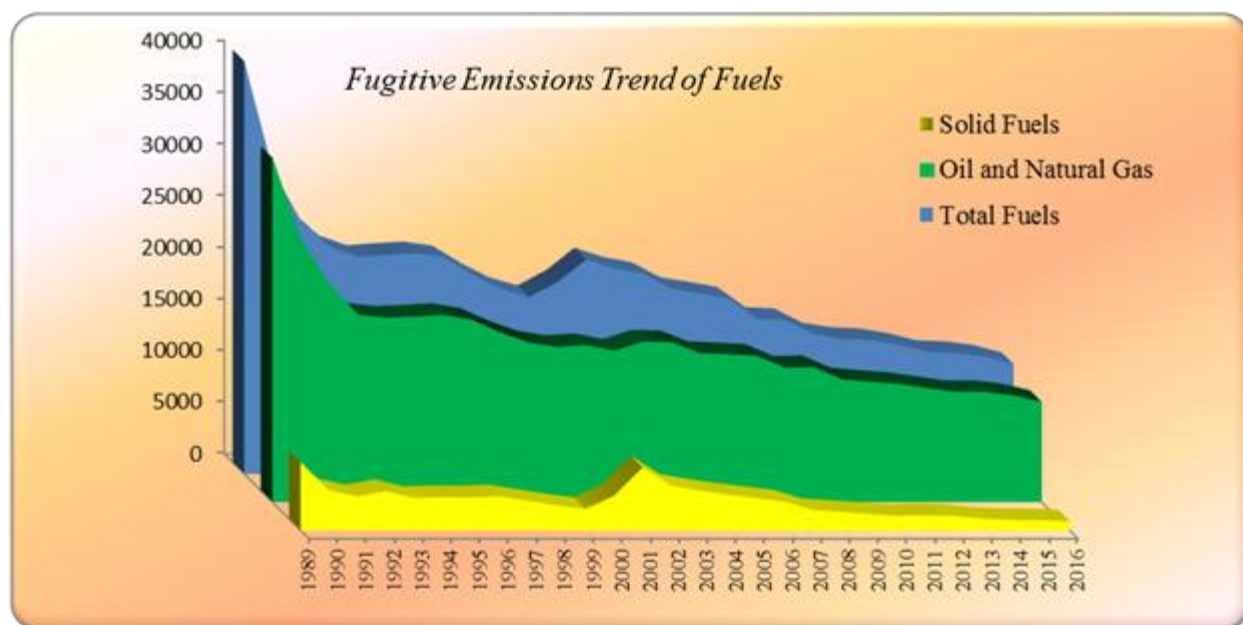
- ❖ CH<sub>4</sub> emissions from Solid Fuels;
- ❖ CH<sub>4</sub>, CO<sub>2</sub> and N<sub>2</sub>O emissions from Oil and Natural Gas.

In 2016 GHG emissions from the Fugitive Emissions from Fuels Subsector accounted for 10,633.14 kt CO<sub>2</sub> equivalent, which represent 9.45% 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 39,959.10 kt CO<sub>2</sub> equivalent, which represent 13.20% of the total national GHG emissions in this year (see in the table below).

**Table 3.18 The contribution of Fugitive Emissions from Fuels Subsector emissions to the total GHG in Romania, for 1989–2016 period**

<b>Year</b>	<b>Total GHG emissions (excl. LULUCF) [kt CO<sub>2</sub> equiv.]</b>	<b>GHG emissions from Fugitive Emissions [kt CO<sub>2</sub> equiv.]</b>	<b>Contribution of Fugitive Emissions in total GHG emissions [%]</b>
<b>1989</b>	302,630.63	39,959.10	13.20
<b>1990</b>	246,747.86	29,436.38	11.93
<b>1995</b>	180,478.41	21,373.91	11.84
<b>2000</b>	140,733.62	18,592.78	13.21
<b>2005</b>	147,827.94	17,476.70	11.82
<b>2007</b>	152,984.04	15,013.93	9.81
<b>2008</b>	148,078.36	14,898.70	10.06
<b>2009</b>	127,661.72	13,515.74	10.59
<b>2010</b>	122,182.25	13,082.75	10.71
<b>2011</b>	127,875.46	12,970.24	10.14
<b>2012</b>	124,847.08	12,500.53	10.01
<b>2013</b>	115,262.27	11,822.28	10.26
<b>2014</b>	115,371.21	11,721.04	10.16
<b>2015</b>	116,211.32	11,359.02	9.77
<b>2016</b>	112,542.36	10,633.14	9.45

**Figure 3.52 Total GHG emissions from Fugitive Emissions from Fuels Subsector for 1989–2016 period**



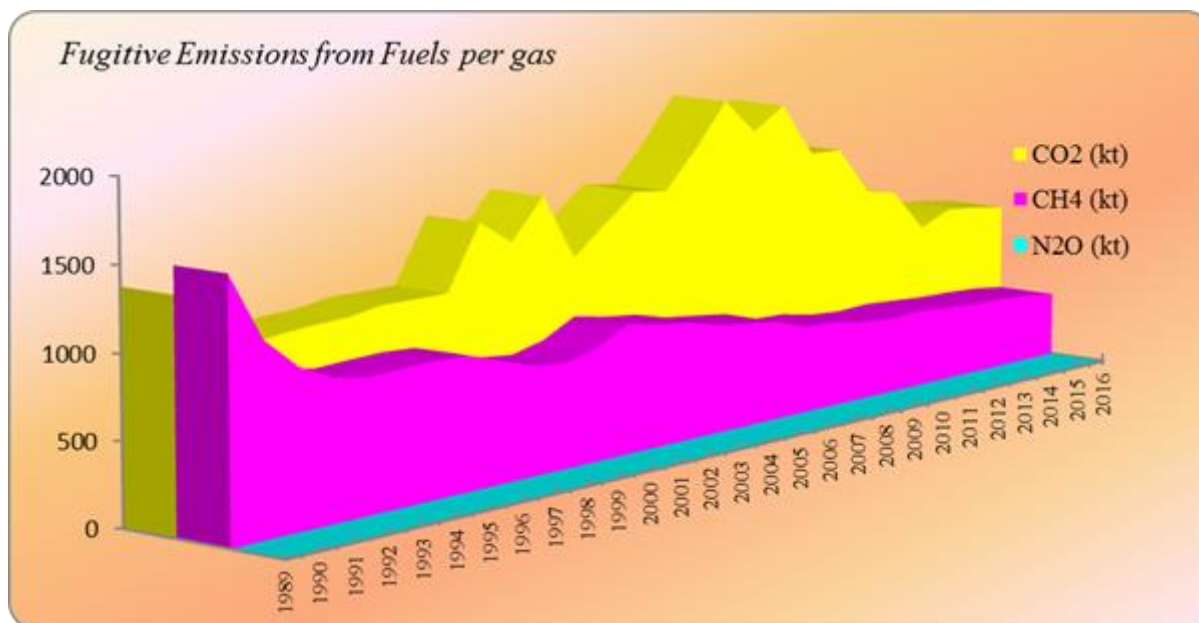
Mostly GHG emissions are resulting from Oil and Natural Gas category, responsible for 91.47 % of total GHG emissions from Fugitive Emissions subsector, Solid Fuels category contributes with 8.53 %.

GHG emissions from *Oil and Natural Gas* and *Solid Fuels* are key category sources: by level and trend for CH<sub>4</sub> emissions from Solid Fuels source category, level and trend for CH<sub>4</sub> and CO<sub>2</sub> emissions from *Oil and Natural Gas* source category, from *Oil* sub-source category, level and trend for CH<sub>4</sub> emissions from *Oil and Natural Gas* source category, from *Natural Gas* sub-source category, level for CH<sub>4</sub> from *Venting and Flaring* sub-source category and from *Other* sub-source category (see Table 3.3).

**Table 3.19 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 – 2016 period**

Year	Total emissions from Fugitive Emissions from Fuels Subsector [kt CO <sub>2</sub> equiv.]	CH <sub>4</sub> emissions		CO <sub>2</sub> emissions		N <sub>2</sub> O emissions	
		kt CO <sub>2</sub> equiv.	%	kt CO <sub>2</sub>	%	kt CO <sub>2</sub> equiv.	%
1989	39,959.10	38,577.46	96.54	1,377.53	3.45	4.12	0.010
1990	29,436.38	28,256.27	95.99	1,176.62	4.00	3.49	0.012
1995	21,373.91	20,285.53	94.91	1,085.29	5.08	3.10	0.015
2000	18,592.78	17,045.48	91.68	1,544.50	8.31	2.80	0.015
2005	17,476.70	15,813.49	90.48	1,660.68	9.50	2.53	0.014
2007	15,013.93	13,308.57	88.64	1,703.18	11.34	2.18	0.015
2008	14,898.70	13,064.81	87.69	1,831.78	12.29	2.10	0.014
2009	13,515.74	12,015.46	88.90	1,498.29	11.09	1.99	0.015
2010	13,082.75	11,594.12	88.62	1,486.73	11.36	1.90	0.015
2011	12,970.24	11,771.79	90.76	1,196.57	9.23	1.88	0.015
2012	12,500.53	11,352.90	90.82	1,145.86	9.17	1.78	0.014
2013	11,822.28	10,933.30	92.48	887.16	7.50	1.82	0.015
2014	11,721.04	10,750.26	91.72	968.99	8.27	1.79	0.015
2015	11,359.02	10,411.32	91.66	945.93	8.33	1.78	0.016
2016	10,633.14	9,718.34	91.40	913.18	8.59	1.61	0.015



**Figure 3.53 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<sub>4</sub>;
- ❖ Key source: Yes.

The sub-source category "Coal Mining and Handling" is a key source of CH<sub>4</sub> 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 hard coal, lignite and brown coal are extracting. Activity data used to estimate 1.B.1 category related emissions were provided by NIS in the form Eurostat Questionnaire for 1989 and International Energy Agency (IEA)/Eurostat Questionnaire for every year in the 1990-2016 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 2011–2016 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).

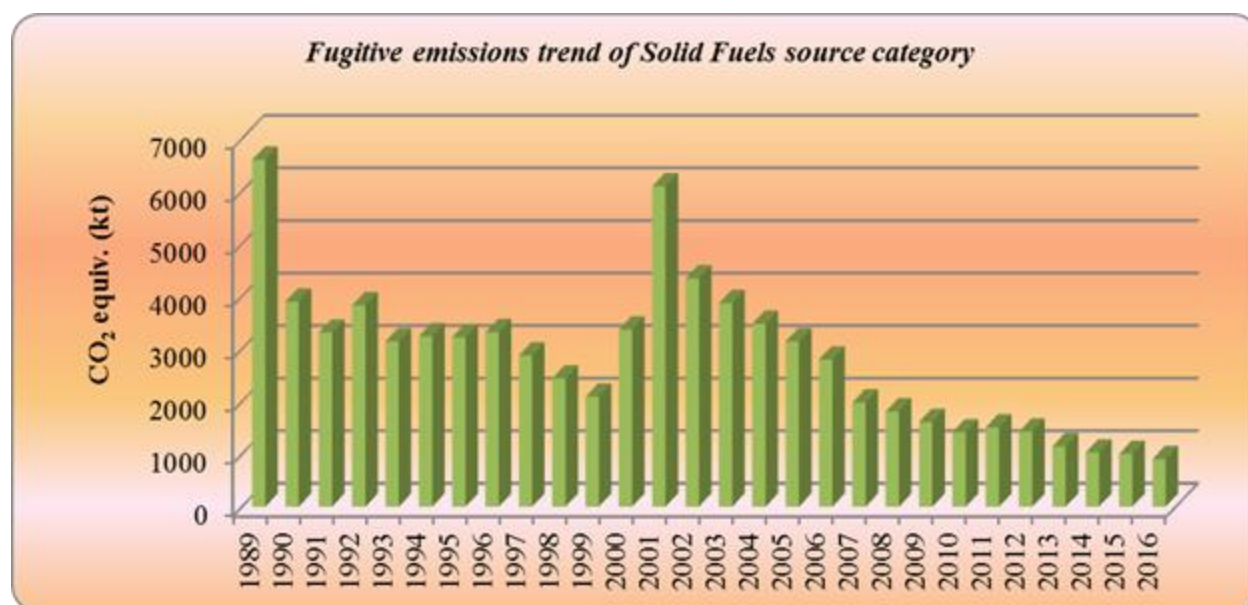
From the 2007-2010 period the emissions started to decrease again after the beginning of global financial crisis which conducted to economic contraction.

In the 2011 – 2012 period there was an increase in coal resources (excluding coke) compared to 2010, along with the decrease of oil, hydro energy and natural gas resources 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 2015 there were increases of 5.9% of the coal production (excluding coke) and at the imports of coal and coke (+ 8.9% ) compared to 2014.

In 2016 there were decreases to coal production (excluding coke) by 88.6% and imports of coal (including coke) with 19,000 tep compared with 2015. (Source – Romanian National Institute for Statistics). The trend of the CH<sub>4</sub> emissions from solid fuels category is shown in the figure below.

**Figure 3.54 Fugitive Emissions of CH<sub>4</sub> 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<sub>4</sub>;
- ❖ Key source: Yes.

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

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

❖ *Abandoned Underground Mines (1.B.1.a.1.iii.).*

### ***Methodology***

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

The formula used in the calculations is *Equation 4.1.1* from 2006 IPCC GL, volume 2, chapter 4.1.3, page 4.9.

### ***Activity Data***

Consequence of the fact that values of the production of lignite from surface mines (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 according with assumptions supplied by study from from National Institute for Statistics (NIS) and Institute for Studies and Power Engineering (ISPE); the 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 change in the fraction from 0.15 in 1999 to 0.26 in 2000 from underground mines is explained by the values for lignite from surface mines began available in the Eurostat/IEA data and changing trend in the lignite exploitation amount: more amount began to be exploited from underground mines.

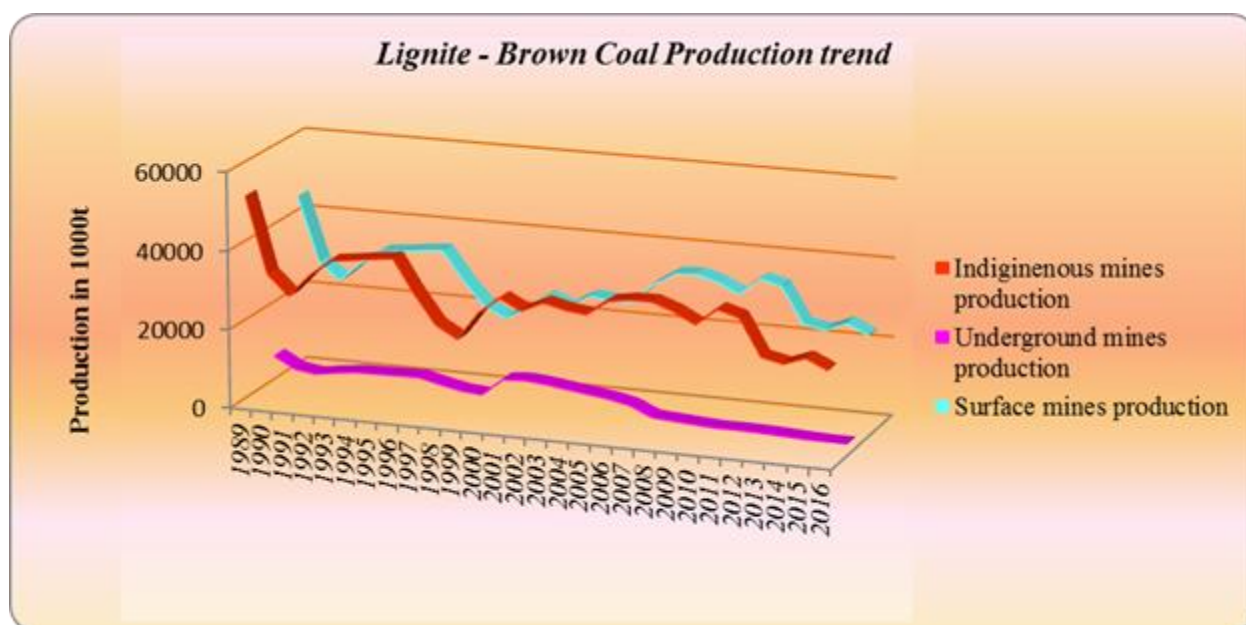
The activity data include:

1989\_BAL\_Romania have been used for 1989, and IEA/ Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

- ❖ *Underground Coal Production (Mt):* IEA/Eurostat Questionnaire 2016 - 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 2000-2016 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<sup>3</sup>/t* (average CH<sub>4</sub> Emission Factor) according to 2006 IPCC GL for “Mining Underground Coal Production” has been used.
- ❖ *The default value of 2.5 m<sup>3</sup>/t* (average CH<sub>4</sub> Emission Factor) according to 2006 IPCC GL for “Post Mining Underground Coal Production” has been used;
- ❖ *Conversion Factor*: this is the density of CH<sub>4</sub> and converts volume of CH<sub>4</sub> to mass of CH<sub>4</sub>. The density is taken at 20°C and 1 atmosphere pressure and has a value of 0.67 Gg/10<sup>6</sup> m<sup>3</sup> (0.00000067 Gg/m<sup>3</sup>).

**Figure 3.55 Lignite – Brown Coal Production trend****Abandoned Underground Mines (CRF 1.B.1.a.1.iii)**

The emissions from Abandoned underground mines were estimated according to the Mining Industry Strategy. The data used for the estimation of pit coal mining emissions were provided from CNH Petrosani Company utterly and only 5% of the total number of the mines closed at national level (mines administrated by S.N.L.O. Tg. Jiu and S.N.C. Ploiesti companies), were considered as abandoned underground mines of lignite (used as AD).

## ***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 in table on page 15 of the Mining Industry Strategy:

[http://www.minind.ro/resurse\\_minerale/Strategia\\_Industriei\\_Miniere\\_2012\\_2035.pdf](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 associated with the activity of the CNH Petrosani company, activity of lignite extraction from surface mines; the other companies are dealing with the extraction of uranium, salt and other mineral resources.

Therefore, information held on abandoned mines does not refer strictly to closed mines but also to mines undertaking the closure procedures. In respect to the CH<sub>4</sub> emissions in the underground abandoned mines, the calculation takes into account all data and information available; according to this the data used to estimate emissions of pit coal mines are from CNH Petrosani company, which exploits only underground pits coal mine (a number of 24 mines for 1976-2000 period plus a number of 45 mines for 2001- present period).

In respect to the lignite underground mines the activity data used to estimate emissions (number of mines) is considered to be 5% of all coal mines closed from the S.N.L.O. Tg. Jiu and S.N.C. Ploiesti companies, which exploits quarries 95% and underground mines 5%; according with this, a number of 3 closed underground lignite mines was obtained like 5% in respect to S.N.L.O. Tg. Jiu - 1976-2000 period plus 5% from S.N.C. Ploiești 1976-2000 period S.N.L.O. Tg. Jiu. Additionally, a number of 4 closed underground lignite mines was obtained like 5% from S.N.L.O. Tg. Jiu - 2001- present period plus 5% from S.N.C. Ploiești - 2001- present period S.N.L.O. Tg. Jiu.

In conclusion, the total number of closed mines for 1976-2000 period is 27; additionally, 49 closed mines are considered for 2001- present period.

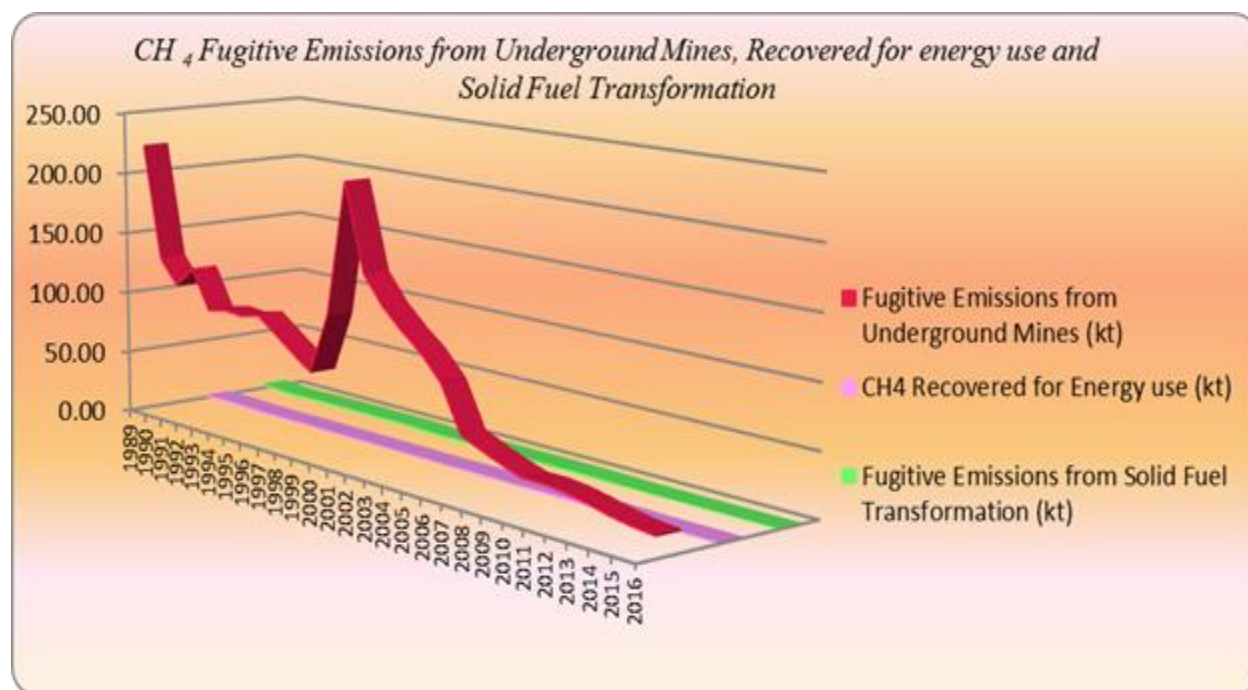
### *Emission factor*

- ❖ *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 3.56 Underground Mines category and Solid Fuel Transformation category emissions trend**



**Table 3.20 Fugitive Emissions of CH<sub>4</sub> from Underground Mines and CH<sub>4</sub> Recovered for energy use**

Year	Underground mines	
	CH <sub>4</sub> fugitive emissions (kt)	CH <sub>4</sub> Recovered for energy use (kt)
<b>1989</b>	221.92	1.36
<b>1990</b>	129.32	1.25
<b>1995</b>	97.54	0.58
<b>2000</b>	115.30	0.45
<b>2005</b>	102.45	0.59
<b>2007</b>	48.91	0.58
<b>2008</b>	42.00	0.91
<b>2009</b>	35.57	0.95
<b>2010</b>	30.12	1.02
<b>2011</b>	30.14	0.93
<b>2012</b>	28.27	0.76
<b>2013</b>	24.81	0.37
<b>2014</b>	20.94	0.49
<b>2015</b>	17.99	0.55
<b>2016</b>	16.25	0.51

**Surface mines (1.B.1.a.2)**

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

**Methodology**

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

The formula used in the calculations is *Equation 4.1.7.* from 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 from surface mines (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 according with assumptions supplied by study from from National Institute for Statistics (NIS) and Institute for Studies and Power Engineering (ISPE); the 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 change in the fraction from 0.85 in 1999 to 0.74 in 2000 from surface mines is explained by the values for lignite from surface mines began available in the Eurostat/IEA data and changing trend in the lignite exploitation amount: more amount began to be exploited from underground mines.

For the 1989-1999 period: *Surface Coal Production (Mt)*: IEA/Eurostat Questionnaire 2016 - Indigenous Production (Lignite/Brown Coal - 85 %)

For the 2000 – 2016 period: *Surface Coal Production (Mt)*: IEA/Eurostat Questionnaire 2016 - 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<sup>3</sup>/t* (average CH<sub>4</sub> Emission Factor) according to 2006 IPCC GL for “Surface Coal Production” has been used;
- ❖ *The default value of 0.1 m<sup>3</sup>/t* (average CH<sub>4</sub> Emission Factor) according to 2006 IPCC GL for “Post mining Surface Coal Production” has been used;
- ❖ *Conversion Factor*: this is the density of CH<sub>4</sub> and converts volume of CH<sub>4</sub> to mass of CH<sub>4</sub>. The density is taken at 20°C and 1 atmosphere pressure and has a value of 0.67 Gg/10<sup>6</sup> m<sup>3</sup> (0.00000067 Gg/m<sup>3</sup>).

### 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 2016- for entire 1990-2016 time series have been used.

- ❖ *Coking Coal Production (Mt):* IEA/Eurostat Questionnaire 2016– 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<sub>4</sub>/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<sub>2</sub>: 200%;
    - CH<sub>4</sub>: 200%;
    - 200.06 % for CO<sub>2</sub> and 200 % for CH<sub>4</sub> 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<sub>2</sub>: 200%;
  - CH<sub>4</sub>: 200%;
  - 200 % for CO<sub>2</sub> and 200 % for CH<sub>4</sub> 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 2016 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 1989-2016 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 nonconformities 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*

No recalculations were made relative to previous submission.

*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<sub>4</sub> and CO<sub>2</sub> 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.

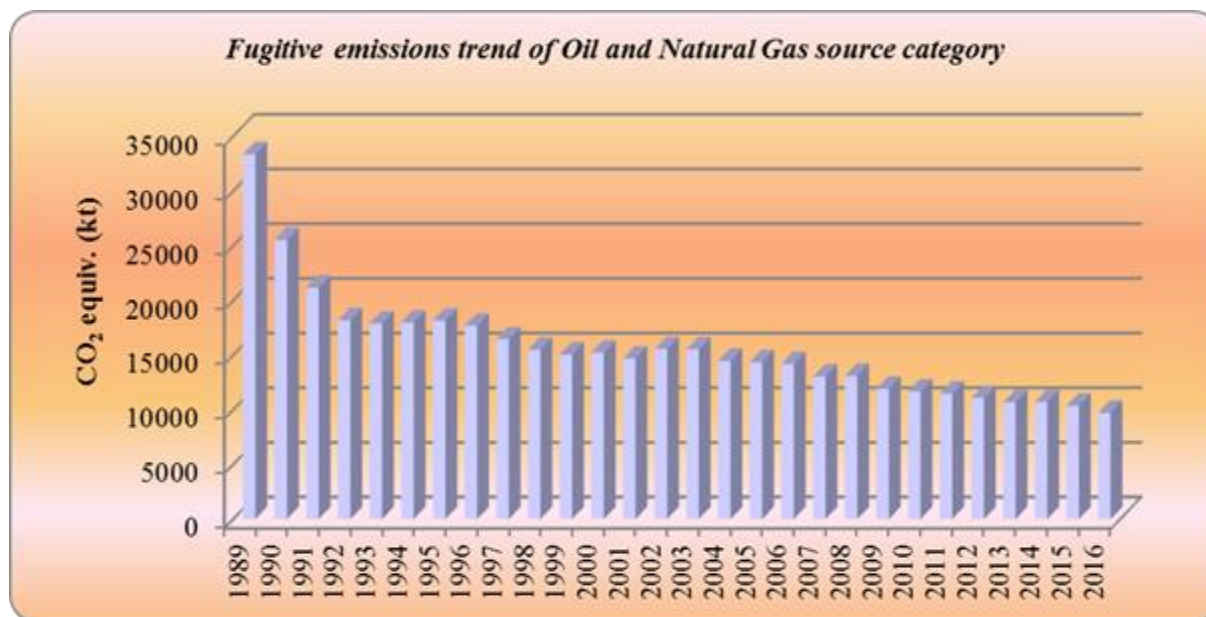
The National Society of Oil, PETROM S.A., has the exclusive right to extract oil from all of the Romanian oil-fields.

The current structure of the Romanian natural gas market, currently includes: an operator of the National Transport System - SNTGN Transgaz S.A. Medias, 6 manufacturers: Petrom, Romgaz, Amromco, Toreador, Wintershall Medias, Aurelian Oil & Gas, 3 operators for underground storage: Romgaz, Amgaz, Depomures, 34 companies supplying and distributing natural gas to captive consumers - the largest being Distrigaz Sud and E.ON Gaz Romania, 76 suppliers on the wholesale market.

The National Society for Natural Gas Transportation TRANSGAZ S.A is made up of two national companies - "TRANSGAZ" S.A. Medias (for the transport of natural gas) and "DEPOGAZ" S.A. Ploiesti (for the storage of natural gas), two natural gas distribution companies - "DISTRIGAZ NORD" S.A. Tg. Mureş and "DISTRIGAZ SUD" S.A. Bucharest and a trading company for exploitation - production - "EXPROGAZ" S.A. Medias.

The 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 consuming 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).

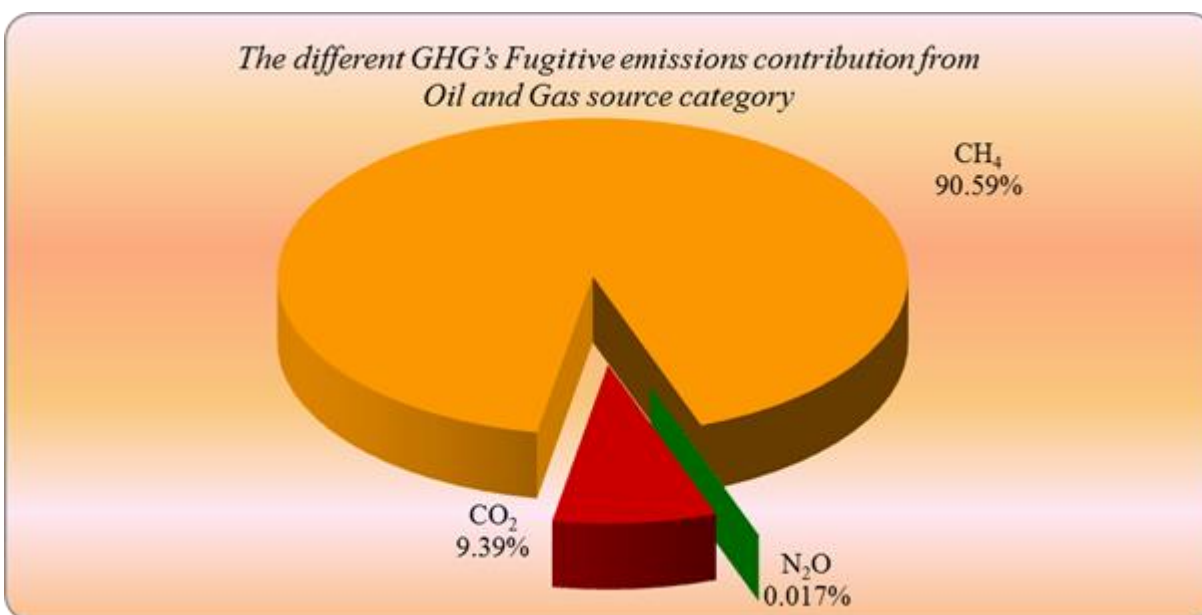
**Figure 3.57 Total GHG Oil and Natural Gas source category emissions trend**

The emissions trend for the entire period is characterized by a continuous 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 especially during 1989–1999 period;
- the decrease of the natural gas national reserves;
- in 2006, the available energy resources rose over the level in the previous year. The increase was based mainly on the increased import of energy carriers, offsetting the small decrease of the primary energy production due to diminished crude oil;
- 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;
- in 2012, the decrease of resources of crude oil and natural gas was accompanied by the decrease of imports of crude oil and natural gas;
- in 2014, among the main sources of primary energy the most important growth has been at the resources of crude oil; meanwhile the resources of natural gas decreased;

- imports of petroleum products was slightly higher than in 2013, mainly due to significant increase in import of crude oil;
- In 2015 there were decreased of 1.2% of the crude oil production and the natural gas production increased with 0.2% compared with 2014.
- In 2016 among the primary energy resources, crude oil had the highest growth (+ 6.5%); the natural gas increased with 0.4% and the imported coke recorded an increase with 1.2%.
- Primary energy production in 2016 decreased in comparison with 2015, and the most significant decrease was the production of natural gas representing -11.4%, compared to the previous year. (Source – Romanian National Institute for Statistics).

**Figure 3.58 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)

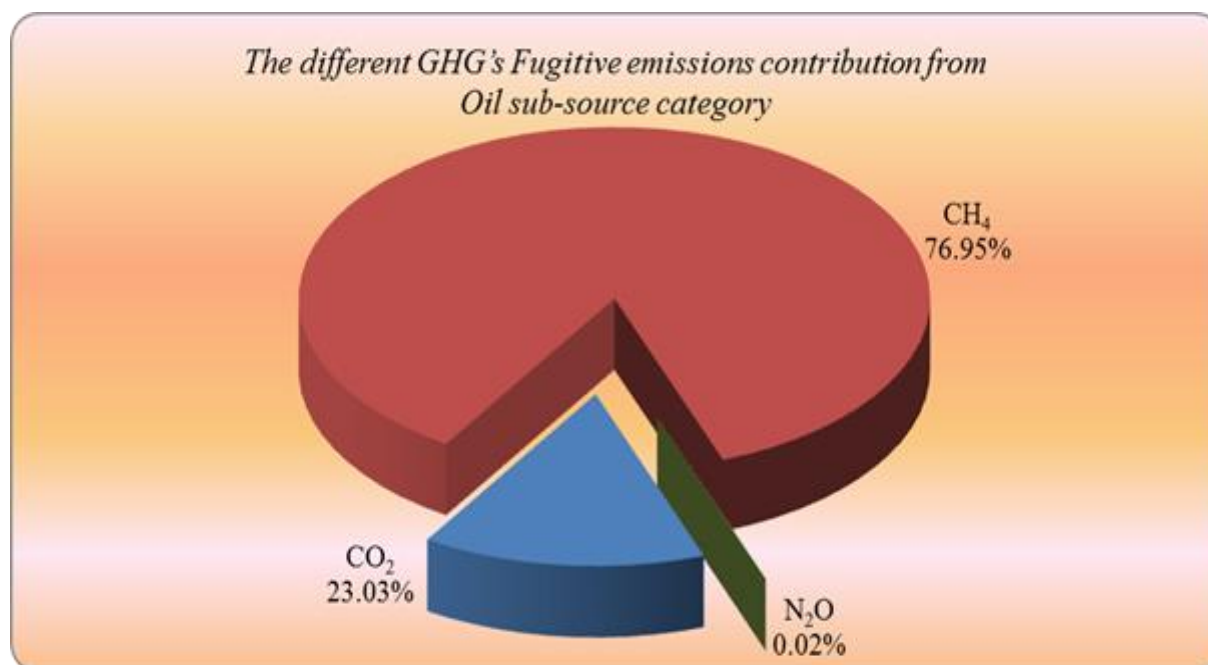
- Emission: CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O
- Key source: Yes

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.

In general, all emission factors are taken from the 2006 IPCC Guidelines, Volume 2, Chapter 4, page 4.55, Table 4.2.5. ‘Tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developing countries and countries with economies in transition’ because all presented values have been adapted from applicable data provided in the 1996 IPCC Guidelines and from limited measurement data available from more recent unpublished studies of natural gas systems in some countries including Romania. For one category it was more appropriate to use the EFs from the 2006 IPCC Guidelines, Volume 2, Chapter 4, page 4.53, Table 4.2.4.

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 3.59 The different GHG's Fugitive emissions contribution from Oil sub-source category***





The most important GHG in the Energy sector is CH<sub>4</sub> emissions and small amounts of CO<sub>2</sub> and N<sub>2</sub>O are emitted in Fugitive emissions from Oil sub-source category also.

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

#### ***Methodology***

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

#### ***Emission Factor***

- ❖ *The default value of 0.001702 Gg/10<sup>3</sup>m<sup>3</sup> (Exploration) for CH<sub>4</sub> (average CH<sub>4</sub> Emission Factor) according to 2006 IPCC GL for “Oil extraction-well drilling, testing, servicing” has been used.*
- ❖ *The default value of 0.080417Gg/10<sup>3</sup>m<sup>3</sup> (Exploration) for CO<sub>2</sub> (average CO<sub>2</sub> 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<sup>3</sup>m<sup>3</sup> (Exploration) for N<sub>2</sub>O (average N<sub>2</sub>O 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 2016 - for entire 1990-2016 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<sup>3</sup> according to <http://hypertextbook.com/facts/2007/ArtemGindin.shtml>) ;
- ❖ ***Natural Gas Liquids*** - indigenous production (density ≈ 476 kg/m<sup>3</sup> according to <http://asgmt.com/wp-content/uploads/2016/02/014.pdf>) ;

- ❖ **Other Hydrocarbons** - indigenous production (density = 550 kg/m<sup>3</sup> according to <http://pubs.acs.org/doi/abs/10.1021/je60058a030>).
- ❖ **NCV** - from IEA/Eurostat Questionnaire 2016 - 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are different.

### ***Production and upgrading (CRF 1.B.2.a.2)***

#### ***Methodology***

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

#### ***Emission Factor***

*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
<b>CH<sub>4</sub></b>	0.0022	0.037	0,0196000	Gg per 10 <sup>3</sup> m <sup>3</sup> total oil production
<b>CO<sub>2</sub></b>	0.00028	0.0047	0,0024900	Gg per 10 <sup>3</sup> m <sup>3</sup> total oil production

N<sub>2</sub>O – N.A.

#### ***Activity data***

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 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<sup>3</sup> according to <http://hypertextbook.com/facts/2007/ArtemGindin.shtml>;
- ❖ *Natural Gas Liquids* - Indigenous Production – (density ≈ 476 kg/m<sup>3</sup> according to <http://asgmt.com/wp-content/uploads/2016/02/014.pdf>);
- ❖ *Other Hydrocarbons*- Indigenous Production – (density = 550 kg/m<sup>3</sup> according to <http://pubs.acs.org/doi/abs/10.1021/je60058a030>).
- ❖ *NCV*- from IEA/Eurostat Questionnaire 2016 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons in [kJ/kg].

***Transport (CRF 1.B.2.a.3) - N.O.***

### ***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 0,00000054 Gg/10<sup>3</sup>m<sup>3</sup> (Oil Transport Pipelines) for CH<sub>4</sub> 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<sup>3</sup>m<sup>3</sup> (Oil Transport Pipelines) for CO<sub>2</sub> 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<sub>2</sub>O – N.A.*

**Activity data**

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

From *IEA/Eurostat Questionnaire 2016 Petrol - Indigenous Production + Import + Export*:

❖ Crude Oil, Natural Gas Liquids and Other Hydrocarbons;

NCV- from IEA/Eurostat Questionnaire 2016 - Petrol – Crude oil, Natural Gas Liquids and Other Hydrocarbons) in [kJ/kg].

**Refining / Storage (1 B 2 a 4)****Methodology**

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

**Emission factor**

*Default Emission factor for Refining and Storage* from Table 4.2.4, page 4.53 according to 2006 IPCC GL, volume 2, have been used. This value has been selected considering that the best available techniques/equipments used in refining oil are aligned with those used in the European Union based on applicable legislation

*Default Emission Factors*: “Oil Refining” according to 2006 IPCC GL for “All”, Volume 2, chapter 4.2.2.3, page 4. 53, Table 4.2.4.

	lower	upper	average	units
<b>CH<sub>4</sub></b>	0.0000026	0.000041	0.0000218	Gg per 10 <sup>3</sup> m <sup>3</sup> oil refined

*The country specific values of EF for CO<sub>2</sub> has been used:*

<b>Refining Storage</b>	<b>1989- 2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>
CO <sub>2</sub> (kt/PJ)	93.73	94.52	91.85	94.02	98.50	96.83	92.80	92.34	94.93	95.55

### ***Activity data***

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

From *IEA/Eurostat Questionnaire 2016* Refinery Intake (Observed):

❖ Crude oil, Natural Gas Liquids and Other Hydrocarbons.

NCV- from IEA/Eurostat Questionnaire 2016 - 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 (1 B 2 a 5)***

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

CO<sub>2</sub> – N.A.

CH<sub>4</sub> – N.A.

N<sub>2</sub>O – N.A.

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

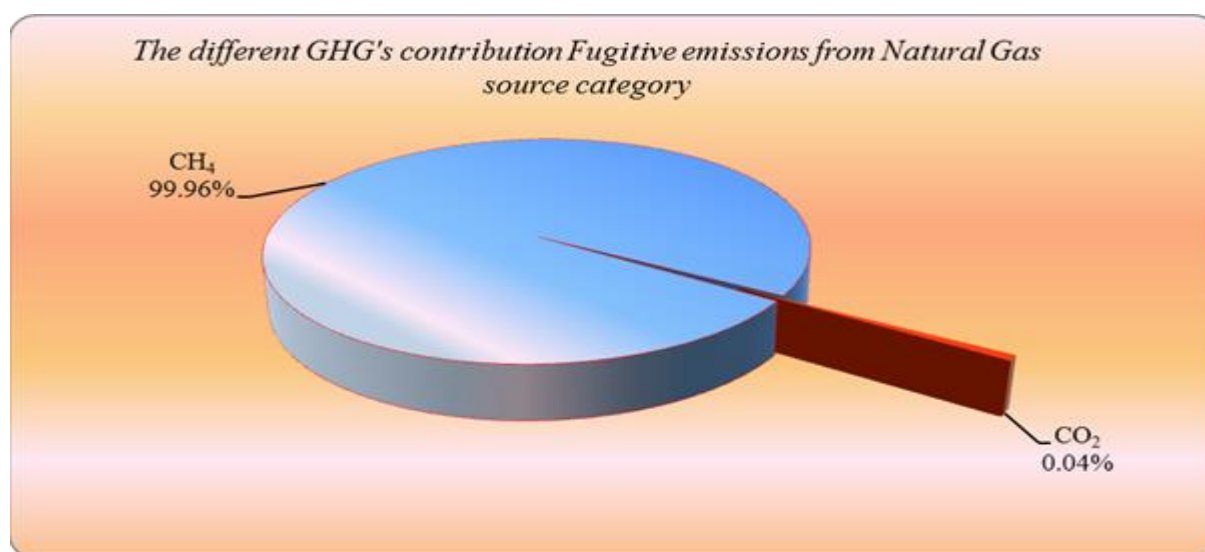
➤ Emissions: CH<sub>4</sub>, CO<sub>2</sub>

➤ Key source: Yes.

This *sub-source category* comprises emission from venting, flaring and all other fugitive sources associated with the exploration, production, processing, transmission, storage and

distribution of natural gas (including both associated and non-associated gas). Tier 1 Methodology of the 2006 IPCC Guidelines, Volume 2, Chapter 4 and Default Emission Factors the reporting are used. In general, all emission factors are taken from the 2006 IPCC Guidelines, Volume 2, Chapter 4, page 4.55, Table 4.2.5. ‘Tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developing countries and countries with economies in transition’ because all presented values have been adapted from applicable data provided in the 1996 IPCC Guidelines and from limited measurement data available from more recent unpublished studies of natural gas systems in some countries including Romania. For one category it was more appropriate to use the EFs from the Revised 1996 IPCC GL. The formula used in the calculations is presented in *Equation 4.2.1 Tier 1: Estimating Fugitive Emissions from an industry segment*.

**Figure 3.60 The different GHG's Natural Gas sub-source category emissions contribution**



### ***Production (1 B 2 b 2)***

#### ***Methodology***

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

**Emission factor**

*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 <sub>4</sub>	0.00038	0.024	0.01219	Gg per 10 <sup>6</sup> m <sup>3</sup> gas production
CO <sub>2</sub>	0. 000014	0.00018	0.000097	Gg per 10 <sup>6</sup> m <sup>3</sup> gas production

N<sub>2</sub>O – N.A.

**Activity data**

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

From *IEA/Eurostat Questionnaire 2016* Indigenous Production:

- ❖ **Natural Gas**– in both units – 10<sup>6</sup> m<sup>3</sup> and TJ (GCV) \* 0.9 → TJ (NCV); (density = 0.77 kg/m<sup>3</sup> according to <http://ro.wikipedia.org/wiki/Gaz>).

**Processing (1 B 2 b 3)****Methodology**

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

**Emission factor**

*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
<b>CH<sub>4</sub></b>	0.000012	0.000028	0.00002	Gg per 10 <sup>6</sup> m <sup>3</sup> gas production
<b>CO<sub>2</sub></b>	0.00015	0.00035	0.00025	Gg per 10 <sup>6</sup> m <sup>3</sup> gas production

*N<sub>2</sub>O* – N.A.

### **Activity data**

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

From *IEA/Eurostat Questionnaire 2016* Indigenous Production:

- ❖ **Natural Gas**– in both units –  $10^6 \text{ m}^3$  and  $TJ \text{ (GCV)} * 0.9 \rightarrow TJ \text{ (NCV)}$ ; (density = 0.77 kg/m<sup>3</sup> according to <http://ro.wikipedia.org/wiki/Gaz>).

### **Transmission and Storage (1.B.2.b.4)**

This category includes Fugitive emissions from natural gas systems used to transport processed natural gas to market. Thus, fugitive emissions from *Transmission and Storage* category represent the sum of emissions from *Transmission* and *Storage*.

### **Methodology**

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

### **Emission factor (Transmission)**

*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
<b>CH<sub>4</sub></b>	0.0000166	0.0011	0.000633	Gg per 10 <sup>6</sup> m <sup>3</sup> of marketable gas
<b>CO<sub>2</sub></b>	0.00000088	0.000002	0.00000144	Gg per 10 <sup>6</sup> m <sup>3</sup> of marketable gas

*N<sub>2</sub>O* – N.A.

### **Activity data (Transmission)**

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

From *IEA/Eurostat Questionnaire 2016* Indigenous Production + Import:

❖ **Natural Gas**– in both units – 10<sup>6</sup> m<sup>3</sup> and TJ (GCV) \* 0.9 → TJ (NCV); (density = 0.77 kg/m<sup>3</sup> according to <http://ro.wikipedia.org/wiki/Gaz>)

### **Emission factor (Storage)**

*Default Emission Factors*: “Gas Transmission & Storage” according to 2006 IPCC GL for “Storage”, Volume 2, chapter 4.2.2.3, page 4. 57, Table 4.2.5.

	lower	upper	average	units
<b>CH<sub>4</sub></b>	0.000025	0.000058	0.0000415	Gg per 10 <sup>6</sup> m <sup>3</sup> of marketable gas
<b>CO<sub>2</sub></b>	0.00000011	0.00000026	0.000000185	Gg per 10 <sup>6</sup> m <sup>3</sup> of marketable gas

### **Activity data (Storage)**

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

From *IEA/Eurostat Questionnaire 2016* Closing stock level (National territory);

❖ **Natural Gas**– in both units – 10<sup>6</sup> m<sup>3</sup> and TJ (GCV) \* 0.9 → TJ (NCV); (density = 0.77 kg/m<sup>3</sup> according to <http://ro.wikipedia.org/wiki/Gaz>).

***Distribution (1.B.2.b.5)******Methodology***

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

***Emission factor***

*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
<b>CH<sub>4</sub></b>	0.0011	0.0025	0.0018	Gg per 10 <sup>6</sup> m <sup>3</sup> per utility sales
<b>CO<sub>2</sub></b>	0.000051	0.00014	0.0000955	Gg per 10 <sup>6</sup> m <sup>3</sup> per utility sales

*N<sub>2</sub>O* – N.A.

***Activity data***

- 1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

From *IEA/Eurostat Questionnaire 2016* Indigenous Production + Import:

- ❖ **Natural Gas**– in both units –  $10^6 \text{ m}^3$  and  $TJ \text{ (GCV)}$  \* 0.9 →  $TJ \text{ (NCV)}$ ; (density = 0.77 kg/m<sup>3</sup> according to <http://ro.wikipedia.org/wiki/Gaz>)

***Other (1.B.2.b.6)***

This category includes Fugitive emissions from natural gas systems not otherwise accounted for in the above categories. Thus, fugitive emissions from *Other Leakage* category represent the sum of emissions from *Industrial plants and power stations* and *Residential and commercial sectors*.

***Industrial plants and power stations******Methodology***

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

***Emission factors***

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

	lower	upper	average	units
<b>CH<sub>4</sub></b>	175,000	384,000	279,500	kg/PJ

***Activity data***

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 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 –  $10^6 \text{ m}^3$  and TJ (GCV) \* 0.9 → TJ (NCV); (density =  $0.77 \text{ kg/m}^3$  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 <sub>4</sub>	87,000	192,000	139,500	kg/PJ

**Activity data**

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used:

- **Natural Gas** - sheet “2ii\_TFC\_EnergyUse” row 24 (Other sectors) – in both units – 10<sup>6</sup> m<sup>3</sup> and TJ (GCV) \* 0.9 → TJ (NCV); (density = 0.77 kg/m<sup>3</sup> according to <http://ro.wikipedia.org/wiki/Gaz>).

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

- Emissions: CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O
- Key source:

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

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

**Emission Factor**

*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
<b>CH<sub>4</sub></b>	0.0087	0.012	0.01035	Gg per 10 <sup>6</sup> m <sup>3</sup> total oil production
<b>CO<sub>2</sub></b>	0.0018	0.0025	0.00215	Gg per 10 <sup>6</sup> m <sup>3</sup> total oil production

*N<sub>2</sub>O* – N.A.

*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
<b>CH<sub>4</sub></b>	0.000044	0.00074	0.000392	Gg per 10 <sup>6</sup> m <sup>3</sup> of marketable gas
<b>CO<sub>2</sub></b>	0.0000031	0.0000073	0.0000052	Gg per 10 <sup>6</sup> m <sup>3</sup> of marketable gas

*N<sub>2</sub>O* – N.A.

### **Activity Data**

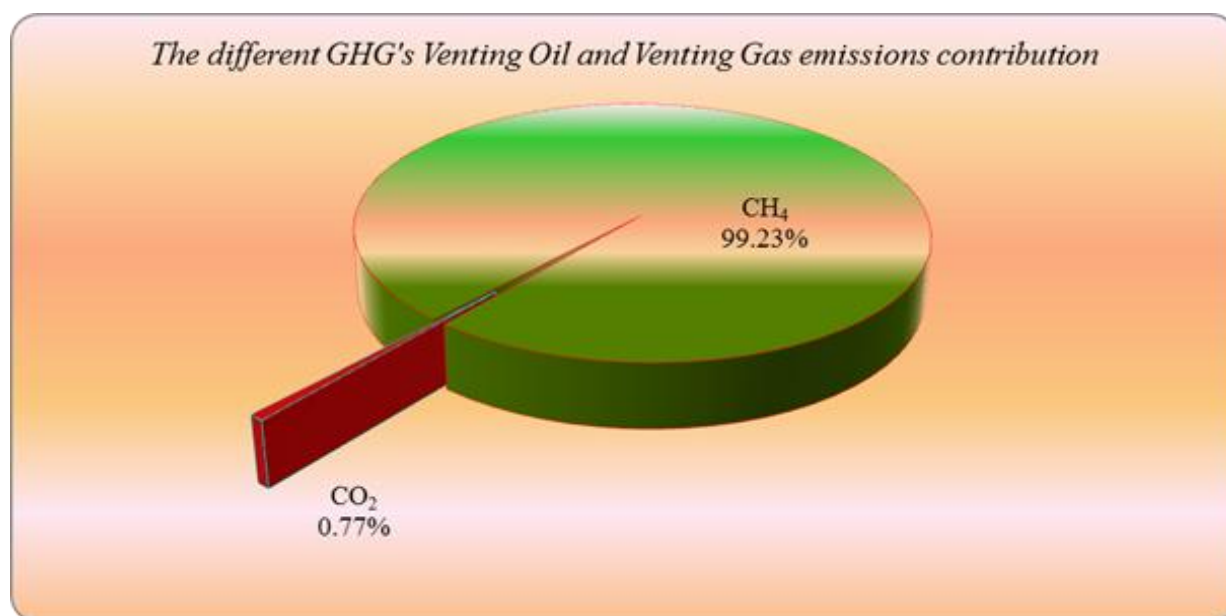
1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

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

- ❖ **Crude oil** - indigenous production (density = 881 kg/m<sup>3</sup> according to <http://hypertextbook.com/facts/2007/ArtemGindin.shtml>) ;
- ❖ **Natural Gas Liquids** - indigenous production (density ≈ 476 kg/m<sup>3</sup> according to <http://asgmt.com/wp-content/uploads/2016/02/014.pdf>) ;
- ❖ **Other Hydrocarbons** - indigenous production (density = 550 kg/m<sup>3</sup> according to <http://pubs.acs.org/doi/abs/10.1021/je60058a030>);
- ❖ **Natural Gas**– Indigenous Production – in 10<sup>6</sup> m<sup>3</sup> units

As long as, the density values for each fuel type are different and the activity data values are not unitary as content on the time series analyzed period, the implied emission factors of CO<sub>2</sub> and CH<sub>4</sub> are different.

***Figure 3.61 The different GHG's Venting oil and Venting Gas emissions contribution***



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

#### ***Methodology***

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

#### ***Emission factor***

*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 <sub>4</sub>	0.000021	0.0000029	0.000025	Gg per 10 <sup>6</sup> m <sup>3</sup> total oil production
CO <sub>2</sub>	0.034	0.047	0.0405	Gg per 10 <sup>6</sup> m <sup>3</sup> total oil production
N <sub>2</sub> O	0.00000054	0.00000074	0.00000064	Gg per 10 <sup>6</sup> m <sup>3</sup> total oil production

### *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.

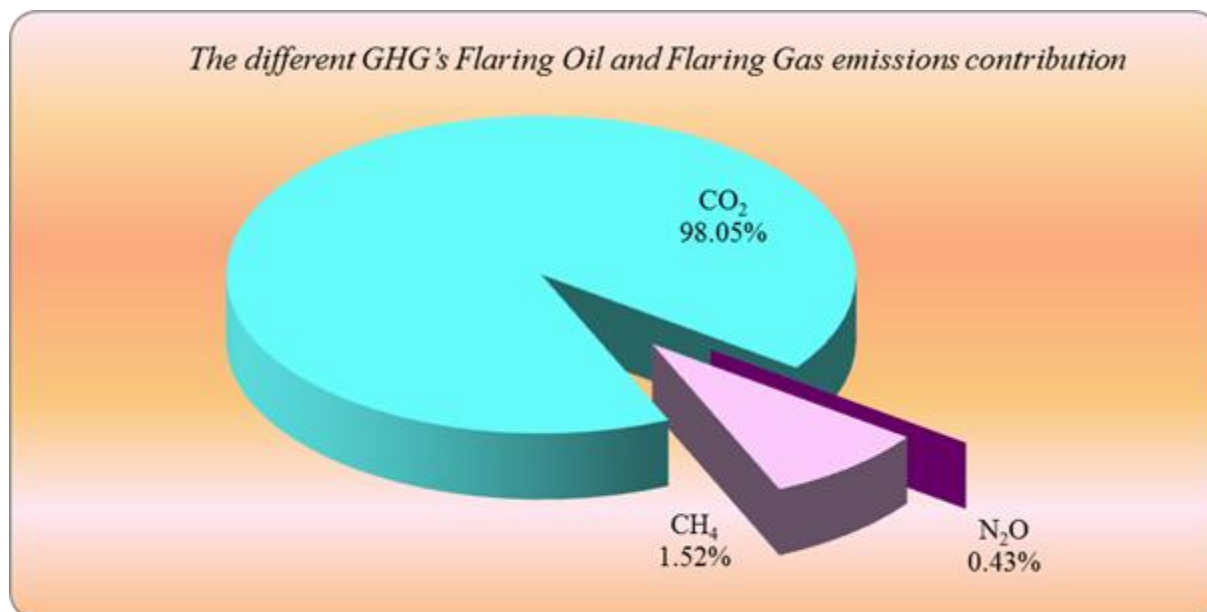
Flaring gas	lower	upper	average	units
CH <sub>4</sub>	0.00000076	0.000001	0.00000088	Gg per 10 <sup>6</sup> m <sup>3</sup> gas production
CO <sub>2</sub>	0.0012	0.0016	0.0014	Gg per 10 <sup>6</sup> m <sup>3</sup> gas production
N <sub>2</sub> O	0.000000021	0.000000029	0.000000025	Gg per 10 <sup>6</sup> m <sup>3</sup> gas production

1989\_BAL\_Romania have been used for 1989, and IEA/Eurostat Questionnaire 2016 - for entire 1990-2016 time series have been used.

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

- ❖ **Crude oil** - indigenous production (density = 881 kg/m<sup>3</sup> according to <http://hypertextbook.com/facts/2007/ArtemGindin.shtml>);
- ❖ **Natural Gas Liquids** - indigenous production (density ≈ 476 kg/m<sup>3</sup> according to <http://asgmt.com/wp-content/uploads/2016/02/014.pdf>);
- ❖ **Other Hydrocarbons** - indigenous production (density = 550 kg/m<sup>3</sup> according to <http://pubs.acs.org/doi/abs/10.1021/je60058a030>);
- ❖ **Natural Gas**– Indigenous Production – in 10<sup>6</sup> m<sup>3</sup> units

As long as, the density values for each fuel type are different and the activity data values are not unitary as content on the time series analyzed period, the implied emission factors of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are different.

**Figure 3.62 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<sub>2</sub>: 50%;
  - CH<sub>4</sub>: 50%;
  - N<sub>2</sub>O: 50%.
  - 50.09 % for CO<sub>2</sub>, 50.09 % for CH<sub>4</sub> and 50.09% for N<sub>2</sub>O 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<sub>2</sub>: 50%;
- CH<sub>4</sub>: 50%;
- 50.05 % for CO<sub>2</sub> and 50.05 % for CH<sub>4</sub> and 2.24% for N<sub>2</sub>O 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<sub>2</sub>: 50%;
  - CH<sub>4</sub>: 50%;
  - 50.05 % for CO<sub>2</sub>, 50.05 % for CH<sub>4</sub> and 2.24% N<sub>2</sub>O 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<sub>2</sub>: 50%;
  - CH<sub>4</sub>: 50%;
  - 50.09 % for CO<sub>2</sub>, 50.09 % for CH<sub>4</sub> and 3% N<sub>2</sub>O 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 1989-2016 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 with 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:

❖ *activity data:*

- Transmission and storage (1.B.2.b.4) category: the emission values for 1989-2015 period have been updated because additional activity data related to storage of natural gas has been added;
- Other (1.B.2.b.6) category: it was necessary to reallocate the activity data in 1.B.2.b.6 because new data from 1.B.2.d have been coming;
- Other (please specify)(1.B.2.d): the activity data have been reallocated to Other (1.B.2.b.6) category.

❖ ***emission factors:***

- Refining/Storage (1.B.2.a.6) category: the emission value of CO<sub>2</sub> for 2015 has been updated because the Country Specific Emission Factor value for 2015 has been updated;
- Refining/Storage (1.B.2.a.6) category: the CH<sub>4</sub> emission values for 1989-2015 period have been updated because the Emission Factor value for 1989-2015 period has been changed (the value of 880 kg/PJ has been replaced by 0.0000218 (Gg per 10<sup>3</sup>m<sup>3</sup> oil refined);
- Transmission and storage (1.B.2.b.4) category: the CO<sub>2</sub> and CH<sub>4</sub> emission values for 1989-2015 period have been updated because additional activity data related to storage of natural gas have been added
- Other (1.B.2.b.6) category: it was necessary to reallocate the CH<sub>4</sub> emissions in 1.B.2.b.6 because new emissions from 1.B.2.d have been coming;
- Other (please specify)(1.B.2.d): CH<sub>4</sub> emissions have been reallocated to category 1.B.2.b.6

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

***Table 3.21 Change made at activity data and their effects on CO<sub>2</sub> emission estimates  
Oil and Natural Gas category***

Year	Effects of changes on CO <sub>2</sub> emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	

Year	Effects of changes on CO <sub>2</sub> emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	
1989	1,377.53	1,377.53	0.000
1990	1,176.62	1,176.62	0.000
1995	1,085.35	1,085.29	-0.005
2000	1,544.54	1,544.50	-0.003
2005	1,660.71	1,660.68	-0.002
2007	1,703.19	1,703.18	-0.001
2008	1,831.83	1,831.78	-0.002
2009	1,498.29	1,498.29	0.000
2010	1,486.73	1,486.73	0.000
2011	1,196.61	1,196.57	-0.004
2012	1,145.89	1,145.86	-0.003
2013	887.18	887.16	-0.003
2014	969.00	968.99	-0.001
2015	936.52	945.93	1.005

*Table 3.22 Change made at activity data and their effects on CH<sub>4</sub> emission estimate  
Oil and Natural Gas category*

Year	Effects of changes on CH <sub>4</sub> emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	
1989	1,279.56	1,279.22	-0.026
1990	974.54	974.28	-0.027
1995	682.66	682.49	-0.068
2000	547.24	547.13	-0.078
2005	507.03	506.88	-0.074
2007	453.18	453.04	-0.070
2008	450.21	450.07	-0.060

Year	Effects of changes on CH <sub>4</sub> emission estimates [kt]		Difference [%]
	NGHGI 2017	NGHGI 2018	
2009	416.39	416.26	-0.041
2010	407.33	407.22	-0.045
2011	410.65	410.54	-0.052
2012	397.04	396.94	-0.042
2013	391.55	391.45	-0.033
2014	388.92	388.81	-0.039
2015	376.38	376.27	-0.009

*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<sub>2</sub> transport and storage (CRF 1.C)

CO<sub>2</sub> transport and CO<sub>2</sub> 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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs and SF<sub>6</sub> (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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	PFC
<b>2.A. MINERAL INDUSTRY</b>				
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	✓	NA	NA	NA
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				
<b>2.B. CHEMICAL INDUSTRY</b>				

2 INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions estimation status			
IPCC category	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	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
<b>2.C. METAL INDUSTRY</b>				
2.C.1 IRON AND STEEL PRODUCTION 2.C.1.a. STEEL 2.C.1.b. PIG IRON	✓	✓	NA	NA

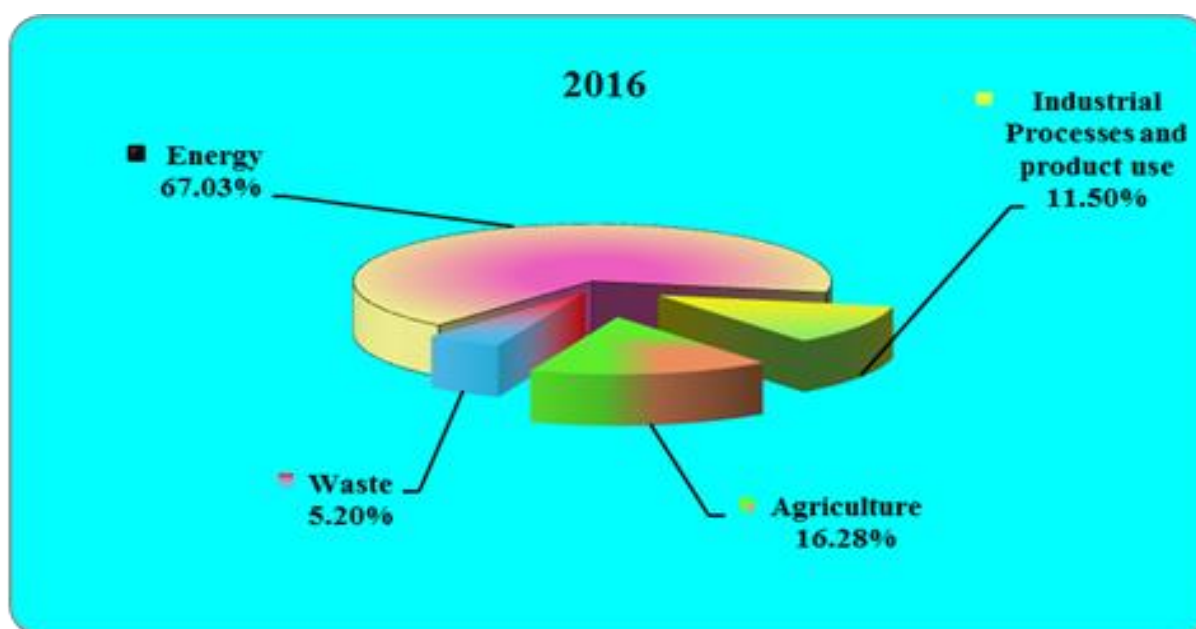
<b>2 INDUSTRIAL PROCESSES AND PRODUCT USE</b>	<b>Emissions estimation status</b>			
<b>IPCC category</b>	<b>CO<sub>2</sub></b>	<b>CH<sub>4</sub></b>	<b>N<sub>2</sub>O</b>	<b>PFC</b>
2.C.1.c. DIRECT REDUCED IRON				
2.C.1.d. SINTER				
2.C.1.e. PELLET				
2.C.1.f. OTHER				
2.C.2. FERROALLOYS PRODUCTION	✓	✓	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
<b>2.D. NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE</b>				
2.D.1. LUBRICANT USE	✓	NA	NA	NA
2.D.2. PARAFFIN WAX USE	✓	NA	NA	NA
2.D.3. OTHER	✓	NA	NA	NA
<b>2.E. ELECTRONICS INDUSTRY</b>				
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
<b>2.F. PRODUCT USES AS SUBSTITUTES FOR ODS</b>				
2.F.1. REFRIGERATION AND AIR CONDITIONING	NA	NA	NA	✓
2.F.2. FOAM BLOWING AGENTS	NA	NA	NA	✓
2.F.3. FIRE PROTECTION	NA	NA	NA	✓
2.F.4. AEROSOLS	NA	NA	NA	✓
2.F.5. SOLVENTS	NA	NA	NA	✓
2.F.6. OTHER APPLICATIONS	NA	NA	NA	✓



2 INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions estimation status			
IPCC category	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	PFC
<b>2.G. OTHER PRODUCT MANUFACTURE AND USE</b>				
2.G.1. ELECTRICAL EQUIPMENT	NO	NO	NO	✓
2.G.2. SF <sub>6</sub> AND PFCS FROM OTHER PRODUCT USE	NO	NO	NO	NO
2.G.3. N <sub>2</sub> O FROM PRODUCT USES	NO	NO	✓	NO
2.G.4. Other	NO	NO	NO	NO
<b>2.H. Other</b>				
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 2016 the GHG emissions from Industrial Processes and Product Use Sector contributed with 11.50% 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 2016 year*



Emissions from this sector estimated in 2016 decreased by 71.03% compared with 1989 and increased with 1.42% compared with 2015.

The decrease from 1989 to 2016 is the result of the restructuration and privatization in various activity sectors.

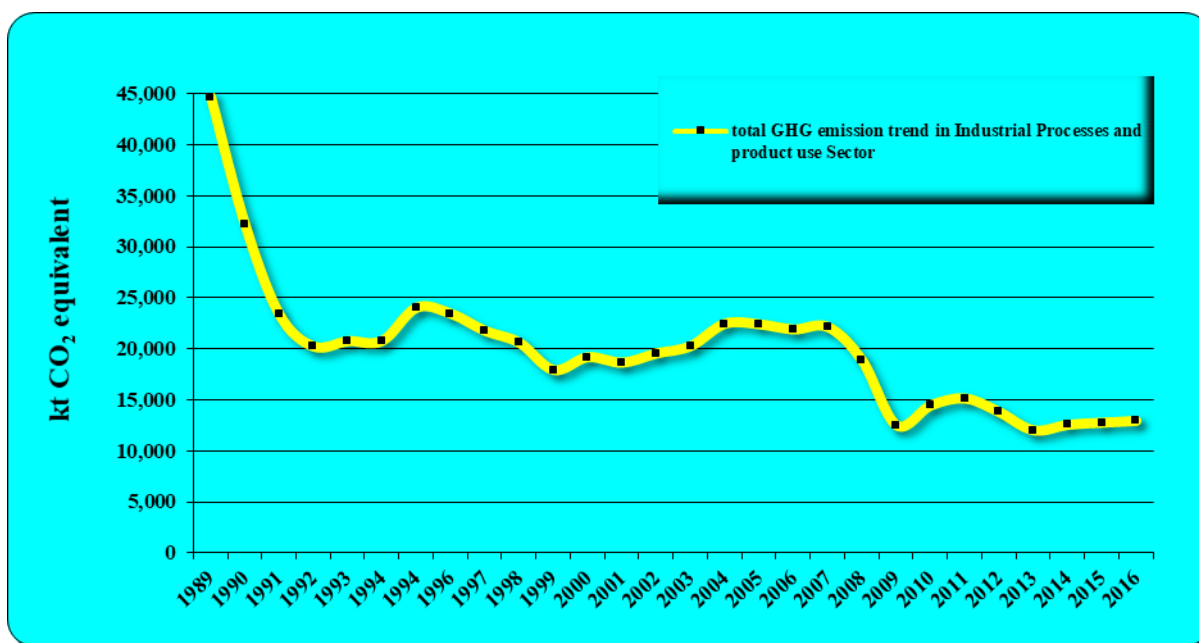
After 1989 the whole Romania recorded a decrease within the Industrial Processes and Product Use because many categories of industrial production have decreased (Chemical Industry, Mineral Industry and Metal Industry):

- after 1989 the whole Romania recorded a decrease within the Industrial Processes, because many categories of industrial production have decreased (Chemical Industry, Mineral Industry and Metal Industry);
- starting with 2007 the emissions mainly decreased due to the reduction of various productions;
- starting with 2004 the Cement Production has recorded a minor increase. In 2009 a significant decrease of emissions level was recorded in cement, lime, limestone and dolomite, soda ash and glass industries due to the economic crisis;
- in 2010-2011 the emissions have recorded a increase due to increase of various industry productions (cement production, lime production, limestone and dolomite consumption, ammonia production and iron and steel production sub-sectors);
- in 2014-2016 the emissions increased due to increase of various production activities (cement production, glass production, limestone and dolomite consumption, nitric acid production, calcium carbide consumption, soda ash production, iron and steel production, lead production, product uses as substitutes for ODS sub-sectors - commercial refrigeration, industrial refrigeration, transport refrigeration, mobile air-conditioning, stationary air-conditioning);
- the reduction of PFC emissions from production of aluminum due to changes in technology starting with 1997 and 2003.

Metal Industry contributes with 31.87% to the total GHG emissions from Industrial Processes and Product Use Sector in 2016.

Mineral Industry and Chemical Industry are the two other main contributing Sub-sectors with 33.98% and 10.55%, respectively, of the total GHG emissions in this sector.

**Figure 4.2 Total GHG emissions trend in Industrial Processes and Product Use Sector, for 1989–2016 period**

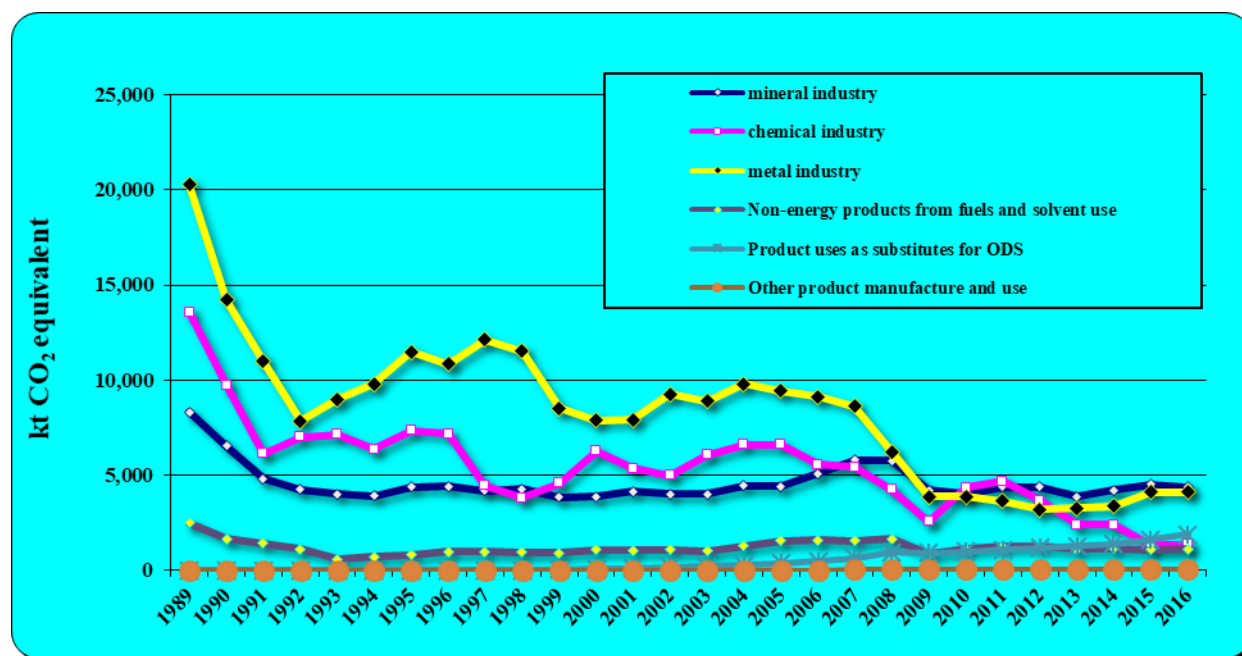


The contribution of Product uses as ODS substitutes Sub-sector to the overall sector is 14.64%.

The contribution of Non-energy product from fuels and solvent use Sub-sector to the overall sector is low: 8.55%.

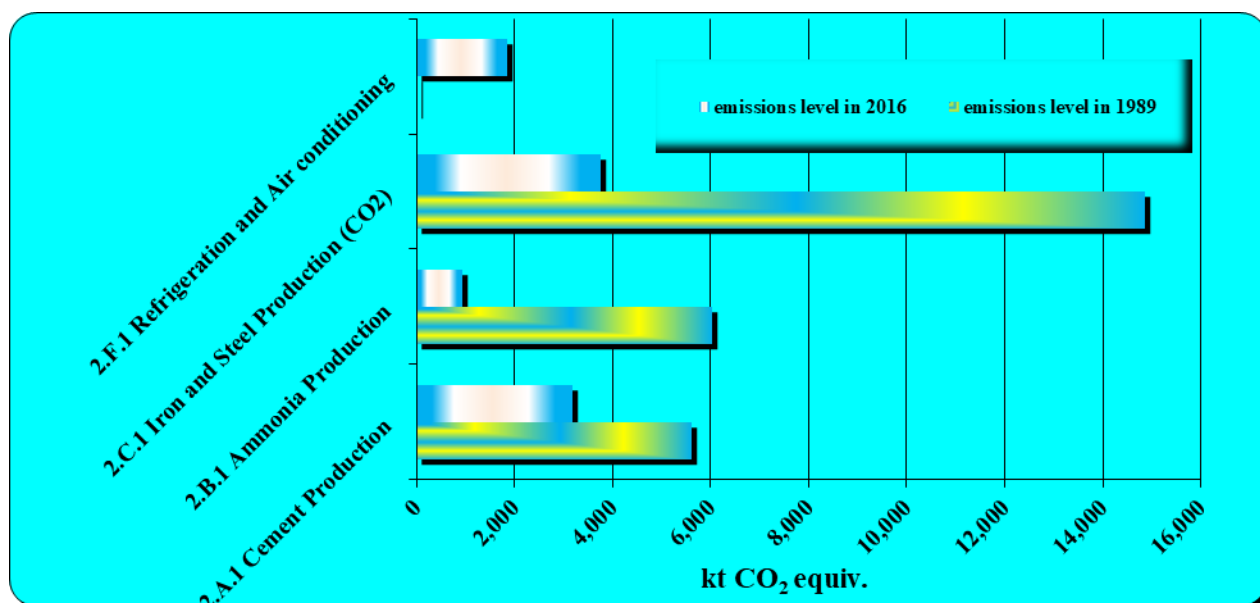
Other product manufacture and use contributes with 0.41% to the total GHG emissions from Industrial Processes and Product Use Sector.

**Figure 4.3 GHG emissions trends in Industrial Processes and Product Use Sector, by sub-sectors, for 1989–2016 period**



In the base year, various Industrial Processes and Product Use Sub-sectors contributions were: Mineral Industry 18.61%, Chemical Industry 30.39%, Metal Industry 45.38%, Non-energy product from fuels and solvent use 5.63%, 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 2016 year, both by level and trend criteria**



The Tier 1 key category analysis performed for 2016 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 2016 year**

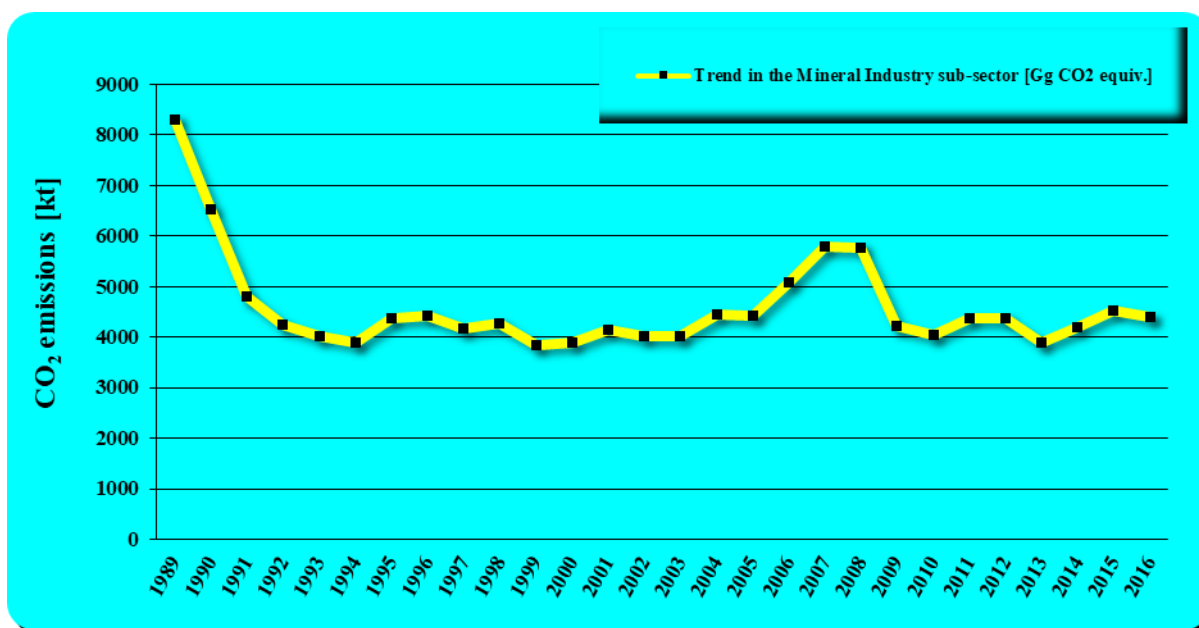
Key category	GHG	Criteria	Contribution in total GHG emissions [%]
<b>2.A.1 Cement Production</b>	CO <sub>2</sub>	L,T (Tier 1, excluding and including LULUCF)	2.83%
<b>2.B.1 Ammonia Production</b>	CO <sub>2</sub>	L,T (Tier 1, excluding and including LULUCF)	0.83%
<b>2.C.1 Iron and Steel Production</b>	CO <sub>2</sub>	L,T (Tier 1, excluding and including LULUCF)	3.35%
<b>2.F.1 Refrigeration and Air conditioning</b>	HFC	L,T (Tier 1, excluding and including LULUCF)	1.65%

## 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<sub>2</sub> emissions from cement production represent an important key category of the inventory because of its contribution to the total inventory emissions level (in 2016 CO<sub>2</sub> emissions from production of cement contributed with 2.83% to total greenhouse gas emissions). In the base year, these emissions accounted for 1.85% from the total GHG emissions.

**Figure 4.5 GHG emissions trend in the Mineral Industry Sub-sector for 1989–2016 period**



GHG emissions in the Mineral Industry Sub-sector were decreased after 1989 year due to the decrease recorded in Cement Production, Lime Production, Glass Production and Other Process Uses of Carbonates; the emissions were relatively stable during 1993–2005 period.

In 2004-2008 period the emissions rised due to increase of cement production, other process uses of carbonates, glass production.

In 2009 a significant decrease of emissions level was recorded in cement, lime, limestone and dolomite, soda ash and glass industries due to the economic crisis.

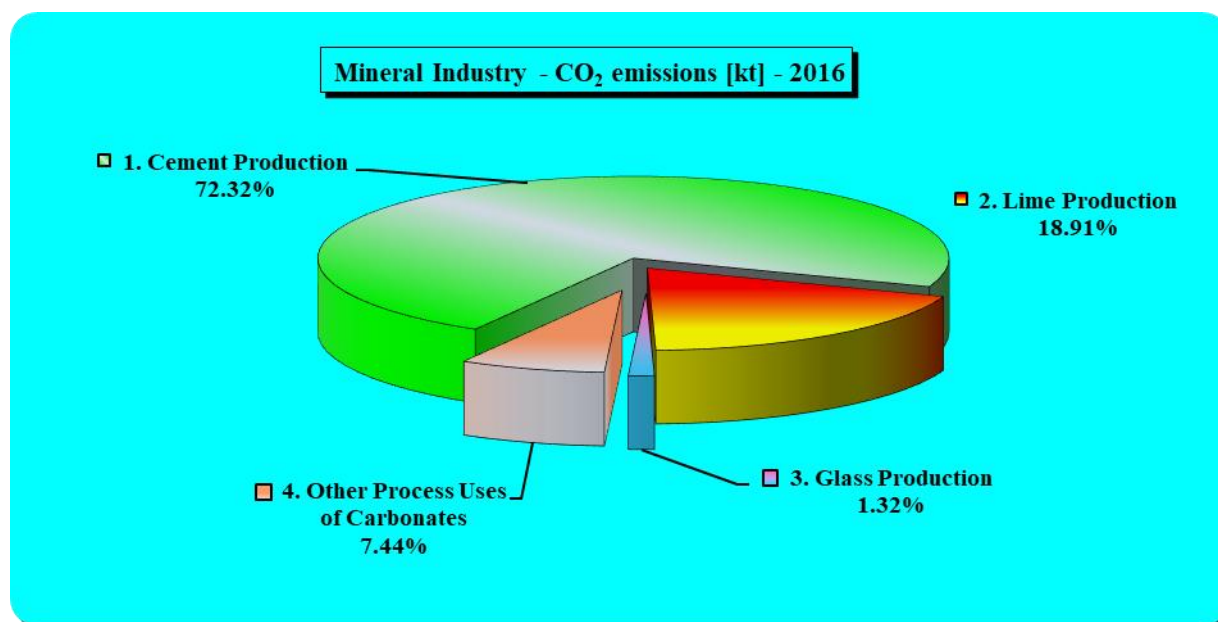
In 2015-2016 period the emissions rised due to increase of cement production, other process uses of carbonates, soda ash use.

Mineral Industry Sub-sector was responsible for 33.98% of the Industrial Processes and Product Use Sector related GHG emissions in 2016.

**Table 4.3 CO<sub>2</sub> emissions in the Mineral Industry Sub-sector, in the 2016 year**

Sector	CO <sub>2</sub> emissions [Gg]
<b>2.A Mineral Industry</b>	<b>4,398.32</b>
<b>2.A.1 Cement Production</b>	3,181.00
<b>2.A.2 Lime Production</b>	831.86
<b>2.A.3 Glass Production</b>	58.03
<b>2.A.4 Other Process Uses of Carbonates</b>	327.42

**Figure 4.6 Structure of the Mineral Industry Sub-sector, in 2016 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> is emitted during the production of clinker (calcination process) when calcium carbonate (CaCO<sub>3</sub>) is heated in a cement kiln. During this process calcium carbonate is converted into lime (CaO – Calcium Oxide) and CO<sub>2</sub>. Activity data related to the calcinations process were collected directly from the companies.

Clinker production data was provided by each company 1989-2016 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 reported 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 CO<sub>2</sub>/t clinker) and the emission factor from 2008 (the first year with laboratory analyses for plant specific CaO and MgO content in clinker), 0.530 t CO<sub>2</sub>/t clinker, the resulted specific emission factor is 0.5285 t CO<sub>2</sub>/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 CO<sub>2</sub> 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<sub>2</sub> 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, 0.657 for CaO and 0.014 for MgO for 2016 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> EF for clinker production and CO<sub>2</sub> 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<sub>2</sub> emissions from Clinker Production in the 1989–2016 period**

Year	Activity data and CO <sub>2</sub> emissions from Cement Production Sub-sector		
	Clinker production [kt]	Emission factor [tCO <sub>2</sub> /t clinker]	CO <sub>2</sub> Emissions [kt]
<b>1989</b>	10,571.00	0.5285	5,609.10
<b>1990</b>	8,379.00	0.5285	4,445.30
<b>1995</b>	5,937.82	0.5285	3,145.84
<b>2000</b>	5,005.78	0.5285	2,655.96
<b>2005</b>	6,006.96	0.5285	3,174.81
<b>2007</b>	7,670.40	0.5285	4,053.98

Year	Activity data and CO <sub>2</sub> emissions from Cement Production Sub-sector		
	Clinker production [kt]	Emission factor [tCO <sub>2</sub> /t clinker]	CO <sub>2</sub> Emissions [kt]
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
2016	5,932.98	0.53040	3,181.00

#### 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<sub>2</sub> 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 ( $\text{t CO}_2 / \text{t CaO}$  for lime or  $\text{t CO}_2 / \text{t CaO} \cdot \text{MgO}$  for dolomite lime);
- Specific average CaO or CaO·MgO content ( $\text{t CaO/t lime}$  or  $\text{t CaO} \cdot \text{MgO/t lime dolomite}$ );
- 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 1989–2016***

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 1989–2016 was divided into two periods:

- 2009–2016 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 1989–2016***

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  $\text{CO}_2$  and  $\text{CaO}$  or  $\text{CaO} \cdot \text{MgO}$  adjusted with the content of  $\text{CaO}$  or  $\text{CaO} \cdot \text{MgO}$  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  $\text{CaO}$  or the  $\text{CaO} \cdot \text{MgO}$  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  $0.785 \text{ t CO}_2/\text{t CaO}$ . 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  $0.7200 \text{ t CO}_2/\text{t CaO}$  and  $0.9650 \text{ t CO}_2/\text{t CaO}$ . For each year in the period 2005–2016 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 report
	t CO <sub>2</sub> /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
2013	0.9055
2014	0.8815
2015	0.8781
2016	0.8644

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
<b>1989-2008</b>	0.9094	0.785
<b>2009</b>	0.9053	0.785
<b>2010</b>	0.9126	0.785
<b>2011</b>	0.9144	0.785
<b>2012</b>	0.9086	0.785
<b>2013</b>	0.9055	0.785
<b>2014</b>	0.8815	0.785
<b>2015</b>	0.8781	0.785
<b>2016</b>	0.8644	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 2005–2016 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
<b>2005</b>	0.9366
<b>2006</b>	0.9141
<b>2007</b>	0.9045
<b>2008</b>	0.9124
<b>2009</b>	0.9193
<b>2010</b>	0.9195
<b>2011</b>	0.9126
<b>2012</b>	0.9151
<b>2013</b>	0.9198
<b>2014</b>	0.9229
<b>2015</b>	0.9290
<b>2016</b>	0.9257

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<sub>2</sub> emissions it is recommended to use the following values. 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.

**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	2016
<b>Lime producers</b>	0.9155	0.9193	0.9195	0.9126	0.9151	0.9198	0.9229	0.9290	0.9257

***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<sub>2</sub> emissions calculated in according with IPCC 2006 – Chapter 2 – page 2.24.

***Estimating the CO<sub>2</sub> emission levels for the calcium lime production and for the dolomite lime production***

In order to estimate the CO<sub>2</sub> 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 1989–2016. 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<sub>2</sub> emissions from Lime Production in the period 1989–2016**

Year	Emissions from Lime Production Sub-sector
	CO <sub>2</sub> emissions [kt]
1989	2,474.837
1990	1,897.608
1995	1,104.894
2000	1,136.683
2005	1,173.827
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
2015	831.361
2016	831.860

#### 4.2.2.3 Glass Production (CRF 2.A.3)

##### ***Methodology***

Total CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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 (1989–2016) 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 1989–2016.

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<sub>2</sub> emissions afferent to the plain/float glass production. For the period 1989–2002 the data series are represented by those obtained by extrapolation, on the base of average percentages calculated for the period 2003–2012. For the period 2014–2016 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 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 2008–2016 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 2009–2015 it is recommended to use the activity data collected because they represent the quantity of melted glass wool. For the year 2016 no activity data were reported by economic operators.

### ***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<sub>2</sub>/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<sub>2</sub>/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<sub>2</sub>/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<sub>2</sub>/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 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<sub>2</sub> emissions from Glass Production in the 1989–2016 period***

Year	Emissions from Glass Production Sub-sector
	CO <sub>2</sub> emissions [kt]
1989	183.286
1990	149.944
1995	97.323
2000	61.846
2005	46.902
2007	74.846
2008	77.286
2009	61.475
2010	68.34
2011	65.308
2012	62.383
2013	62.288
2014	56.126
2015	58.726
2016	58.034

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

##### ***Methodology***

The Other Process Uses of Carbonates is a key category from trend point of view (Tier 1, excluding LULUCF). The method for calculating emissions of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emission estimates for CRF category 2.A.4 - Other process uses of carbonates, as follows: the CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions estimation methodology in the period 2007-2014***

For the period 2007-2014, the CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions estimates for the period 1989-2006.

### ***CO<sub>2</sub> 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 ratio 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.

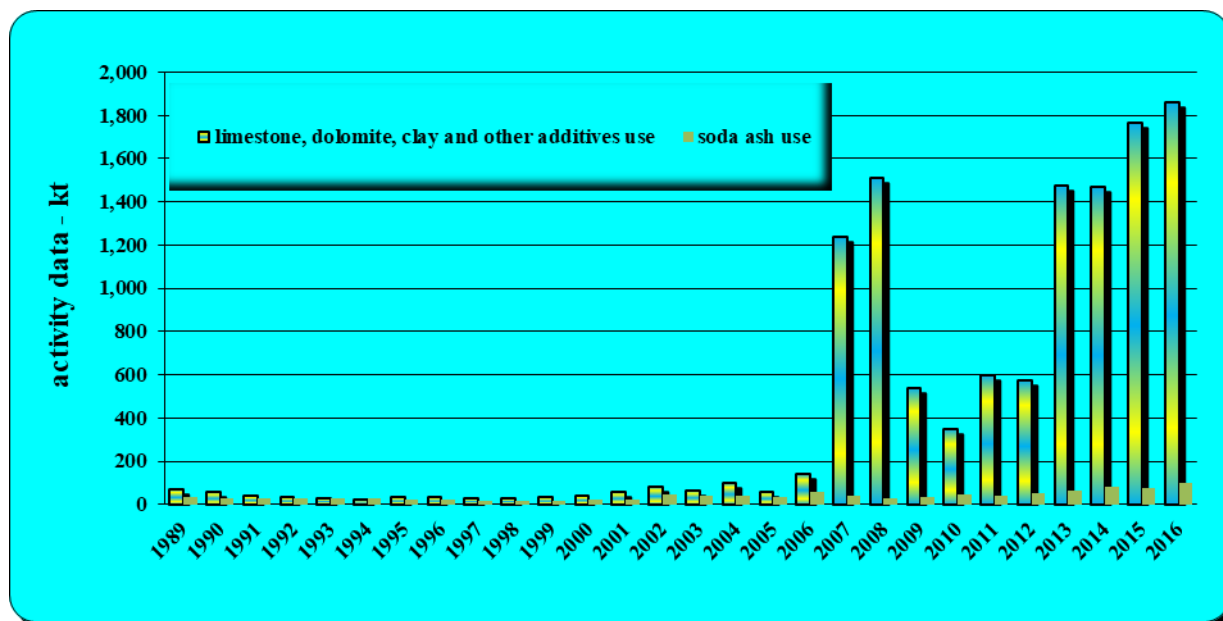
**Table 4.12 Amount of Other Process Uses of Carbonates and CO<sub>2</sub> emissions in the 1989–2016 period**

Year	Activity data and CO <sub>2</sub> emissions from Other Process Uses of Carbonates Sub-sector			
	Limestone, dolomite, clay, fly ash and other additives use (2.A.4.a Ceramics)	Limestone and Dolomite Use (2.A.4.d Other)	Soda ash use (2.A.4.b Other uses of Soda Ash)	CO <sub>2</sub> emission from Other Process Uses of Carbonates
	[kt]			[kt]
<b>1989</b>	10.85	59.22	33.21	44.70
<b>1990</b>	10.86	48.79	28.85	38.31
<b>1995</b>	11.02	24.94	23.94	25.85

Year	Activity data and CO <sub>2</sub> emissions from Other Process Uses of Carbonates Sub-sector			
	Limestone, dolomite, clay, fly ash and other additives use (2.A.4.a Ceramics)	Limestone and Dolomite Use (2.A.4.d Other)	Soda ash use (2.A.4.b Other uses of Soda Ash)	CO <sub>2</sub> emission from Other Process Uses of Carbonates
	[kt]			[kt]
<b>2000</b>	11.98	26.57	22.38	26.42
<b>2005</b>	21.33	33.65	36.16	39.47
<b>2007</b>	1,231.10	7.94	42.24	139.63
<b>2008</b>	1,504.38	6.77	30.08	143.79
<b>2009</b>	537.73	0.43	31.67	108.58
<b>2010</b>	345.56	0.39	44.40	127.30
<b>2011</b>	501.24	96.24	39.30	175.50
<b>2012</b>	256.48	316.47	53.83	239.32
<b>2013</b>	1,187.58	287.13	65.31	220.95
<b>2014</b>	1,158.02	312.44	80.40	248.67
<b>2015</b>	1,401.56	363.90	75.06	287.72
<b>2016</b>	1,426.29	436.46	101.08	327.42

### *Emission factors*

The default emission factors 440 kg CO<sub>2</sub>/tonne limestone, 477 kg CO<sub>2</sub>/tonne dolomite, 522 kg CO<sub>2</sub>/tonne magnesite and 415 kg CO<sub>2</sub>/tonne soda ash are used.

**Figure 4.7 CO<sub>2</sub> emissions from Other Process Uses of Carbonates in the 1989–2016 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 1989–2016.

#### 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 1989–2016.

#### 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 1989–2016.

#### 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 1989–2016.

#### *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<sub>2</sub> 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<sub>2</sub> emissions from Lime Production, Glass Production and Other Process Uses of Carbonates, were compared with the emissions reported in monitoring plans of GHG emissions for the EU-ETS installations. Further elements are presented within Annex 6.5.

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

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 2017	NGHGI 2018	Differences [%]
	CO <sub>2</sub> emissions [kt]		
1989	8,311.93	8,311.93	0.00
1990	6,531.16	6,531.16	0.00
1995	4,373.91	4,373.91	0.00
2000	3,880.91	3,880.91	0.00
2005	4,435.01	4,435.01	0.00
2007	5,792.32	5,792.32	0.00
2008	5,758.57	5,758.57	0.00
2009	4,211.16	4,211.17	0.00

The effects of recalculations in Mineral Industry Sector			
Years	NGHGI 2017	NGHGI 2018	Differences [%]
	CO <sub>2</sub> emissions [kt]		
2010	4,030.78	4,030.78	0.00
2011	4,382.29	4,382.29	0.00
2012	4,377.12	4,377.12	0.00
2013	3,878.39	3,878.39	0.00
2014	4,200.90	4,200.90	0.00
2015	4,515.27	4,515.27	0.00
2016		4,398.32	

Recalculation have been made for the 2007-2015 period. Recalculations were made as a result of due to an improvement in activity data for the 2.A.4.d Other category (a new operator has sent data on limestone and dolomite consumption for those years).

*Table 4.14 Recalculations of CO<sub>2</sub> emissions in the Other Process Uses of Carbonates Sub-sector*

The effects of recalculations in Other Process Uses of Carbonates Subsector			
Years	NGHGI 2017	NGHGI 2018	Differences [%]
	CO2 emissions [kt]		
1989	44.70	44.70	0.00
1990	38.31	38.31	0.00
1995	25.85	25.85	0.00
2000	26.42	26.42	0.00
2005	39.47	39.47	0.00
2007	139.63	139.63	0.00
2008	143.79	143.79	0.00
2009	108.57	108.58	0.00
2010	127.30	127.30	0.00



The effects of recalculations in Other Process Uses of Carbonates Subsector			
Years	NGHGI 2017	NGHGI 2018	Differences [%]
	CO <sub>2</sub> emissions [kt]		
2011	175.50	175.50	0.00
2012	239.32	239.32	0.00
2013	220.94	220.95	0.00
2014	248.67	248.67	0.00
2015	287.72	287.72	0.00
2016		327.42	

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

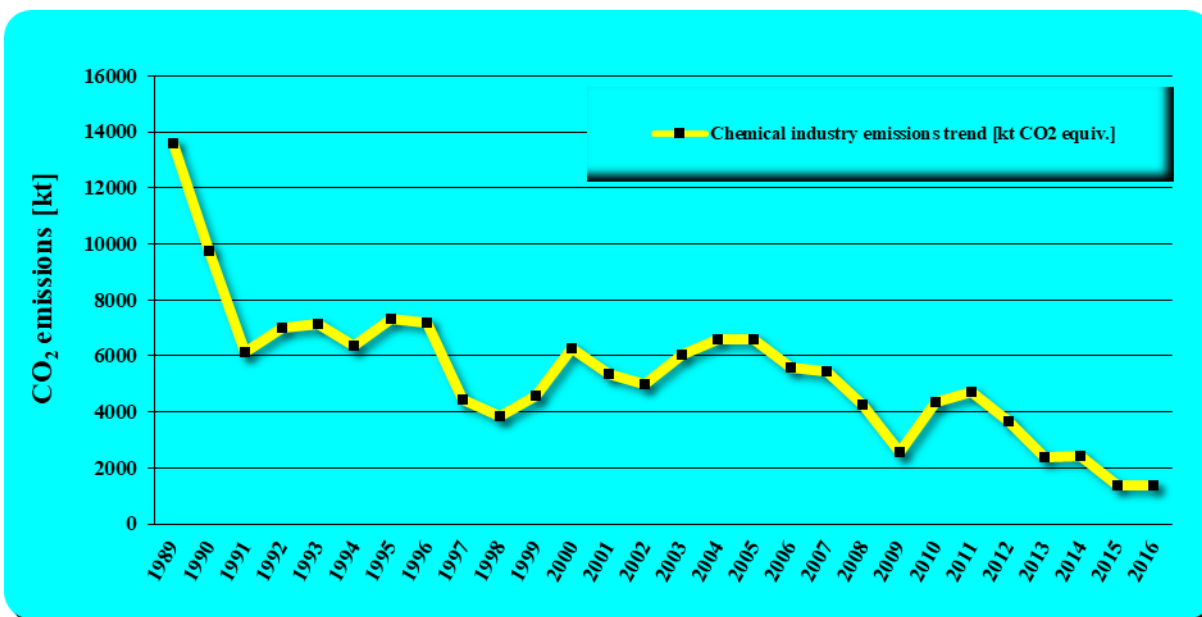
More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

### **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 10.96% of the total Industrial Processes Sector GHG emissions in 2016.

*Figure 4.8 GHG emissions trend in the Chemical Industry Sub-sector for 1989–2016 period*

GHG emissions trend in the Chemical Industry Sub-sector for 1989–2016 period due:

- lowest level of emissions from the ammonia production was recorded in 1997–1998 period (production decreased by almost 50% compared to the previous and the next year) due to closing of a producing plant in 1997 and closing of another plant in 1998 and reopening it the next year;
- nitric acid production decreased after 1989;
- adipic acid production had stopped at the end of 2001;
- carbide production had recorded a decrease after 1989 and it was stopped starting with 2007;
- for 2007–2009 a significant decrease of emissions level was recorded due to the economic crisis;
- in 2010–2011 the emissions rised due to increase of various production activities (ammonia production, nitric acid production, soda ash production and silicon carbide production);
- in 2012–2016 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 2016 year**

Sector	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	[kt] - 2016		
<b>2.B Chemical Industry</b>	<b>1,015.43</b>	<b>0.31</b>	<b>1.15</b>
<b>2.B.1</b> Ammonia Production	936.83	NE	NE
<b>2.B.2</b> Nitric Acid Production	NO	NO	1.15
<b>2.B.3</b> Adipic Acid Production	NO	NO	NO
<b>2.B.4</b> Caprolactam, glyoxal and glyoxylic acid production	NO	NO	NO
<b>2.B.5.a</b> Silicon Carbide Production	IE	0.31	NO
<b>2.B.5.b</b> Calcium Carbide Production	7.45	NE	NO
<b>2.B.6</b> Titanium dioxide production	IE	NO	NO
<b>2.B.7</b> Soda ash production	71.14	NO	NO
<b>2.B.8</b> Petrochemical and carbon black production	NO	NO	NO
<b>2.B.9</b> Fluorochemical production	NO	NO	NO
<b>2.B.10</b> 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<sub>2</sub>CO<sub>3</sub>. 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<sub>2</sub> emissions from ammonia production are estimated according to the Tier 3 methodology. In order to estimate the CO<sub>2</sub> 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 1997-1998 period, due to the activity data decreased by almost a half compared to the previous and next year. This happened as one producing plant has stopped its activity since 1998 and another plant has been closed in 1998 and reopened in the next year. In 2012–2016 the emissions decreased due to decrease of ammonia production.

### ***Activity data***

In order to estimate de CO<sub>2</sub> 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 1989–2016. In 2015 two ammonia production plants have ceased its activities, remaining three plants that provided data on the production of ammonia. In 2016 one ammonia production plant have ceased its activities, remaining two plants that provided data on the production of ammonia. 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<sup>3</sup>/year;
- Carbon content of natural gas used as feedstock in Ammonia Production process, kg carbon/m<sup>3</sup> gas;

- Annual amount of CO<sub>2</sub> resulted from Ammonia Production process with is used in urea production, kg/year;
- Annul amount of urea production, kg/year.

According to the BREF-BAT documentation (source 2.3.2), ch. 2.3.1, table 2.6, division of energy consumption in ammonia production is:

- 71.9% of energy contained in natural gas used as feedstock
- 28.1% of energy contained in natural gas used as fuel and other energy consumption converted into natural gas

Based on these percentages, are calculated the annual quantity of natural gas used as fuel in the production of ammonia.

### ***Emission factors***

In order to estimate the CO<sub>2</sub> 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<sub>2</sub> emissions***

- Unit measurement: kt CO<sub>2</sub> emissions/ year;
- Carbon dioxide is formed by oxidation of carbon from the fuel (natural gas);
- CO<sub>2</sub> emissions estimation is done by calculations using Tier 3 method, in compliance with 2006 IPCC methodology. CO<sub>2</sub> emissions are calculated based on natural gas consumption (energy and non-energy use). CO<sub>2</sub> emissions from the use of natural gas as fuel were calculated on the basis of the emission factors and net calorific values country specific from the Energy sector (see *Table 3.6 Country-Specific CO<sub>2</sub> emission factors for stationary combustion, oxidation included, from ETS verified reports and Annex 3.1 Detailed discussion of meth. and data for estimating CO<sub>2</sub> emissions from fossil fuel combustion\_stationary combustion*).

## ***Methodology***

### ***Annual amount of natural gas used as feedstock***

- Unit measurement: Nm<sup>3</sup>/year;
- Amount of natural gas is proportional to the production of ammonia 100% expressed in t / year;
- For accurate calculations, the amount of natural gas used as feedstock is obtained from the operators;

### ***Annual amount of natural gas used as fuel***

- Unit measurement: Nm<sup>3</sup>/year;
- For accurate calculations, the amount of natural gas used as fuel is obtained from the study “Elaboration/documentation of national emission factors/other parameters relevant to National Greenhouse Gas Inventory (NGHGI) Sectors Energy, Industrial Processes, Agriculture and Waste, values to allow for the higher tier calculation methods implementation”, according to the BREF-BAT documentation 28.1% of energy contained in natural gas used as fuel and other energy consumption converted into natural gas;
- CO<sub>2</sub> emissions from the use of natural gas as fuel were calculated on the basis of the emission factors and net calorific values country specific from the Energy sector.

Total CO<sub>2</sub> emissions are calculated based on natural gas consumption (energy and non-energy use). From CO<sub>2</sub> emissions from ammonia production are subtracted, in addition to the CO<sub>2</sub> emissions resulting from the use of urea as a fertilizer, which are included in the Agriculture sector in H, and the annual amount of CO<sub>2</sub> used for the production of urea exported.

### ***Carbon content of natural gas used as feedstock***

- Unit measurement: kg C / Nm<sup>3</sup> natural gas;
- In order to convert Nm<sup>3</sup> of natural gas in kg of natural gas, the density of the natural gas was used ( $\rho = 0.8779 \text{ kg/m}^3$ );
- 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<sub>2</sub> (44) and molecular weight of carbon – C (12). Value is 44/12.

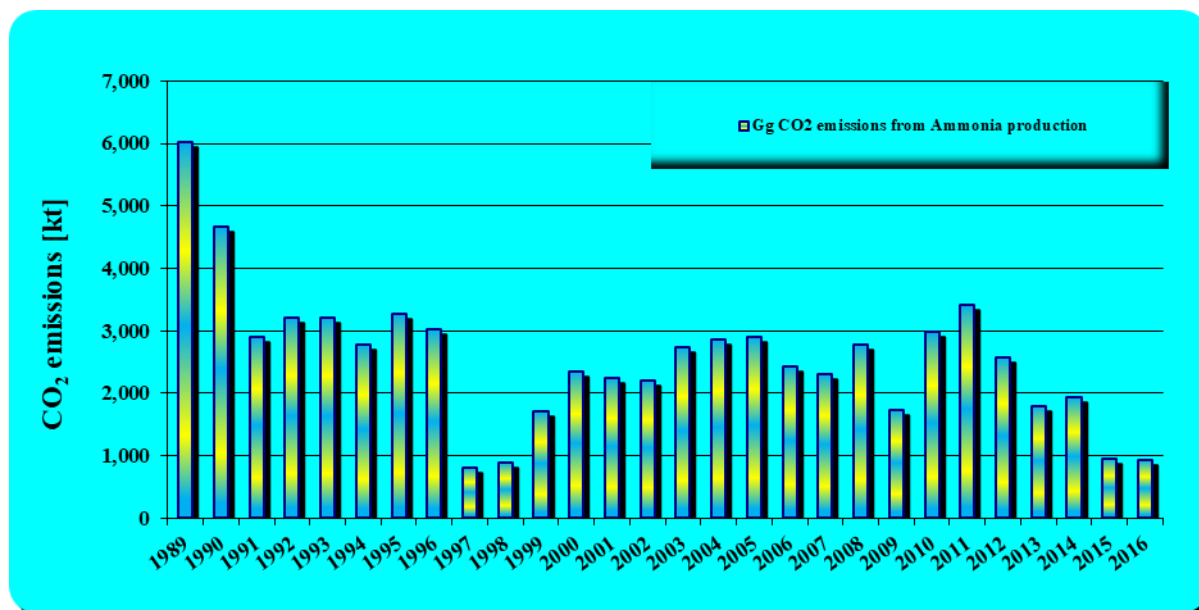
***Ammonia annual production***

- 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<sub>2</sub> emissions in the 1989–2016 period***

Year	Activity data and emissions from Ammonia Production Subsector	
	Natural gas consumption [kt]	CO <sub>2</sub> emissions [kt]
<b>1989</b>	2,707.96	6,033.02
<b>1990</b>	2,101.40	4,677.85
<b>1995</b>	1,943.01	3,262.93
<b>2000</b>	1,314.41	2,357.36
<b>2005</b>	1,615.83	2,900.82
<b>2007</b>	1,279.31	2,301.04
<b>2008</b>	1,443.92	2,776.70
<b>2009</b>	1,039.08	1,734.31
<b>2010</b>	1,504.20	2,974.37
<b>2011</b>	1,732.17	3,413.00
<b>2012</b>	1,449.87	2,567.02
<b>2013</b>	974.04	1,801.85
<b>2014</b>	1,013.22	1,937.06
<b>2015</b>	469.67	946.12
<b>2016</b>	459.19	936.83

**Figure 4.9 The trend of CO<sub>2</sub> emissions from Ammonia Production in the 1989–2016 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<sub>3</sub> 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<sub>2</sub>O 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 in:

- Medium and high pressure operation facilities (six plants);
- Old facilities, erected before 1975, without NSCR (one plant).

In 2016 year there are currently two chemical plants, where four HNO<sub>3</sub> 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<sub>2</sub>O default emission factor is 8 – 10 kg N<sub>2</sub>O/t HNO<sub>3</sub>, according to the 2000 IPCC GPG, table 3.8 (for dual pressure, double absorption plants) and 9 kg N<sub>2</sub>O/t HNO<sub>3</sub>,

according to the 2006 IPCC Guideline, table 3.3 (for high pressure plants). A **9 kg N<sub>2</sub>O/t HNO<sub>3</sub>** 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<sub>2</sub>O emission factor is 10 – 19 kg N<sub>2</sub>O/t HNO<sub>3</sub>, according to the 2000 IPCC GPG, Table 3.8. The **14.5 kg N<sub>2</sub>O/t HNO<sub>3</sub>** 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<sub>3</sub> 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<sub>2</sub>O emission level tend was carried out under the following conditions:

- The HNO<sub>3</sub> production facilities are old, as they were erected between 1963 and 1978;
- The HNO<sub>3</sub> 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 two chemical plants, where four HNO<sub>3</sub> production facilities are in operation;
- Four operating HNO<sub>3</sub> production facilities are fitted with nitrogen oxide reduction and emission monitoring systems;
- Upgrading efforts are made in all seven operating HNO<sub>3</sub> production facilities, to reduce nitrogen oxide emissions.

In the Table 4.17 are presented the estimations of the N<sub>2</sub>O 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 1989–2016 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 <sub>2</sub> O Emissions kt]	N <sub>2</sub> O Emissions [kt]
<b>1989</b>	1,993.70	1.06	17.28
<b>1990</b>	1,260.98	0.81	10.85
<b>1995</b>	1,025.81	0.10	9.17
<b>2000</b>	874.12	0.26	7.70
<b>2005</b>	1,102.14	0.21	9.79
<b>2007</b>	981.38	0.28	8.66
<b>2008</b>	867.39	0.56	3.07
<b>2009</b>	642.48	0.31	1.97
<b>2010</b>	1,055.38	0.50	3.48
<b>2011</b>	1,076.96	0.68	3.29
<b>2012</b>	983.80	0.55	2.80
<b>2013</b>	949.58	0.23	1.48
<b>2014</b>	1,001.15	0.36	1.00
<b>2015</b>	734.50	NO	1.13
<b>2016</b>	668.01	NO	1.15

### ***HNO<sub>3</sub> production trend***

The HNO<sub>3</sub> production trend decreased between 1989 and 2001, following the economic decline; several low-efficiency production capacities were shut down. The HNO<sub>3</sub> production trend increased between 2002 and 2014, following the economic recovery; several production capacities were upgraded. In 2015 the HNO<sub>3</sub> production decreased because two nitric acid

production plants have ceased its activities, remaining three plants that provided data on the production of nitric acid. In 2016 year there are currently two chemical plants, where four HNO<sub>3</sub> production facilities are in operation.

### ***N<sub>2</sub>O 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<sub>2</sub>O reduction systems.

### ***N<sub>2</sub>O emission monitoring systems***

N<sub>2</sub>O emission monitoring systems use analyzers manufactured by internationally renowned companies, designed according to the U.S. EPA 40 CFR 60875 norms and the 2000/76/EC (WID), 2001/80/EC (LCPD) norms. The type of flow analyzers is the MIR 9000 Multi – Gas InfraRed GFC Analyzer.

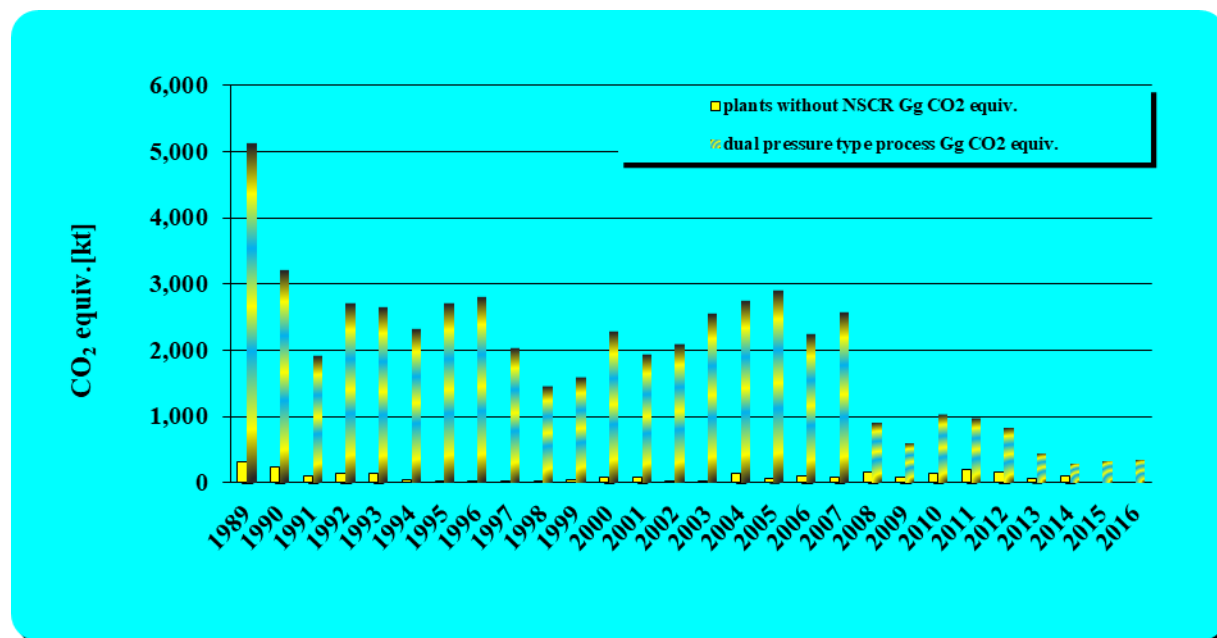
The calculation formula used to estimate the N<sub>2</sub>O and NO<sub>x</sub> emission levels in the Nitric acid production sub-sector - emissions estimated according to approach level 2 – IPCC 2006 is:

$$EN_{2O} = \Sigma [EF_i * NAP_i * (1 - DF_j * ASUF_j)]$$

Where:

- EN<sub>2O</sub> = N<sub>2</sub>O emissions, expressed in kg/year
- EF<sub>i</sub> = The N<sub>2</sub>O emission factor for the type “i” technology, expressed in N<sub>2</sub>O kg / 100% HNO<sub>3</sub> tons
- NAP<sub>i</sub> = Nitric acid production obtained via the type “i” technology, expressed in 100% HNO<sub>3</sub> tons / year
- DF<sub>j</sub> = The destruction factor for the type “j” technology, expressed in a fraction
- ASUF<sub>j</sub> = The utilization of the type “j” technology, expressed in a fraction

The DF<sub>j</sub> \* ASUF<sub>j</sub> product is the efficiency of the oxide emission reduction system. If there is an oxide emission reduction system, the economic agents have also specified the efficiency of the oxide emission reduction system values in the range of 80-87.77%.

**Figure 4.10 The trend of CO<sub>2</sub> emissions from Nitric Acid Production, 1989–2016 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**

<b>EMISSION FACTORS FOR ADIPIC ACID PRODUCTION (KG/TONNE PRODUCT)</b>	
	<b>N<sub>2</sub>O</b>
	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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>4</sub> 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<sub>4</sub> emission factor was used, considering that the Silicon Carbide Sub-sector is not a key source category. The CO<sub>2</sub> emissions from Silicon Carbide Production are noted as IE because the emissions related with coke consumption are accounted in Energy Sector (1AA2F- Other non-specified - solid fuels subsector). Within the Romanian Energy Balance there are provided the information related with coke consumption on “Manufacture of other non-metallic mineral products”, the data are not disaggregated per industry type, the coke consumption being provided from all “Manufacture of other non-metallic mineral products industry” and implicitly for the production of silicon carbide subsector.

##### ***Activity data***

National Statistics provided annually the amount of Silicon Carbide Production starting with 2003 year. In 2007 the production was stopped and was reopened in 2008. The data related with Silicon Carbide Productions are confidential starting with 2008.

##### ***Emission factors***

For confidentiality reasons the presentation of CH<sub>4</sub> 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<sub>2</sub> 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<sub>2</sub> emission factor were used (Table 3.8, page 3.44), considering that the Calcium Carbide Sub-sector is not a key source category.

##### ***Activity data***

As activity data, carbide production and carbide use were used. The calcium carbide production data provided by the National Institute for Statistics. The calcium carbide used amount was obtained as balance of production, import and export data provided by the National Institute for Statistics (the amount used equals the production amount plus the imported amount minus the exported amount; starting with 2007 year, the production was stopped; for 1989, 1990, 1991 and 1993 years calcium carbide was not imported).

##### ***Emission factors***

According with 2006 IPCC GL in order to estimate CO<sub>2</sub> emission from Calcium Carbide Subsector were used default emission factors provided in production process of calcium carbide: the 1.09 tonnes CO<sub>2</sub>/tonne carbide corresponding to the reduction step and the default emission factor of 1.100 tonnes CO<sub>2</sub>/tonne carbide corresponding to the use of product. Emissions from the CaO step are reported as emissions from lime production.



**Table 4.19 CO<sub>2</sub> emissions from Calcium Carbide Production in the 1989–2016 period**

<b>Years</b>	<b>Emissions from Calcium Carbide Subsector</b>		
	<b>CO<sub>2</sub> emissions from Carbide production [kt]</b>	<b>CO<sub>2</sub> emissions from Carbide use [kt]</b>	<b>Total CO<sub>2</sub> emissions [kt]</b>
<b>1989</b>	196.20	92.57	288.77
<b>1990</b>	140.61	83.69	224.30
<b>1995</b>	98.10	65.39	163.49
<b>2000</b>	59.95	31.90	91.85
<b>2005</b>	37.06	23.82	60.88
<b>2007</b>	NO	21.68	21.68
<b>2008</b>	NO	13.19	13.19
<b>2009</b>	NO	15.82	15.82
<b>2010</b>	NO	18.35	18.35
<b>2011</b>	NO	13.61	13.61
<b>2012</b>	NO	9.39	9.39
<b>2013</b>	NO	6.59	6.59
<b>2014</b>	NO	0.69	0.69
<b>2015</b>	NO	6.12	6.12
<b>2016</b>	NO	7.45	7.45

**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<sub>2</sub> 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<sub>2</sub> 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 the Titanium dioxide production category is not a key category and therefore apply level 1 for the estimation of the CO<sub>2</sub> emissions. Because no national emission factor is available for titanium slag production, in the 2006 IPCC guide an emission factor default cannot 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 (1AA2a- Iron and steel – liquid fuels subsector).

***Emission factors***

For confidentiality reasons the presentation of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions from natural soda ash production from 2006 IPCC GL – page 3.53 (Figure 3.7).

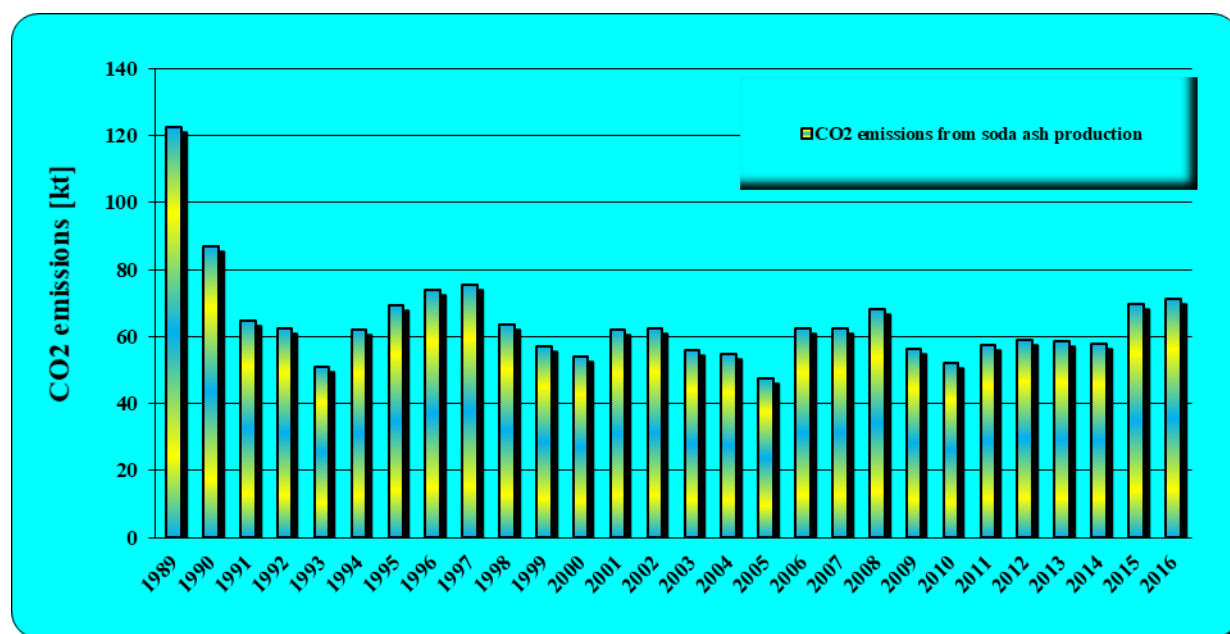
***Activity data***

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<sub>2</sub> emission factor used to estimate emission from Soda Ash Production is omitted.

*Figure 4.11 CO<sub>2</sub> emissions from Soda Ash Production in the 1989–2016 period*



*Table 4.20 CO<sub>2</sub> emissions from Soda Ash Production in the 1989–2016 period*

Year	Emissions from Soda Ash Production Sub-sector
	CO <sub>2</sub> emissions [kt]
1989	122.57
1990	87.14
1995	69.49
2000	53.91
2005	47.70
2007	62.32
2008	68.11

Year	Emissions from Soda Ash Production Sub-sector
	CO <sub>2</sub> emissions [kt]
2009	56.39
2010	51.98
2011	57.49
2012	59.01
2013	58.60
2014	57.77
2015	69.63
2016	71.14

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

##### *Methodology*

Total CO<sub>2</sub> 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<sub>2</sub> emissions from petrochemical industry and carbon black industry from 2006 IPCC GL – page 3.63 (Figure 3.8). Total CH<sub>4</sub> 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<sub>4</sub> 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, polypropylene, 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<sub>2</sub> and CH<sub>4</sub> 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 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

#### 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 1989–2016.

#### 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 1989–2016.

#### 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.

#### *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 2017	NGHGI 2018	Differences [%]
	CO2 emissions [kt]		
1989	11,828.92	13,575.29	14.76
1990	8,393.27	9,748.46	16.15
1995	7,206.29	7,335.86	1.80
2000	6,024.39	6,260.61	3.92
2005	6,312.30	6,599.13	4.54
2007	5,209.53	5,436.44	4.36
2008	3,788.49	4,233.92	11.76
2009	2,451.34	2,566.74	4.71
2010	3,863.83	4,349.41	12.57

The effects of recalculations in Chemical Industry Sector			
Years	NGHGI 2017	NGHGI 2018	Differences [%]
	CO2 emissions [kt]		
2011	4,254.04	4,701.91	10.53
2012	3,791.95	3,682.36	-2.89
2013	2,132.30	2,388.40	12.01
2014	2,106.56	2,414.90	14.64
2015	1,121.87	1,368.99	22.03
2016		1,364.78	

Recalculation have been made for the entire period 1989-2015 due to an improvement in the activity data used in the CO<sub>2</sub> emissions estimates from category 2.B.1 Ammonia Production. CO<sub>2</sub> emissions are calculated based on natural gas consumption (energy and non-energy use). From CO<sub>2</sub> emissions from ammonia production are subtracted, in addition to the CO<sub>2</sub> emissions resulting from the use of urea as a fertilizer, which are included in the Agriculture sector in H and the annual amount of CO<sub>2</sub> used for the production of urea exported. (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 2017	NGHGI 2018	Differences [%]
	CO2 emissions [kt]		
1989	4,286.66	6,033.02	40.74
1990	3,322.66	4,677.85	40.79
1995	3,133.36	3,262.93	4.14
2000	2,121.14	2,357.36	11.14
2005	2,614.00	2,900.82	10.97
2007	2,074.12	2,301.04	10.94
2008	2,331.27	2,776.70	19.11
2009	1,618.90	1,734.31	7.13

The effects of recalculations in Ammonia Production Subsector			
Years	NGHGI 2017	NGHGI 2018	Differences [%]
	CO <sub>2</sub> emissions [kt]		
2010	2,488.78	2,974.37	19.51
2011	2,965.13	3,413.00	15.10
2012	2,676.61	2,567.02	-4.09
2013	1,545.74	1,801.85	16.57
2014	1,628.72	1,937.06	18.93
2015	699.00	946.12	35.35
2016		936.83	

*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<sub>6</sub> in Aluminium and Magnesium Foundries is not applicable in Romania. Metal Industry Sub-sector is responsible for 31.87% of the total Industrial Processes and Product Use Sector GHG emissions in 2016.

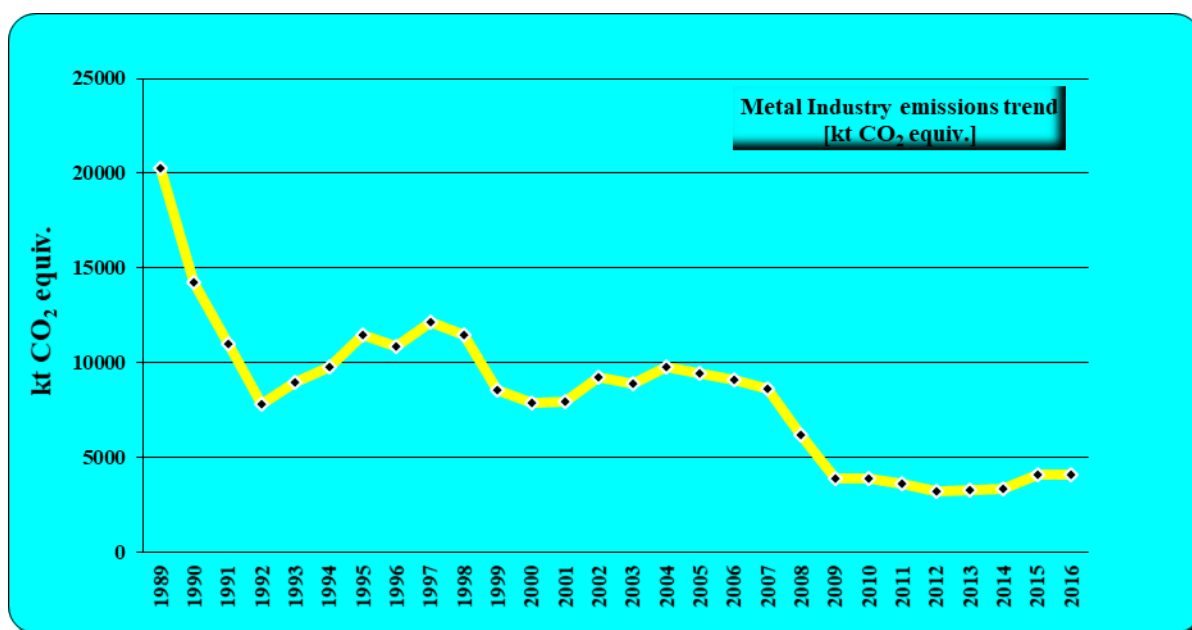
CO<sub>2</sub> emissions from Iron and Steel Production represent an important key category of the inventory because of its contribution to the total inventory level (in 2016 CO<sub>2</sub> emissions from production of iron and steel contributed 3.36% to total greenhouse gas emissions). In the base year, these emissions accounted for 4.92% from the total GHG emissions. The CO<sub>2</sub> emissions from Ferroalloys Production have been included in the inventory. Aluminium Production results

in a smaller quantity of CO<sub>2</sub> emissions and also PFCs emissions. PFCs emissions from Aluminium Production represent a significant source of emissions due to high GWP values.

GHG emissions trend in the Metal Industry Sub-sector for 1989–2016 period due:

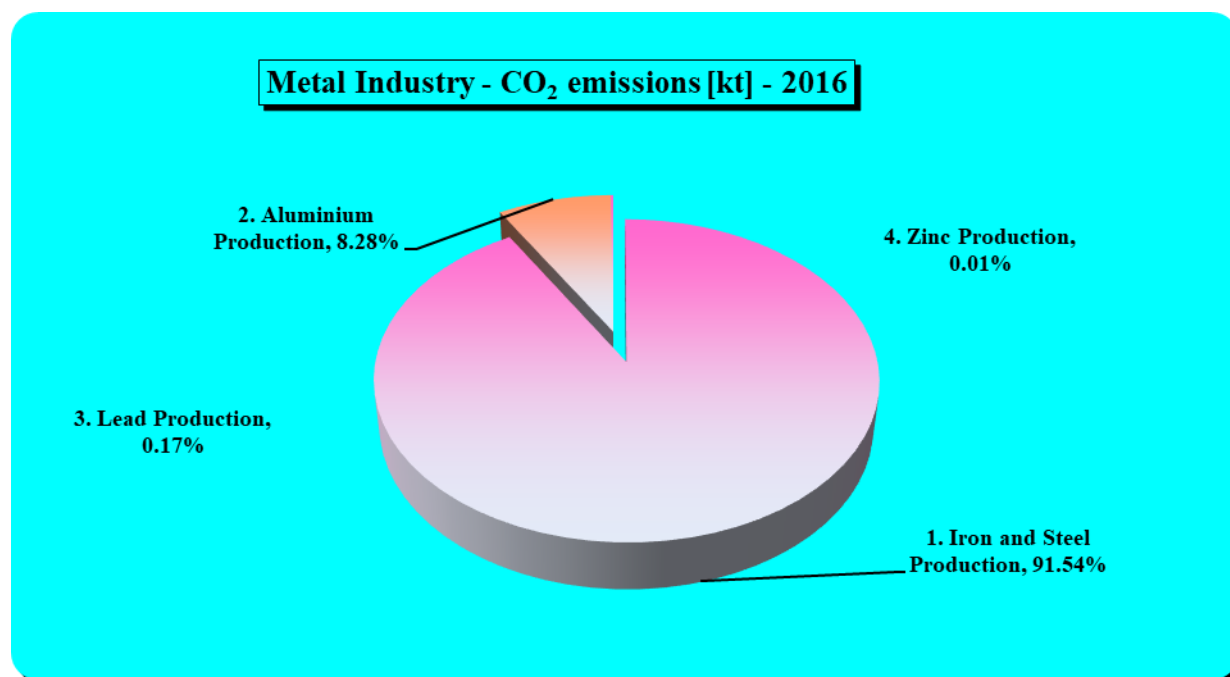
- iron and steel production recorded decreases after 1989;
- ferroalloys production has recorded a decrease after 1989. The lowest level of emissions was recorded in 1999 due to the cease of production;
- the reduction of PFC emissions from production of aluminium due to changes in technology starting with 1997 and 2003;
- after 2008 the trend of emission decreases due to reduction of production level recorded in iron and steel production, aluminium production and ferroalloys production;
- in 2010–2014 period the emissions trends have recorded an decrease due to decreased of various production activities (iron and steel production, lead production, zinc production and ferroalloys production);
- in 2015-2016 period the emissions trends have recorded an increase due to increased of various production activities (iron and steel production, aluminium production, lead production and zinc production).

**Figure 4.12 GHG emissions trend in the Metal Industry Sub-sector for 1989–2016 period**



**Table 4.23 GHG emissions from Metal Industry Sub-sector, in the 2016 year**

Sector	CO <sub>2</sub>	CH <sub>4</sub>	PFCs
	CO <sub>2</sub> equivalent [kt]		
<b>2.C Metal Industry</b>	<b>4,114.95</b>	<b>4.525</b>	<b>5.44</b>
2.C.1 Iron and Steel Production	3771.31	4.53	0.00
2.C.2 Ferroalloys Production	0.00	0.00	0.00
2.C.3 Aluminium Production	336.09	0.00	5.44
2.C.4 Magnesium Production	0.00	0.00	0.00
2.C.5. Lead Production	7.00	0.00	0.00
2.C.6. Zinc Production	0.56	0.00	0.00

**Figure 4.13 Structure of the Metal Industry Sub-sector, in 2016 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>4</sub> 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<sub>4</sub> 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 2016.



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	√	√

Parameter type	Quantity, t or GJ	Average carbon content, tC/t product or tC/GJ
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<sub>2</sub> Emissions for Iron and Steel Production (CRF 2.C. 1) for 1989–2016 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions were calculated with the Tier 3 method presented in IPCC 2006 Guide, for the period 1989-2016. 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 dolomite/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<sub>2</sub> emissions estimated for the period 1989-2016.

*Table 4.26 CO<sub>2</sub> emissions estimated for the 1989–2016 period*

Year	CO <sub>2</sub> emissions [kt CO <sub>2</sub> equivalent]
<b>1989</b>	11,661.95
<b>1990</b>	8,846.24
<b>1995</b>	6,872.59
<b>2000</b>	5,661.09
<b>2005</b>	8,618.03
<b>2007</b>	7,998.31
<b>2008</b>	5,640.97
<b>2009</b>	3,528.20
<b>2010</b>	3,482.39
<b>2011</b>	3,232.41

Year	CO <sub>2</sub> emissions [kt CO <sub>2</sub> equivalent]
2012	2,826.04
2013	2,912.20
2014	3,020.35
2015	3,745.65
2016	3,756.40

### *Estimation of CO<sub>2</sub> emissions for the Electric Flow*

The data used in CO<sub>2</sub> 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 necessary 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<sub>2</sub> emissions using tier 3 method are poor in the begining of the time serie. Calculation of the CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emissions estimated for the 1989–2016 period.

*Table 4.27 CO<sub>2</sub> emissions estimated for the 1989–2016 period*

<b>Year</b>	<b>Total CO<sub>2</sub> emissions EAF [kt CO<sub>2</sub> equivalent]</b>
<b>1989</b>	342.74
<b>1990</b>	195.01
<b>1995</b>	98.82
<b>2000</b>	39.29
<b>2005</b>	45.79
<b>2007</b>	31.13
<b>2008</b>	23.63
<b>2009</b>	12.85
<b>2010</b>	24.38
<b>2011</b>	26.72
<b>2012</b>	25.75
<b>2013</b>	21.05
<b>2014</b>	17.85
<b>2015</b>	13.68
<b>2016</b>	14.91

*Estimation of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>/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<sub>2</sub> emissions estimated.

***Table 4.28 CO<sub>2</sub> emissions for steel production in OHF***

<b>Year</b>	<b>CO<sub>2</sub> emissions [kt CO<sub>2</sub> equivalent]</b>
<b>1989</b>	2,853.33
<b>1990</b>	1,739.96
<b>1991</b>	1,029.03
<b>1992</b>	731.27
<b>1993</b>	1,644.32
<b>1994</b>	1,735.48
<b>1995</b>	1,664.96

Year	CO <sub>2</sub> emissions [kt CO <sub>2</sub> equivalent]
1996	1,611.64
1997	1,608.20
1998	1,155.84

***Estimation of CO<sub>2</sub> Emissions for Iron and Steel Production (CRF 2.C.1)***

CO<sub>2</sub> emissions for Iron and Steel Production during the period 1989–2016, represent the sum of CO<sub>2</sub> 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.

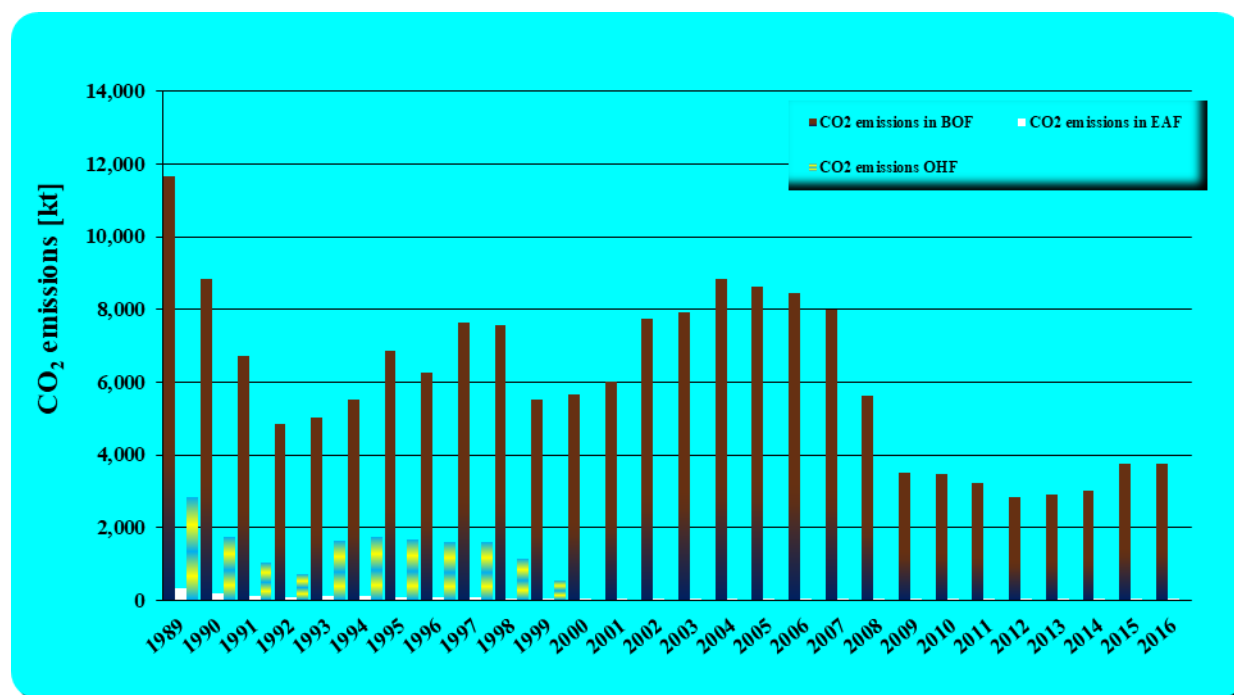
***Table 4.29 CO<sub>2</sub> emissions from Iron and Steel Production for the 1989–2016 period***

Year	CO <sub>2</sub> emissions [kt CO <sub>2</sub> equivalent]					Total CO <sub>2</sub> emissions [kt CO <sub>2</sub> 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
1995	6,872.59	98.82	0.00	0.00	1,664.96	8,636.37
2000	5,661.09	39.29	0.00	0.00	0.00	5,700.37
2005	8,618.03	45.79	0.00	0.00	0.00	8,663.81
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

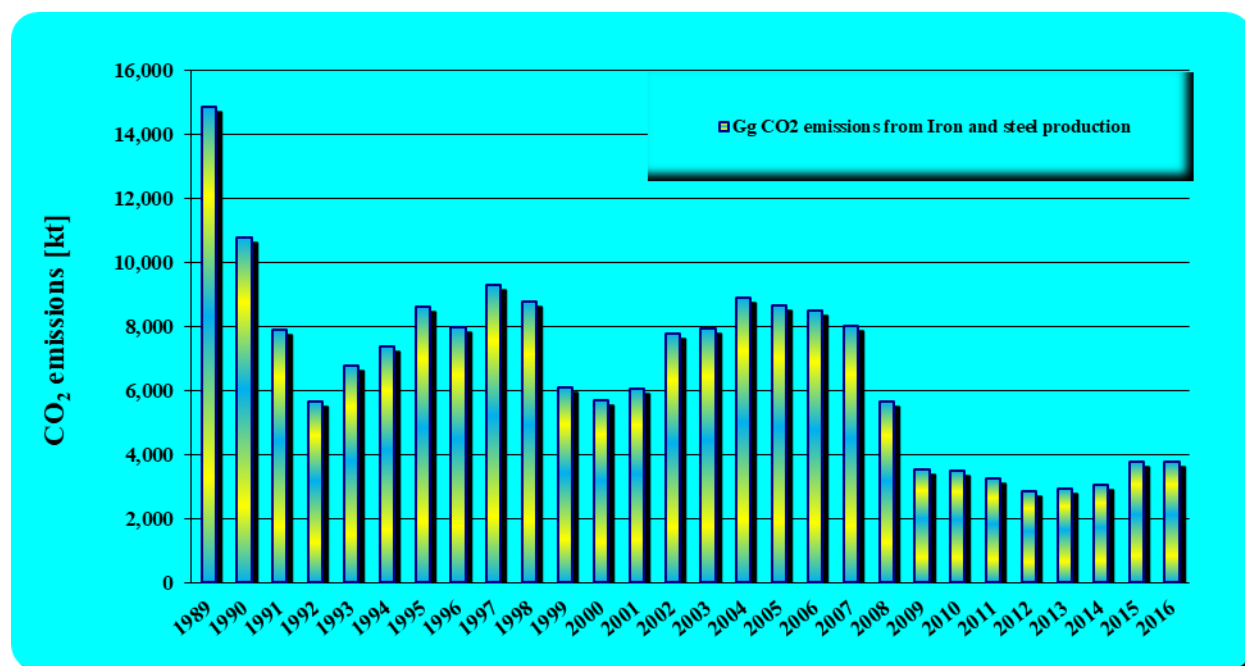


Year	CO <sub>2</sub> emissions [kt CO <sub>2</sub> equivalent]					Total CO <sub>2</sub> emissions [kt CO <sub>2</sub> equivalent]
	BOF	EAF	CI	Cupola furnace	OHF	
2014	3,020.35	17.85	0.00	0.00	0.00	3,038.20
2015	3,745.65	13.68	0.00	0.00	0.00	3,759.34
2016	3,756.40	14.91	0	0	0	3,771.31

*Figure 4.14 The trend of CO<sub>2</sub> emissions from Iron and Steel Production (BOF, EAF and OHF) in the 1989–2016 period*



**Figure 4.15 The trend of CO<sub>2</sub> emissions from Iron and Steel Production in the 1989–2016 period**



**Estimation of CH<sub>4</sub> Emissions for Iron and Steel Production (CRF 2.C.1) for the 1989–2016 period**

The CH<sub>4</sub> emissions for the period 1989–2016 were estimated based on the Tier 1 methodology in IPCC 2006 (sinter production data x default emission factor). Table 4.30 shows the CH<sub>4</sub> emissions for category CRF 2.C.1 – Iron and Steel Production.

**Table 4.30 CH<sub>4</sub> emissions for Iron and Steel production for the 1989-2016 period**

Year	Sinter [kt]	Emission factor [kg/t]	CH <sub>4</sub> emissions [kt CO <sub>2</sub> equivalent]
1989	13,626.00	0.07	23.85
1990	11,357.00	0.07	19.88
1995	6,671.00	0.07	11.68
2000	3,875.00	0.07	6.78

Year	Sinter [kt]	Emission factor [kg/t]	CH <sub>4</sub> emissions [kt CO <sub>2</sub> equivalent]
2005	6,600.00	0.07	11.55
2007	6,359.22	0.07	11.13
2008	3,445.55	0.07	6.03
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
2016	2,592.59	0.07	4.525

The NMVOC, NO<sub>x</sub>, CO, SO<sub>2</sub> 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<sub>2</sub> and CH<sub>4</sub> 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<sub>2</sub> emissions have increased due to improve the Production of Silicon Manganese.

In 2011 – 2012 period the Ferroalloys Production and the CO<sub>2</sub> emissions have decreased due to decreasing of the Ferrochromium Production. Starting with 2002 year there are no emissions of CH<sub>4</sub> 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<sub>2</sub> emission factors used to estimate emission from Ferroalloys Production are omitted.

***Table 4.31 CO<sub>2</sub> emission from Ferroalloys Production in the 1989–2016 period***

<b>Years</b>	<b>Emissions from Ferroalloys Production Subsector</b>
	<b>CO<sub>2</sub> emissions [kt]</b>
<b>1989</b>	451.72
<b>1990</b>	313.06
<b>1995</b>	213.79
<b>2000</b>	123.07
<b>2005</b>	165.55
<b>2007</b>	37.62
<b>2008</b>	19.21
<b>2009</b>	19.99
<b>2010</b>	43.97
<b>2011</b>	32.98
<b>2012</b>	19.11

Years	Emissions from Ferroalloys Production Subsector
	CO <sub>2</sub> emissions [kt]
2013	NO
2014	NO
2015	NO
2016	NO

*Table 4.32 CH<sub>4</sub> emission from Ferroalloys Production in the 1989–2016 period*

Years	Emissions from Ferroalloys Production Subsector
	CH <sub>4</sub> emissions [kt]
1989	0.07
1990	0.05
1995	0.02
2000	0.01
2005	NO
2007	NO
2008	NO
2009	NO
2010	NO
2011	NO
2012	NO
2013	NO
2014	NO
2015	NO

Years	Emissions from Ferroalloys Production Subsector
	CH <sub>4</sub> emissions [kt]
2016	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<sub>2</sub>)** 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<sub>4</sub>** and **C<sub>2</sub>F<sub>6</sub>** during anode effects;

The PFC process emissions calculation taking into account the technology use within the facility along the time period 1989–2016:

- 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<sub>2</sub>** 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<sub>4</sub>** emissions and also **IPCC 2006 Methodology (Tier 2 Method)** for **C<sub>2</sub>F<sub>6</sub>** emissions, considering the type of technology use within the facility.
- **Starting with 2003** the **CO<sub>2</sub>** 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 (1989–2016), 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<sub>2</sub> emissions** are calculated based on **Aluminium Production** in line with **IPCC 2006 Methodology (Tier 1 Method)**. The calculation of CO<sub>2</sub> 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<sub>4</sub> emissions** and **IPCC 2006 Methodology (Tier 2 Method)** for **C<sub>2</sub>F<sub>6</sub> 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<sub>2</sub> emissions** are also calculated based on **Aluminium Production** in line with **IPCC 2006 Methodology (Tier 1 Method)**. The calculation of CO<sub>2</sub> 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<sub>4</sub> emissions** and **IPCC 2006 Methodology (Tier 2 Method)** for **C<sub>2</sub>F<sub>6</sub> emissions**;
- **Starting with 2003** the technology was changed to **CWPB** (Centre Worked Pre-baked). **The CO<sub>2</sub> 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<sub>2</sub>F<sub>6</sub>/CF<sub>4</sub> from **IPCC 2006 Methodology**.

**Table 4.33 The activity data, PFC and CO<sub>2</sub> emissions from Aluminium Production Sub-sector in the 1989–2016 period**

Year	Emissions and activity data from Aluminium Production Sub-sector			
	CF <sub>4</sub> emissions	C <sub>2</sub> F <sub>6</sub> emissions	CO <sub>2</sub> emissions	Aluminium Production
	[tones]		[kt]	[kt]
<b>1989</b>	424.87	107.07	424.87	265.54
<b>1990</b>	268.38	67.63	268.38	167.74
<b>1995</b>	224.96	56.69	224.96	140.60
<b>2000</b>	173.27	32.32	277.23	173.27
<b>2005</b>	10.75	1.30	372.62	239.01
<b>2007</b>	3.18	0.38	402.14	262.51
<b>2008</b>	2.02	0.24	399.93	265.24
<b>2009</b>	0.92	0.11	299.04	200.56
<b>2010</b>	1.03	0.12	314.75	206.72
<b>2011</b>	1.44	0.17	335.98	224.51
<b>2012</b>	0.84	0.10	335.63	202.08
<b>2013</b>	0.70	0.08	319.57	197.25
<b>2014</b>	0.71	0.09	317.51	195.25
<b>2015</b>	0.74	0.09	334.03	205.88
<b>2016</b>	0.61	0.07	336.09	207.33

### ***Emission factors***

Along the period 1989–2016 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<sub>2</sub> emissions** are calculated based on primary Aluminium Production data and the **default EF (1.6 tonnes CO<sub>2</sub>/tonne Al)** in line with **IPCC 2006 Methodology (Tier 1 Method)**. The calculation of CO<sub>2</sub> 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<sub>4</sub> emissions and IPCC 2006 Methodology (Tier 2 Method) for C<sub>2</sub>F<sub>6</sub> emissions**. **Emissions of CF<sub>4</sub>** were estimated by multiplying annual primary Aluminium Production with the default emission factor (**1.6 kg CF<sub>4</sub>/tonne Al**) provided by **IPCC 2006 Methodology (Tier 1 Method)** and considering the technologies in this period, **SWPB** (Side Worked Pre-baked). Compliance with **IPCC 2006 Methodology (Tier 2 Method)** it is recommended that the default rate **C<sub>2</sub>F<sub>6</sub>/CF<sub>4</sub> = 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<sub>2</sub> emissions** are also calculated based on Aluminium Production data and the **default EF (1.6 tonnes CO<sub>2</sub>/tonne Al)** in line with **IPCC 2006 Methodology (Tier 1 Method)**. The calculation of CO<sub>2</sub> 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<sub>4</sub> emissions and IPCC 2006 Methodology (Tier 2 Method) for C<sub>2</sub>F<sub>6</sub> emissions**; **Emissions of CF<sub>4</sub>** were estimated by multiplying annual primary Aluminium Production with the default emission factors (**1.6 kg CF<sub>4</sub>/tonne Al – SWPB technology and 0.4 kg CF<sub>4</sub>/tonne Al – CWPB technology**) provided by **IPCC 2006 Methodology (Tier 1 Method)** and considering the **percentage of each technology** for every period years (SWPB and CWPB). Compliance with **IPCC 2006 Methodology (Tier 2)** it is recommended that the default rate **C<sub>2</sub>F<sub>6</sub>/CF<sub>4</sub> = 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<sub>2</sub> 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<sub>2</sub> emissions** are: total metal production (aluminium), net prebaked anode consumption, CO<sub>2</sub> 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<sub>4</sub> 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<sub>4</sub> 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.

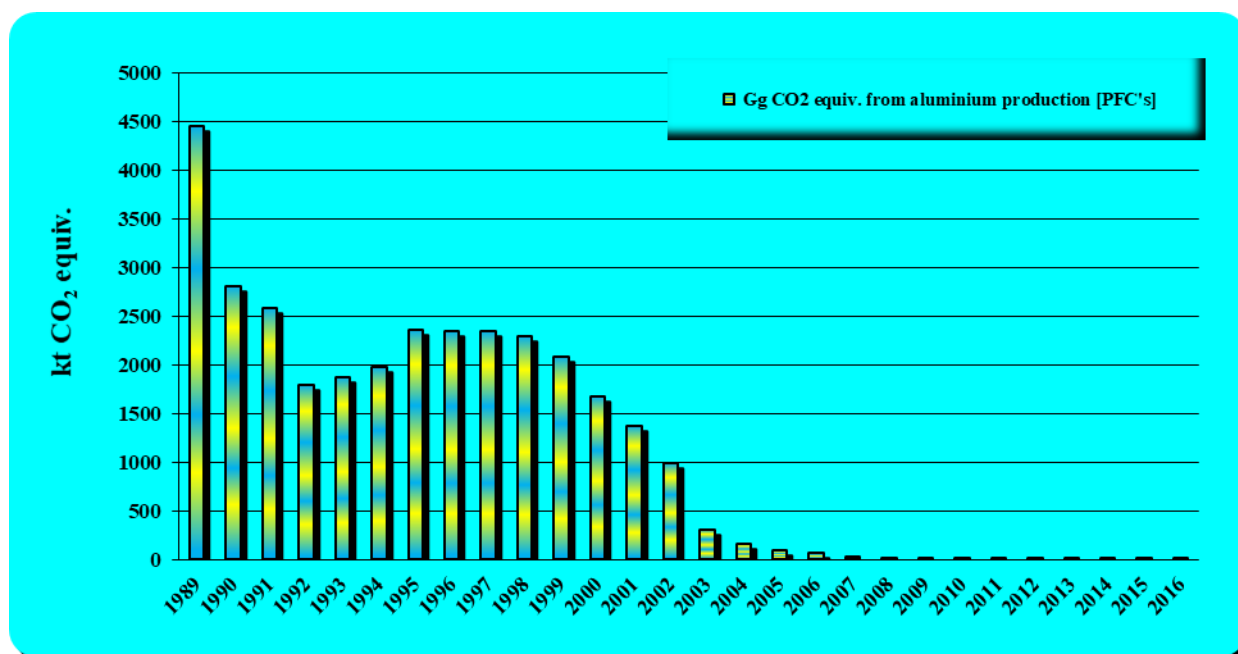
Measurement data are not available to determine smelter-specific Overvoltage coefficients, therefore default coefficients were used (an average parameters from measurements at numerous facilities), compliance with **IPCC 2006 Methodology (Tier 2 Method – Table 4.16 at page 4.54)**: Overvoltage Coefficient = **1.16 [(kg CF<sub>4</sub>/tAl) / (mV)]**.

Anode effect overvoltage parameter greatly decreased due to changing production technology leading to lower emission factor for CF<sub>4</sub>.

In order to **calculate C<sub>2</sub>F<sub>6</sub> 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<sub>2</sub>F<sub>6</sub>/CF<sub>4</sub>, kg C<sub>2</sub>F<sub>6</sub>/kg CF<sub>4</sub> was in line with **2006 IPCC Methodology (Tier 2 Method – Table 4.16)**: weight fraction is **C<sub>2</sub>F<sub>6</sub>/CF<sub>4</sub> = 0.121**.

**Figure 4.16** *The trend of PFC emissions from Primary Aluminium Production Sub-sector in the 1989–2016 period*



#### 4.4.2.4 Magnesium Production (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<sub>6</sub> is used. It is known that this gas is inert and therefore easily emitted into the atmosphere. Meanwhile, independent studies have shown that SF<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>2</sub> in a proportion of up to 3% SO<sub>2</sub>.

### ***Activity data***

Magnesium are not produced in Romania and therefore there are no CO<sub>2</sub> emissions from manufacturing.

From the secondary magnesium production there are no CO<sub>2</sub> emissions, only SO<sub>2</sub> emissions.

### ***Emission factors***

The default IPCC emission factors for CO<sub>2</sub> 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<sub>2</sub> from Lead Production is in line with the 2006 IPCC GL (Tier 1), considering the “Decision tree for estimation of CO<sub>2</sub> 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<sub>2</sub> emissions from lead production are estimated for the entire period 1989–2016.

***Emission factors***

For confidentiality reasons the presentation of CO<sub>2</sub> 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<sub>2</sub> from Zinc Production is in line with the 2006 IPCC GL (Tier 1 method), considering the “Decision tree for estimation of CO<sub>2</sub> 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<sub>2</sub> emissions from zinc production are estimated for the entire period 1989–2016.

***Emission factors***

For confidentiality reasons the presentation of CO<sub>2</sub> 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 1989–2016.

##### 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 1989–2016.

#### 4.4.3.3 Aluminium Production (CRF 2.C.3)

##### 4.4.3.3.1 CO<sub>2</sub> 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 1989–2016.

##### 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 1989–2016.

#### 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 1989–2016.

#### 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 1989–2016.

#### 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 1989–2016.

#### *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.

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

AD on primary Aluminium Production obtained from economic agent has been checked against the data obtained from the National Statistics. The differences in AD generated by these two different data sources are negligible (there are some small differences in the first part of the time series, when statistical data are a little bit higher, but the data from plant are consider to be more reliable).

Both the operator, the data/information provider, and the National Environmental Protection Agency (NEPA), the inventory compiler, performs Quality Control checks as outlined within the IPCC 2006 Methodology in relation to every inventory submission. Considering that the latest available plant-specific data/information, provided by the operator, data used in emission

estimation, and the quality control activities described above, the data series are considered to be consistent, according with the provisions in the IPCC 2006 Methodology. The CO<sub>2</sub> emissions from Iron and Steel Production were compared with the emissions reported in monitoring plans of GHG emissions for the EU-ETS installations. Further elements are presented within Annex 6.5.

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

No recalculations were made relative to previous submission.

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

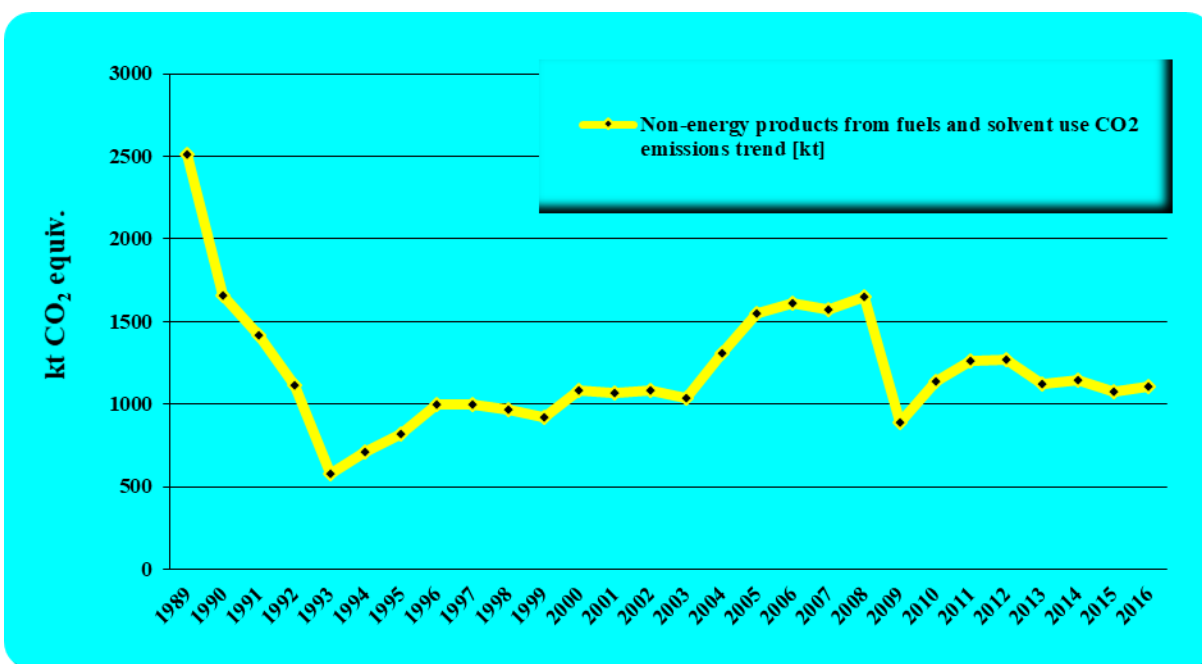
More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

### **4.5 Non-energy products from fuels and solvent use (CRF 2.D)**

#### *4.5.1 Category description*

The Non-energy products from fuels and solvent use is a key category from level point of view (Tier 1, excluding and including LULUCF). 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 8.55% of the total Industrial Processes and Product Use Sector GHG emissions in 2016.

**Figure 4.17 CO<sub>2</sub> emissions trend in the Non-energy products from fuels and solvent use Sub-sector for 1989–2016 period**



**Table 4.34 CO<sub>2</sub> emissions from Non-energy products from fuels and solvent use Sub-sector, in the 2016 year**

Sector	CO <sub>2</sub> emissions [kt]
<b>2.D Non-energy products from fuels and solvent use</b>	<b>1,106.53</b>
2.D.1 Lubricant use	252.68
2.D.2 Paraffin wax use	4.16
2.D.3.a Other - Solvent use	161.18
2.D.3.d Other - Petroleum coke use	688.51

#### *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<sub>2</sub> from Lubricant use is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the “Decision tree for CO<sub>2</sub> 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\_2016\_0000, Lubricants - Gross inland deliveries for non energy use (Annex 4.2).

#### ***Emission factors***

CO<sub>2</sub> 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<sub>2</sub>/C) yields the emission factor (expressed as tonne CO<sub>2</sub>/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<sub>2</sub> 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<sub>2</sub> 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\_2016\_0000, Paraffin waxes - Gross inland deliveries for non energy use (Annex 4.2).

##### ***Emission factors***

CO<sub>2</sub> 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<sub>2</sub>, which is included in the total greenhouse gas emissions reported to the UNFCCC Secretariat. These source categories are:

- Paint Application - source category includes emissions resulted from: domestic use, automobile manufacture and repairing, construction and buildings;
- Degreasing and Dry Cleaning - source category refers to emissions resulted from metal degreasing, dry cleaning, electronic components manufacturing, other industrial cleaning;
- Chemical Products, Manufacture and Processing - source category includes emissions from chemicals manufacturing or processing: polyester processing, polyvinyl chloride processing, polyurethane foam processing, rubber processing, pharmaceutical products manufacturing, paints manufacturing, glues manufacturing;
- Other product use - source category refers to emissions resulted from other use of solvents, such as: mineral wool induction, preservation of wood, domestic solvent use (other than paint application), under seal treatment and conservation of vehicles.

### ***Methodology***

IPCC guidelines do not provide methodology to determine NMVOC emissions, which is the main source of emissions in this sector. Due to this reason, the NMVOC emissions resulted from Solvents and Other Product Use are estimated based on EMEP/EEA air pollutant emission inventory guidebook 2016, using the correspondence between IPCC categories and SNAP codes (Table 4.37).

***Table 4.35 Correspondence between IPCC categories and SNAP codes***

<b>IPCC categories</b>	<b>SNAP codes</b>
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 2018 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*

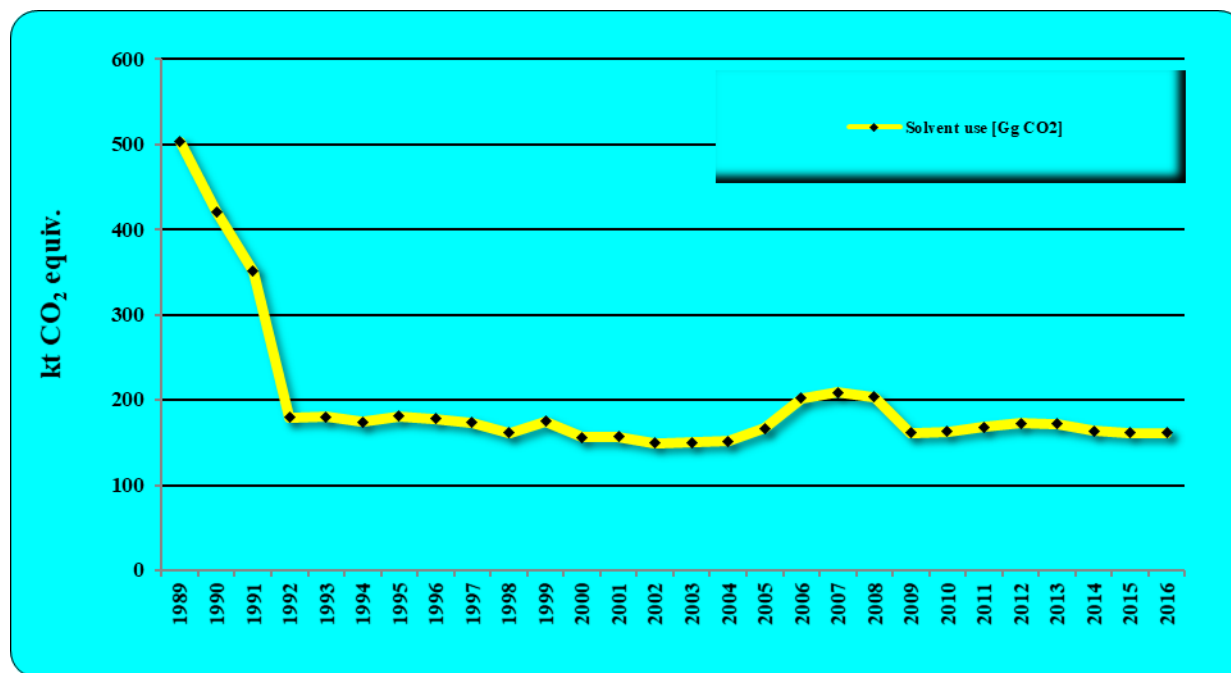
The CO<sub>2</sub> emissions from Solvent Use were calculated from NMVOC emissions of this sector and is calculated using the carbon content conversion factor (0.60) multiplying with (44/12) and multiplying with emissions of the NMVOC.

**Table 4.36 CO<sub>2</sub> emissions resulted from Solvent Use in the 1989–2016 period**

<b>Solvents Use</b>					
<b>Year</b>	<b>Paint application</b>	<b>Degreasing and Dry Cleaning</b>	<b>Chemical Products, Manufacture and Processing</b>	<b>Other</b>	<b>Total</b>
	<b>CO<sub>2</sub> emissions [kt]</b>				
<b>1989</b>	99.66	71.06	47.52	285.12	<b>503.36</b>
<b>1990</b>	78.76	62.26	39.60	240.46	<b>421.08</b>
<b>1995</b>	31.02	21.82	19.14	109.12	<b>181.10</b>
<b>2000</b>	1.97	15.05	4.84	133.97	<b>155.84</b>
<b>2005</b>	16.08	14.11	11.09	125.04	<b>166.32</b>
<b>2007</b>	24.97	13.71	48.80	121.74	<b>209.21</b>
<b>2008</b>	17.76	19.20	45.97	120.73	<b>203.66</b>
<b>2009</b>	7.80	17.15	16.04	120.73	<b>161.72</b>
<b>2010</b>	8.75	16.87	17.17	120.36	<b>163.14</b>
<b>2011</b>	10.43	18.05	17.97	121.39	<b>167.84</b>
<b>2012</b>	10.43	17.30	24.77	120.50	<b>172.99</b>
<b>2013</b>	7.90	17.36	28.09	118.53	<b>171.88</b>
<b>2014</b>	4.06	17.07	24.55	118.28	<b>163.96</b>

Solvents Use					
Year	Paint application	Degreasing and Dry Cleaning	Chemical Products, Manufacture and Processing	Other	Total
	CO <sub>2</sub> emissions [kt]				
2015	5.15	16.29	22.36	117.52	161.32
2016	3.54	16.84	22.73	118.06	161.18

*Figure 4.18 The trend of CO<sub>2</sub> emissions resulted from Solvent Use Sector, in the 2016 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 2016.



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

##### ***Methodology***

The method for calculating emissions of CO<sub>2</sub> from Petroleum coke use is in line with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 method), considering the Equation 5.1, page 5.5 from 2006 IPCC Guidelines.

##### ***Activity data***

The data on Petroleum coke use are provided by National statistics and are extracted from ENERGY\_PETRO\_A\_RO\_2016\_0000, Petroleum coke - Gross inland deliveries for non energy use (Annex 4.2).

##### ***Emission factors***

CO<sub>2</sub> emissions are calculated according to Equation 5.1 at page 5.5 from 2006 IPCC GL (Tier 1 method) with aggregated country-specific data for the limited parameters available. The emission factor (country-specific CO<sub>2</sub> emission factors for stationary combustion, oxidation included, from ETS verified reports) is composed of a specific carbon content factor (tonne C/TJ) multiplied by the ODU factor. For petroleum coke the carbon was presumed that is fully emitted and not stored, having the full oxidation during use; ODU factor is 1. A further multiplication by 44/12 (the mass ratio of CO<sub>2</sub>/C) yields the emission factor (expressed as tonne CO<sub>2</sub>/TJ).

#### *4.5.3 Uncertainties and time series consistency*

##### *4.5.3.1 Lubricant use (CRF 2.D.1)*

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

- AD: 15 %;
- EF: 50 %;

- 52.20 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency-University of Graz consortium; additional information are included in Annex 6.3.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2016.

#### *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 1989–2016.

#### *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 1989–2016.

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

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

- AD: 15 %;

- EF: 50 %;

- 52.20 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

The values were collected/elaborated/selected in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency-University of Graz consortium; additional information are included in Annex 6.3.

Time series is consistent: emissions have been calculated using the same emission factors, the same sources of activity data and the same methods for the entire time series 1989–2016.

#### *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.

*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:

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

**Table 4.37 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 2017	NGHGI 2018	Differences [%]
	CO <sub>2</sub> emissions [kt]		
1989	1,406.83	2,513.78	78.68
1990	1,296.24	1,655.42	27.71
1995	475.45	816.97	71.83
2000	567.05	1,079.39	90.35
2005	462.12	1,547.95	234.97
2007	445.85	1,574.61	253.17
2008	393.01	1,650.93	320.07
2009	269.93	891.72	230.36
2010	368.98	1,134.60	207.49
2011	431.39	1,259.81	192.04
2012	434.58	1,270.87	192.44
2013	424.32	1,125.44	165.23
2014	420.22	1,144.57	172.38
2015	436.70	1,077.99	146.85
2016		1,106.53	

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

Recalculation have been made for the 1989-2015 period due to an improvement in the activity data used in the CO<sub>2</sub> emissions estimates from 2D Non-energy products from fuels and solvent use subsector, taking into account emissions from petroleum coke.

**Table 4.38 The effects of recalculations in Solvent use Sub-sector**

The effects of recalculations in Solvent use sub-sector			
Years	NGHGI 2017	NGHGI 2018	Differences [%]
	CO2 emissions [kt]		
1989	503.36	503.36	0.00
1990	421.08	421.08	0.00
1995	181.10	181.10	0.00
2000	176.37	155.84	-11.64
2005	193.34	166.32	-13.98
2007	243.35	209.21	-14.03
2008	226.61	203.66	-10.13
2009	177.83	161.72	-9.06
2010	181.49	163.14	-10.11
2011	185.98	167.84	-9.75
2012	189.17	172.99	-8.55
2013	190.68	171.88	-9.86
2014	181.89	163.96	-9.86
2015	178.20	161.32	-9.47
2016		161.18	

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

Recalculation have been made for the 2000-2015 period. Recalculations were made as a result of due to an improvement in activity data for the consistency of the data used to estimate emissions

in preparation of the greenhouse gas inventories with the data used to prepare inventories of air pollutants under Directive 2001/81/EC and under the UNECE Convention on Long-range Transboundary Air Pollution.

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

Improve in the estimation of CO<sub>2</sub> emissions from urea use in SCR systems under 2.D.3.

## **4.6 Electronics Industry (CRF 2.E)**

### *4.6.1 Category description*

CRF Sector 2.E includes: Integrated circuit or semiconductor (CRF 2.E.1), TFT flat panel display (CRF 2.E.2), Photovoltaics (CRF 2.E.3), Heat transfer fluid (CRF 2.E.4), Other (CRF 2.E.5).

### *4.6.2 Methodological issues*

#### ***Methodology***

Many modern processes for the manufacture of electronic components use fluorinated chemicals needed for cleaning of reaction chambers, temperature control, plasma etching of complex patterns, etc. This industry emits fluorinated chemical compounds that are gases at room temperature and those which are in liquid form. Such substances include CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, C<sub>3</sub>F<sub>8</sub>, C<sub>4</sub>F<sub>6</sub>, C<sub>5</sub>F<sub>8</sub>, CHF<sub>3</sub>, CH<sub>2</sub>F<sub>2</sub>, SF<sub>6</sub> 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 și semiconductori) Baneasa, but the production ceased with the transition to market economy and it was subsequently closed down.

NF<sub>3</sub> 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<sub>3</sub> for other purposes.

The EU study ([http://ec.europa.eu/clima/policies/f-gas/docs/2011\\_study\\_en.pdf](http://ec.europa.eu/clima/policies/f-gas/docs/2011_study_en.pdf)) does not list Romania as a user of NF<sub>3</sub> - only Germany, Ireland, France, Italy, Austria (7%), Netherlands, Great Britain, Finland, and the Czech Republic are mentioned.

Most of the  $\text{NF}_3$  emissions may occur from 2.E.1, 2.E.2, 2.E.3 categories and there are no other activities where consumption of  $\text{NF}_3$  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 1989-2016 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.



*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*

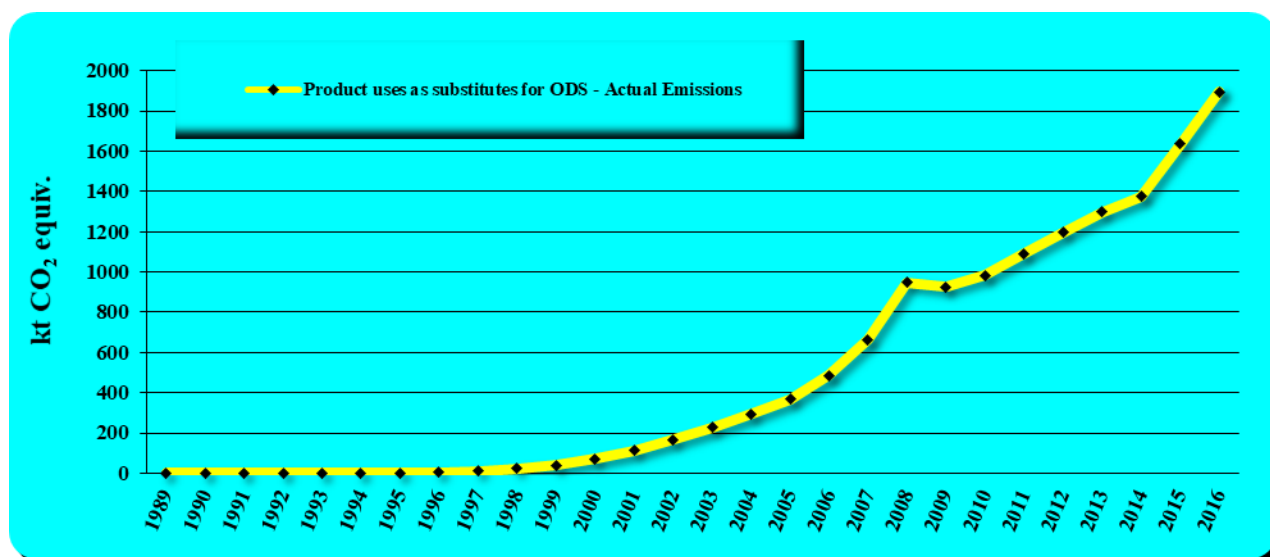
More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

**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 14.63% of the total Industrial Processes and Product Use Sector GHG emissions in 2016. In 2016 year, the actual emissions from CRF 2.F category equal to 1,894.115 kt CO<sub>2</sub>eq. are presented in the Table 4.39.

**Figure 4.19 GHG emissions trend in the Product uses as substitutes for ODS Sub-sector for 1995–2016 period**



**Table 4.39 The Actual emissions in the Product uses as substitutes for ODS Sub-sector for 1989 – 2016 period**

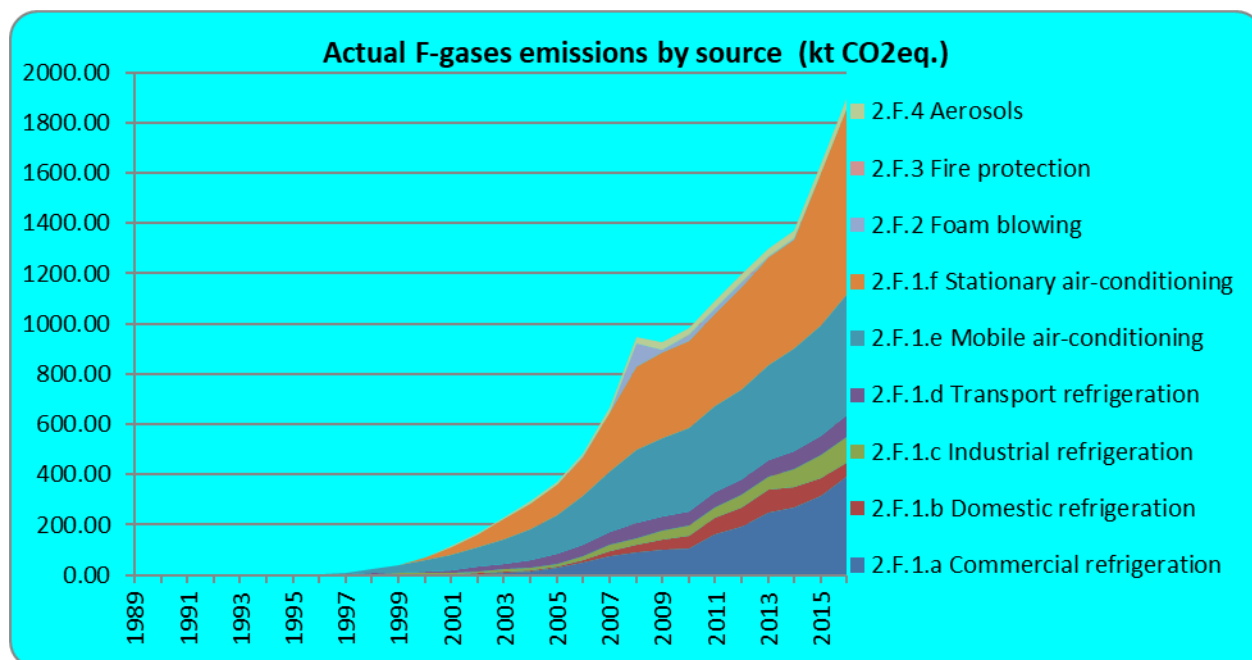
Year	Actual emissions [kt CO <sub>2</sub> eq.]
1989	0.16
1990	0.18
1995	2.53
2000	70.82
2005	368.91
2007	665.63
2008	946.95
2009	924.42
2010	982.46
2011	1,092.14
2012	1,197.29
2013	1,298.45

Year	Actual emissions [kt CO <sub>2</sub> eq.]
2014	1,373.10
2015	1,636.76
2016	1,894.11

There is a stable increasing trend for F-gases emissions, which is valid also for most of the subcategories (Figure 4.20). The major source of emissions is the refrigeration and air-conditioning sector, from which the most significant are mobile air-conditioning, stationary air-conditioning and commercial refrigeration subcategories.

The emission estimates include emissions from manufacturing, operation and decommissioning of equipment containing F-gases. The preferred approach for most of the subcategories is the 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.

*Figure 4.20 Actual F-gases emissions by source for 1989–2016 period*



#### *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)*

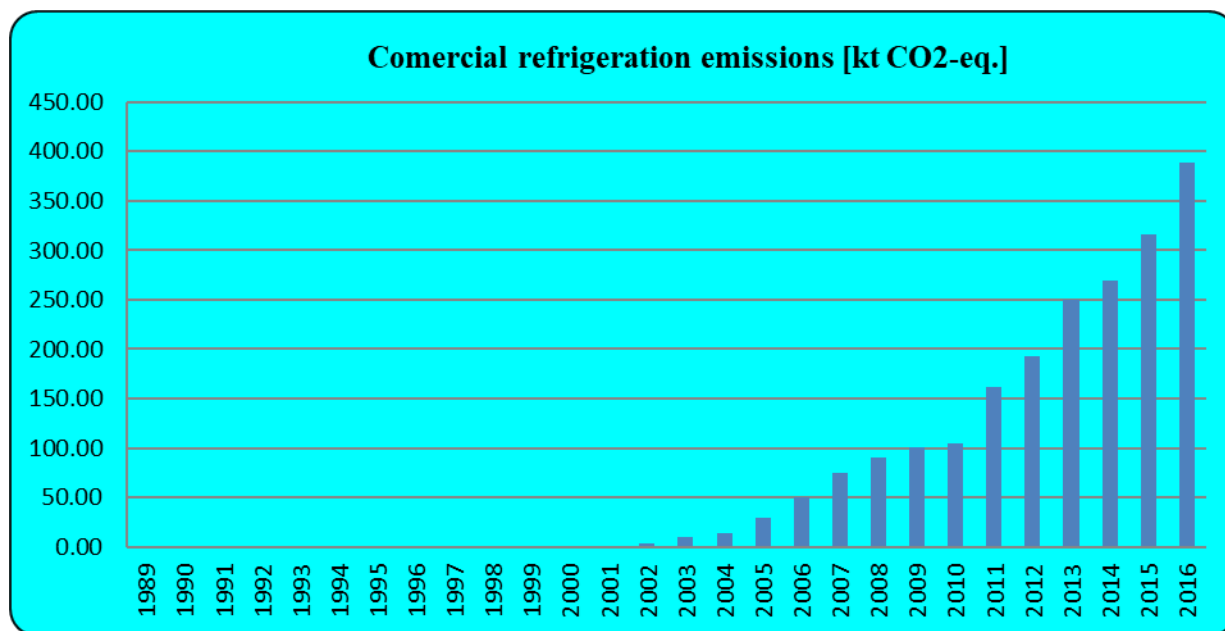
#### ***Methodology***

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 389.096 kt CO<sub>2</sub>eq. for 2016 year.

The actual emissions for the period are represented on the Figure 4.21.

**Figure 4.21 Actual emissions of the Comercial Refrigeration for 1989–2016 period**

The quantity of banked HFCs for this subcategory is estimated at 786 t in 2016 year and is presented in Table 4.40.

**Table 4.40 The quantity of banked HFC of the Comercial Refrigeration for 1989–2016 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 <sub>2</sub> eq.]
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1995	0	0	0	0	0	0
2000	0	0	0	0	0	0
2005	33	55	0	8	0	29
2007	64	143	0	22	0	76
2008	56	178	0	27	0	91

<b>Year</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [t HFC]</b>	<b>Operation emissions [t HFC]</b>	<b>Disposal emissions [t HFC]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>2009</b>	50	201	0	30	0	100
<b>2010</b>	41	211	0	32	0	104
<b>2011</b>	127	306	1	46	0	162
<b>2012</b>	111	370	1	56	0	193
<b>2013</b>	182	496	1	74	0	250
<b>2014</b>	122	542	0.5	81	0	268
<b>2015</b>	178	638	1	96	0	316
<b>2016</b>	245	786	1.5	118	0	389

### *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 2016 year the questionnaire has been sent to 134 companies, only 75 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.

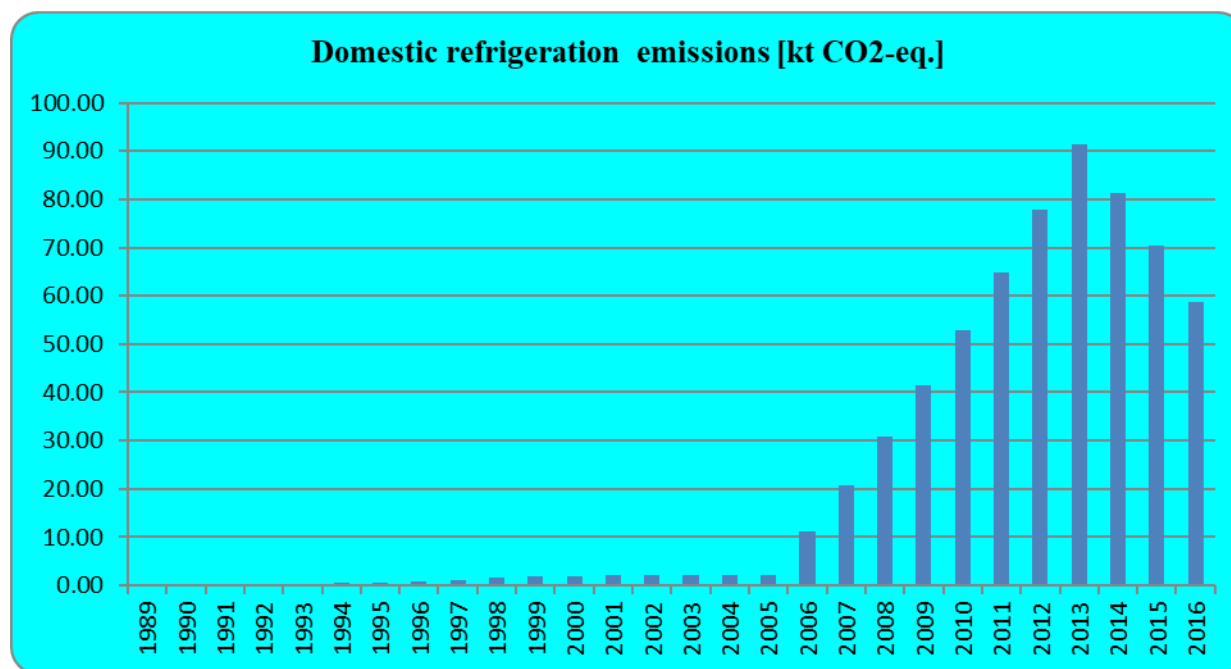
#### ***4.7.2.1.2 Domestic Refrigeration (CRF 2.F.1.b)***

### ***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 – 2016 are represented on the Figure 4.22.

**Figure 4.22 Actual emissions of the Domestic Refrigeration for 1989–2016 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 2016 year from production, operation and decommissioning are equal to 58.64 kt CO<sub>2</sub>eq., of which operation emissions are equal to 0.41 Gg. The detailed results are presented in the Table 4.41.



**Table 4.41 The result detailed of the Domestic Refrigeration for 1989–2016 period**

<b>Year</b>	<b>Produced units</b>	<b>Units placed on the market</b>	<b>HFCs used for production [t]</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [kg HFC-134a]</b>	<b>Operation emissions [kg HFC-134a]</b>	<b>Disposal emissions [kg HFC-134a]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>1989</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
<b>1990</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
<b>1995</b>	145,893.00	310,973.00	18.00	37.00	107.00	105.00	321.00	0.00	0.61
<b>2000</b>	305,233.00	425,453.00	37.00	51.00	382.00	220.00	1,146.00	0.00	1.95
<b>2005</b>	43,075.00	40,087.00	5.00	5.00	489.00	31.00	1,468.00	0.00	2.14
<b>2007</b>	67,442.00	59,430.00	8.00	7.00	479.00	49.00	1,438.00	12,940.00	20.63
<b>2008</b>	61,455.00	48,547.00	7.00	6.00	464.00	44.00	1,391.00	20,065.00	30.75
<b>2009</b>	58,843.00	34,436.00	7.00	4.00	439.00	42.00	1,317.00	27,641.00	41.47
<b>2010</b>	68,549.00	50,242.00	8.00	6.00	408.00	49.00	1,224.00	35,672.00	52.83
<b>2011</b>	0.00	0.00	0.00	0.00	362.49	0.00	1,087.46	44,225.12	64.80
<b>2012</b>	0.00	0.00	0.00	0.00	307.97	0.00	923.90	53,432.02	77.73
<b>2013</b>	0.00	0.00	0.00	0.00	243.83	0.00	731.49	63,211.10	91.44
<b>2014</b>	0.00	0.00	0.00	0.00	186.80	0.00	560.40	56,298.33	81.31
<b>2015</b>	0.00	0.00	0.00	0.00	137.44	0.00	412.31	48,804.54	70.38
<b>2016</b>	0.00	0.00	0.00	0.00	96.31	0.00	288.93	40,714.59	58.64

**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 4.42.

**Table 4.42 Assumptions on data for imports in Bulgaria for Domestic Refrigeration**

<b>CN code</b>	<b>Equipment type</b>	<b>kg/unit</b>
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 2003-2016, and for the imports and exports it was for the period 2000-2016. 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 1,226,000 units were placed on the market in 2016. 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 2011-2016 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***

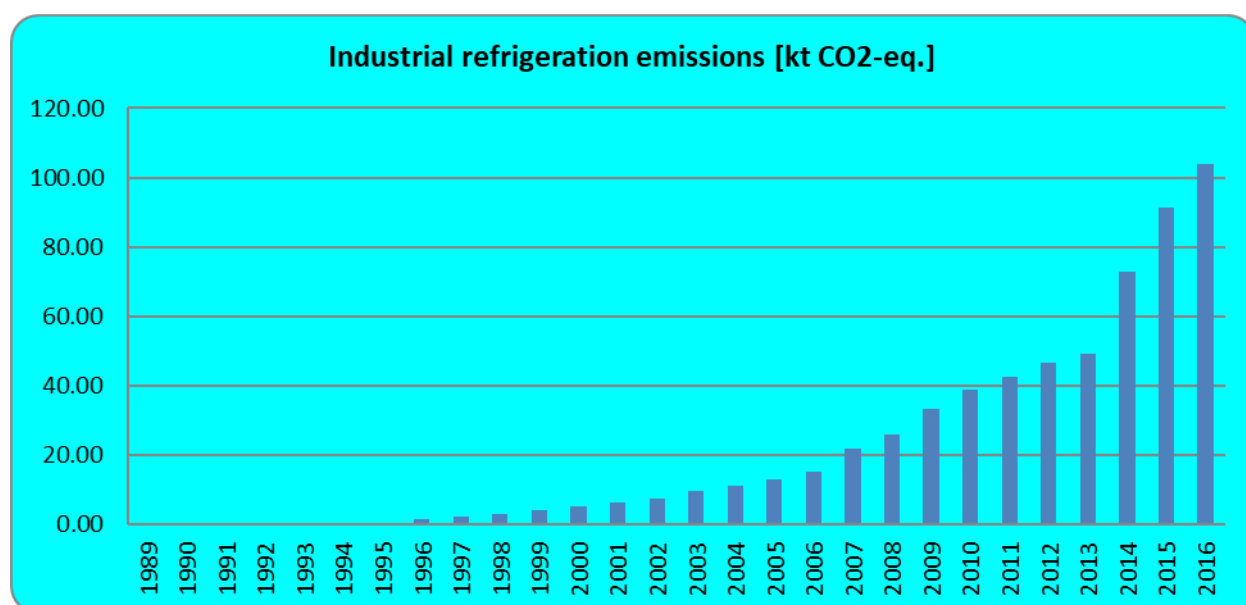
The manufacturing emissions are calculated as a percentage of the initial charge that is released during assembly. The emission factor used for estimating the manufacturing emissions is the default Emission Factor (EF) of 0.6% from the 2000 IPCC GPG. The operation emissions are calculated based on The 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 103.75 kt CO<sub>2</sub>eq. for 2016 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 1989–2016 are represented in the Figure 4.23.

**Figure 4.23 Actual emissions of the Industrial Refrigeration for 1989–2016 period**



The quantity of banked HFCs for this subcategory is estimated at 326 t in 2016 year and is presented in Table 4.43.

**Table 4.43 The quantity of banked HFC of the Industrial Refrigeration for 1989–2016 period**

<b>Year</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [t HFC]</b>	<b>Operation emissions [t HFC]</b>	<b>Disposal emissions [t HFC]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>1989</b>	0	0	0	0	0	0.00
<b>1990</b>	0	0	0	0	0	0.00
<b>1995</b>	1	1	0	0	0	0.52
<b>2000</b>	4	13	0	1	0	5.21
<b>2005</b>	8	37	0.1	4	0	13.12
<b>2007</b>	21	60	0.2	6	0	21.77
<b>2008</b>	19	72	0.1	7	0	25.80
<b>2009</b>	32	97	0.2	10	0	33.32
<b>2010</b>	28	115	0.2	12	0.18	38.78
<b>2011</b>	27	130.5	0.2	13	0.32	42.61
<b>2012</b>	27.5	144.4	0.14	14	0.33	46.66
<b>2013</b>	22.6	152.1	0.07	15.2	0.35	49.38
<b>2014</b>	76.7	213.2	0.61	21.3	0.37	72.74
<b>2015</b>	95.1	286.0	0.73	28.6	0.40	91.42
<b>2016</b>	69.5	325.7	0.40	32.6	0.45	103.75

**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

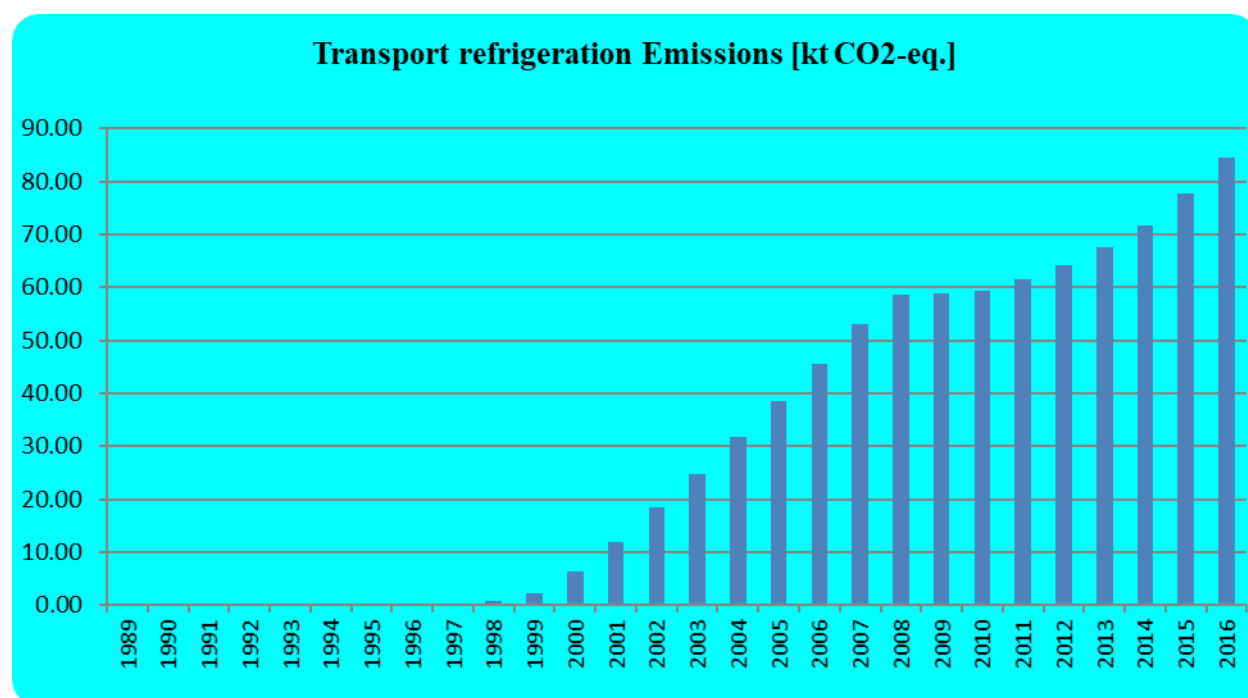
vehicle category). The IPCC guidelines do not provide special guidance regarding different subcategories of transport refrigeration and there is no difference in the proposed ranges by the 2000 IPCC GPG and 2006 IPCC Guidelines.

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 84.43 kt CO<sub>2</sub>eq. for 2016 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 1989–2016 are represented on the Figure 4.24.

**Figure 4.24 Actual emissions of the Transport Refrigeration for 1989–2016 period**



The quantity of banked HFCs for this subcategory is estimated at 113.74 t in 2016 year and is presented in Table 4.44.

**Table 4.44 The quantity of banked HFC of the Transport Refrigeration for 1989–2016 period**

<b>Year</b>	<b>Number of trucks with HFC units</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Operation emissions [kg HFC]</b>	<b>Disposal emissions [kg HFC]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>1989</b>	0	0	0	0	0	0
<b>1990</b>	0	0	0	0	0	0
<b>1995</b>	20	0	0	9	0	0.01
<b>2000</b>	3,174	3	10	2,237	0	6.28
<b>2005</b>	13,591	3	54	11,815	0	38.61
<b>2007</b>	17,903	6	73	15,969	0	52.99
<b>2008</b>	19,890	6	81	17,670	0	58.49
<b>2009</b>	20,291	1	82	17,857	0	58.79
<b>2010</b>	20,522	1	83	18,040	2	59.35
<b>2011</b>	21,559	3	86	18,774	4	61.42
<b>2012</b>	23,001	4	90	19,775	34	64.24
<b>2013</b>	24,400	4	94	20,759	116	67.49
<b>2014</b>	25,988	5.29	99.41	21,968	331	71.60
<b>2015</b>	27,687	5.78	105.19	23,282	913	77.72
<b>2016</b>	29,953	8.55	113.74	25,177	1,097	84.43

**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 through 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 2016 as about 16,200 refrigerated vans and 13,800 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 4.45).

***Table 4.45 The total number of Refrigeration trucks with HFC-containing units for 1993–2016 period***

<b>Year</b>	<b>% N1 and N2 trucks with HFC units</b>	<b>% N3 trucks with HFC units</b>
<b>1993</b>	0%	0%
<b>1994</b>	0%	0%
<b>1995</b>	<b>13%</b>	<b>0%</b>
<b>1996</b>	26%	0%
<b>1997</b>	<b>38%</b>	<b>0%</b>
<b>1998</b>	51%	5%
<b>1999</b>	<b>63%</b>	<b>9%</b>

Year	% N1 and N2 trucks with HFC units	% N3 trucks with HFC units
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%
2016	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.

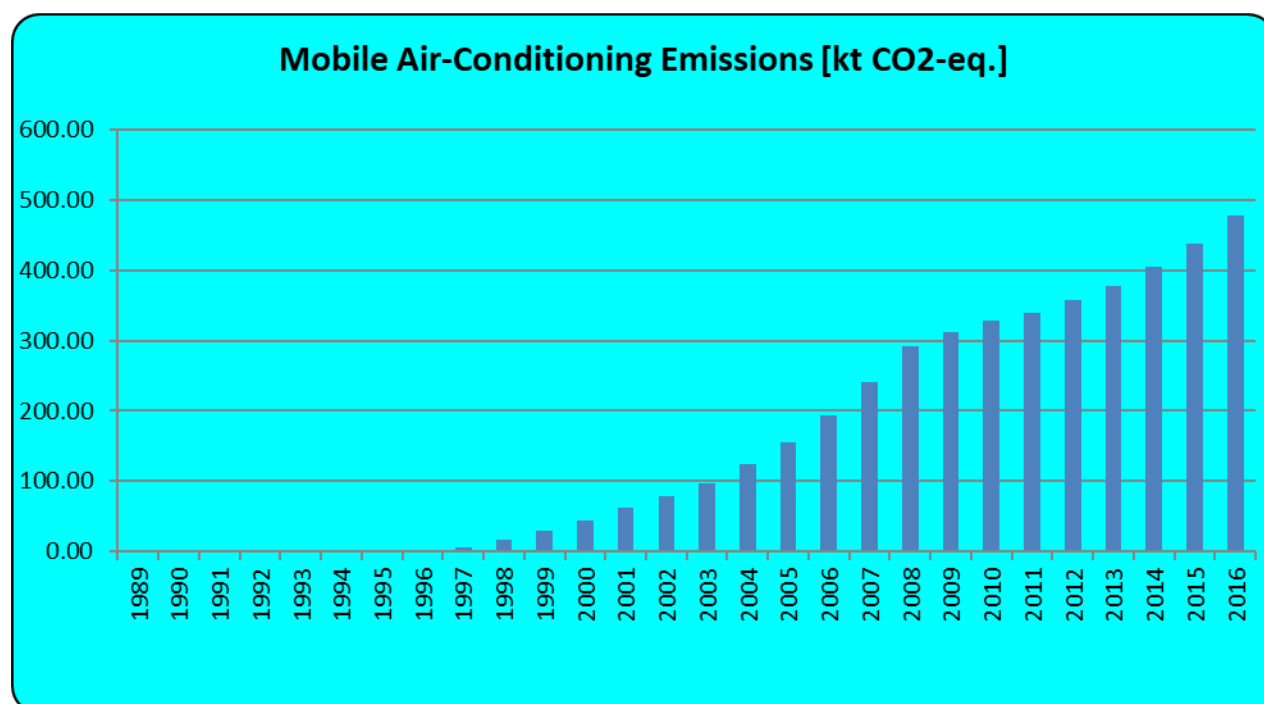
There are three major automobile producers in the country, so the emission estimates also consider initial emissions from mobile air conditioning production. The aggregated emission estimates for all three subcategories result in total actual emissions of 479.05 kt CO<sub>2</sub>eq. for 2016, the majority 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 1989–2016 are represented on the Figure 4.25.

The initial emissions are estimated to be around 1.2 t of HFC-134a, while the operation emissions are around 333 t and the disposal emissions are around 0.961 t.

There is a large quantity of banked HFCs, estimated at 3,132.71 t in 2016 year and is presented in Table 4.46.

**Figure 4.25 Actual emissions of the Mobile Air-Conditioning for 1989–2016 period**



*Table 4.46 The quantity of banked HFC of the Mobile Air-Conditioning for 1989–2016 period*

<b>Year</b>	<b>Produced vehicles with MAC units</b>	<b>Total number of vehicles with MAC units</b>	<b>HFCs used for production [t]</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [kg HFC-134a]</b>	<b>Operation emissions [kg HFC-134a]</b>	<b>Disposal emissions [kg HFC-134a]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>1989</b>	0	0	0	0	0	0	0	0	0
<b>1990</b>	0	0	0	0	0	0	0	0	0
<b>1995</b>	8,577	3,190	8	1	4	39	422	0	1
<b>2000</b>	55,817	270,570	43	85	269	213	30,695	0	44
<b>2005</b>	170,519	1,116,718	114	74	972	570	108,411	0	156
<b>2007</b>	224,742	1,926,815	146	142	1,545	730	167,797	0	241
<b>2008</b>	225,569	2,423,527	146	212	1,888	728	203,594	0	292
<b>2009</b>	274,307	2,658,001	175	88	2,018	874	216,804	0	311
<b>2010</b>	323,105	2,870,474	204	34	2,129	1,021	228,299	0	328
<b>2011</b>	309,193	3,014,349	195	19	2,205	977	236,227	0	339
<b>2012</b>	318,853	3,228,814	201	88	2,329	1,003	249,056	0	358
<b>2013</b>	394,971	3,464,389	247	109	2,463	1,236	263,034	0	378
<b>2014</b>	376,079	3,781,923	235.64	118.83	2,648	1,178	282,363	200.55	405.75
<b>2015</b>	371,806	4,140,719	233.39	142.10	2,858	1,167	304,281	511.12	437.52
<b>2016</b>	345,024	4,553,674	217.15	186.69	3,133	1,086	332,953	961.93	479.05

*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 4.47).

**Table 4.47 The number of new cars, all cars, trucks and busses with HFC-containing units of MAC for 1993–2016 period**

<b>Year</b>	<b>% new cars with AC units produced in that year</b>	<b>% all cars with AC units from the total vehicle fleet</b>	<b>% all N1 trucks with AC units from the total vehicle fleet</b>	<b>% new N1 trucks with AC units produced in that year</b>	<b>% all N2 trucks with AC units from the total vehicle fleet</b>	<b>% new N2 trucks with AC units produced in that year</b>	<b>% all N3 trucks with AC units from the total vehicle fleet</b>	<b>% new N3 trucks with AC units produced in that year</b>	<b>% new busses with AC units produced in that year</b>	<b>% all busses with AC units from the total vehicle fleet</b>
<b>1993</b>	<b>9%</b>	0%	<b>0%</b>	<b>1%</b>	<b>0%</b>	<b>2%</b>	<b>1%</b>	<b>5%</b>	<b>34%</b>	<b>3%</b>
<b>1994</b>	<b>18%</b>	1%	<b>0%</b>	<b>3%</b>	<b>1%</b>	<b>4%</b>	<b>3%</b>	<b>20%</b>	<b>40%</b>	<b>7%</b>
<b>1995</b>	<b>25%</b>	3%	<b>1%</b>	<b>4%</b>	<b>1%</b>	<b>8%</b>	<b>6%</b>	<b>36%</b>	<b>44%</b>	<b>12%</b>
<b>1996</b>	36%	5%	2%	6%	2%	10%	12%	44%	46%	17%
<b>1997</b>	47%	11%	3%	8%	4%	13%	18%	51%	48%	22%
<b>1998</b>	58%	15%	4%	9%	5%	15%	24%	59%	50%	27%
<b>1999</b>	69%	16%	5%	11%	7%	18%	30%	66%	52%	32%
<b>2000</b>	<b>80%</b>	16%	<b>6%</b>	<b>13%</b>	<b>8%</b>	<b>20%</b>	<b>36%</b>	<b>74%</b>	<b>54%</b>	<b>37%</b>
<b>2001</b>	83%	17%	8%	17%	11%	23%	43%	77%	55%	40%
<b>2002</b>	86%	19%	10%	20%	13%	26%	51%	80%	55%	43%
<b>2003</b>	88%	22%	13%	24%	16%	30%	58%	82%	56%	47%
<b>2004</b>	91%	27%	15%	27%	18%	33%	66%	85%	56%	50%

<b>Year</b>	<b>% new cars with AC units produced in that year</b>	<b>% all cars with AC units from the total vehicle fleet</b>	<b>% all N1 trucks with AC units from the total vehicle fleet</b>	<b>% new N1 trucks with AC units produced in that year</b>	<b>% all N2 trucks with AC units from the total vehicle fleet</b>	<b>% new N2 trucks with AC units produced in that year</b>	<b>% all N3 trucks with AC units from the total vehicle fleet</b>	<b>% new N3 trucks with AC units produced in that year</b>	<b>% new busses with AC units produced in that year</b>	<b>% all busses with AC units from the total vehicle fleet</b>
<b>2005</b>	<b>94%</b>	34%	<b>17%</b>	<b>31%</b>	<b>21%</b>	<b>36%</b>	<b>73%</b>	<b>88%</b>	<b>57%</b>	<b>53%</b>
<b>2006</b>	94%	40%	20%	34%	24%	37%	76%	88%	57%	54%
<b>2007</b>	95%	49%	24%	37%	27%	39%	79%	89%	57%	55%
<b>2008</b>	95%	54%	27%	39%	29%	40%	81%	89%	57%	55%
<b>2009</b>	96%	57%	31%	42%	32%	42%	84%	90%	57%	56%
<b>2010</b>	<b>96%</b>	<b>60%</b>	<b>34%</b>	<b>45%</b>	<b>35%</b>	<b>43%</b>	<b>87%</b>	<b>90%</b>	<b>57%</b>	<b>57%</b>
<b>2011</b>	96%	63%	36%	45%	36%	43%	88%	90%	57%	57%
<b>2012</b>	96%	65%	38%	45%	38%	43%	88%	90%	57%	57%
<b>2013</b>	96%	66%	40%	45%	39%	43%	89%	90%	57%	57%
<b>2014</b>	96%	69%	42%	45%	41%	43%	89%	90%	57%	57%
<b>2015</b>	96%	72%	44%	45%	42%	43%	90%	90%	57%	57%
<b>2016</b>	96%	75%	44.2%	45%	42.2%	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  $y$***

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

In order to confirm some of the assumptions were analysed the 10 largest Romanian websites for trade of new and used cars by performing different searches on the available ads. The total number of vehicles on sale was more than 180,000, but the level of ad details and the available search options were very limited in order to produce any significant results. Some of the websites showed that around 80% of the vehicles have air-conditioning units, while for some of the others the percentage was as low as 30%.

To assess the banked quantities of HFCs in MAC units, we need to consider the average quantity of refrigerant per MAC unit and vehicle type. The 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 4.48).

*Table 4.48 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	<b>0.67</b>	<b>0.63</b>	<b>0.80</b>	<b>0.80</b>	<b>1.00</b>	<b>1.00</b>	<b>1.20</b>	<b>1.20</b>	<b>10.40</b>	<b>10.90</b>
2011	0.66	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.82
2012	0.65	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.74
2013	0.64	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.66
2014	0.63	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.58
2015	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.50
2016	0.625	0.63	0.80	0.80	1.00	1.00	1.20	1.20	10.40	10.48

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)*

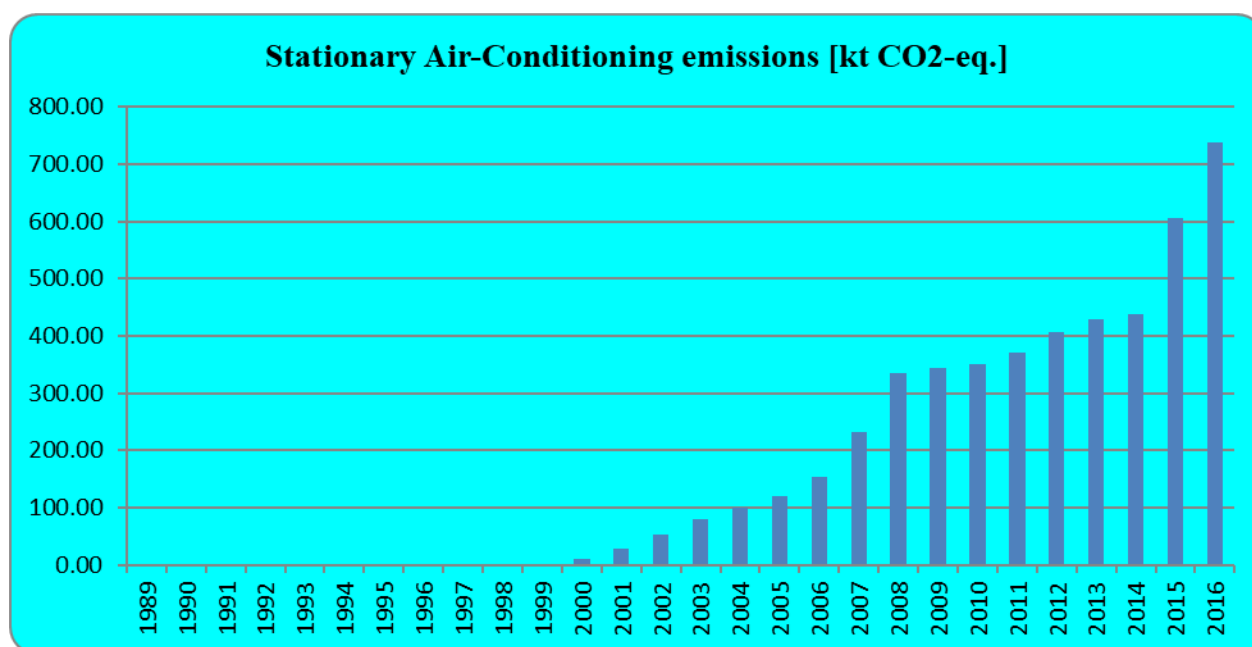
### ***Methodology***

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 1989–2016 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 2016 year banked quantities are equal to more than 4,300 tons, with additional 400 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 652.22 kt CO<sub>2</sub> eq. from AC equipment and 85.75 kt CO<sub>2</sub> eq. 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 4.49 The quantity of banked HFC of the Domestic Air-Conditioning for 1989–2016 period**

<b>Year</b>	<b>Produced units</b>	<b>Units placed on the market</b>	<b>HFCs used for production [t]</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [kg HFCs]</b>	<b>Operation emissions [kg HFCs]</b>	<b>Disposal emissions [kg HFCs]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>1989</b>	0	0	0	0	0	0	0	0	0
<b>1990</b>	0	0	0	0	0	0	0	0	0
<b>1995</b>	0	0	0	0	0	0	0	0	0
<b>2000</b>	28	63,241	0	109	109	0	4,952	0	10
<b>2005</b>	0	151,391	0	244	1,292	0	61,097	0	120
<b>2007</b>	5,298	532,436	8	820	2,459	48	117,827	0	232
<b>2008</b>	5,835	728,756	9	1,108	3,514	53	170,161	0	334
<b>2009</b>	2,991	129,844	4	202	3,607	27	174,605	0	343
<b>2010</b>	0	122,350	0	191	3,676	0	177,891	0	349
<b>2011</b>	0	199,237	0	309	3,890	0	188,307	0	370
<b>2012</b>	0	250,740	0	383	4,267	0	207,011	0	407
<b>2013</b>	0	118,350	0	184	4,493	0	218,191	0	429
<b>2014</b>	0	169,098	0	261	4,580	0	222,490	0	437
<b>2015</b>	0	154,031	0	241	4,555	0	221,449	86,633	605.82
<b>2016</b>	2,243	280,883	3	431	4,685	20	228,240	147,178	737.97

**Activity data**

As with the domestic refrigeration, the activity data for this category was also not given in number of units, but instead in tons. In order to estimate the number of units per category was used data for imports in Bulgaria in units and kilograms, according to the assumptions presented in Table 4.50.

**Table 4.50 Assumptions on data for imports in Bulgaria for Domestic Air-Conditioning**

<b>CN code</b>	<b>Equipment type</b>	<b>kg/unit</b>
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 272,000 AC units and 8,800 heat pumps were placed on the market in 2016 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 2016 year around 408 t of refrigerant have been introduced to the market as contained in AC equipment and 23 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***

$$Banks_n = Banks_{n-1} + HFC \text{ in new units}_n + HFC \text{ for servicing}_n - \\ - Emissions \text{ from operation}_{n-1} - Disposal_n$$

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 4.51.

**Table 4.51 Assumptions on data for imports in Bulgaria for Domestic Air-Conditioning**

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

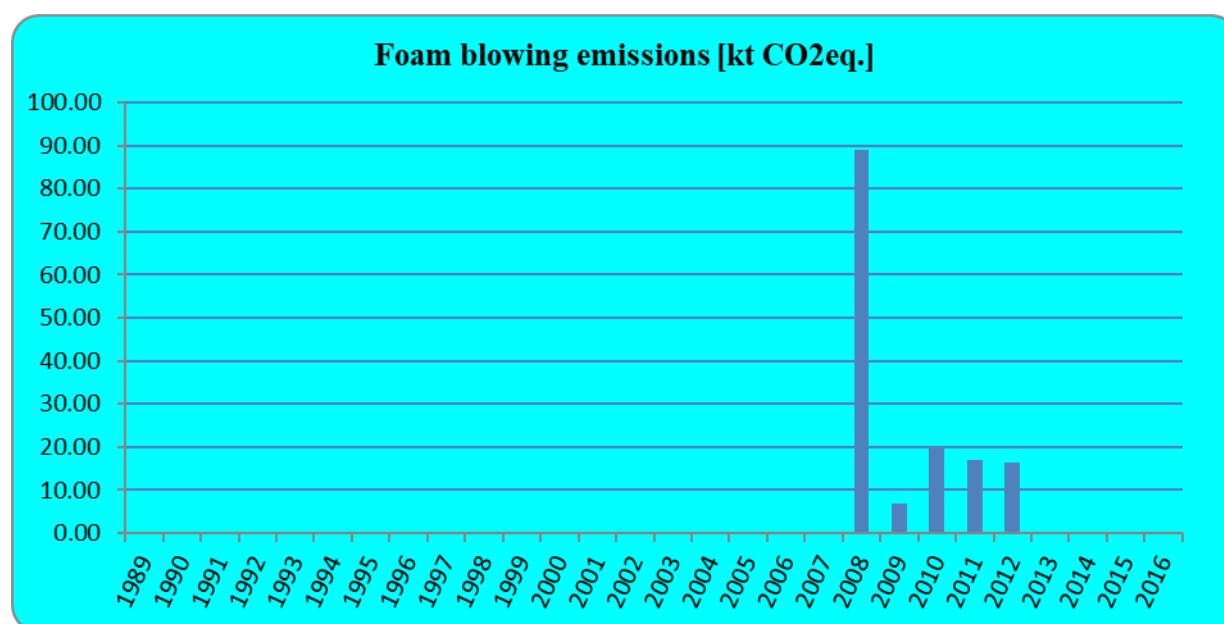
#### ***4.7.2.2 Foam Blowing (CRF 2.F.2)***

### ***Methodology***

Several types of HFCs, CO<sub>2</sub> 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 vary 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 2015-2016 period the company is producing closed-cell (PU spray) foams with HFC-152a. The products manufactured were exported. In 2016 year, the actual emissions from foam blowing were 0.05 kt CO<sub>2</sub>eq. (see Figure 4.27).

**Figure 4.27 Actual emissions of the Foam Blowing for 1989–2016 period**



The banked quantities of HFCs are estimated to be around 3.16 t in 2016 year and are shown in Table 4.52.

**Table 4.52 The quantity of banked HFC of the Foam Blowing for 1989–2016 period**

<b>Year</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [kg HFCs]</b>	<b>Operation emissions [kg HFCs]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>1989</b>	0.0	0.0	0	0	0.0
<b>1990</b>	0.0	0.0	0	0	0.0
<b>1995</b>	0.0	0.0	0	0	0.0
<b>2000</b>	0.0	0.0	0	0	0.0
<b>2005</b>	0.0	0.0	0	0	0.0
<b>2007</b>	0.0	0.0	0	0	0.0
<b>2008</b>	62.3	0.0	62,299	0	89.09
<b>2009</b>	4.9	0.0	4,875	0	6.97
<b>2010</b>	13.9	0.02	13,874	0.35	19.84
<b>2011</b>	12.2	0.43	11,796	6.50	16.84
<b>2012</b>	12.2	1.09	11,528	16.43	16.45
<b>2013</b>	0.625	1.61	93.73	24.15	0.12
<b>2014</b>	1.97	3.26	294.95	48.86	0.34
<b>2015</b>	0.00	3.21	0.00	48.12	0.05
<b>2016</b>	0.00	3.16	0.00	47.40	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 mattresses, 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 of 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*

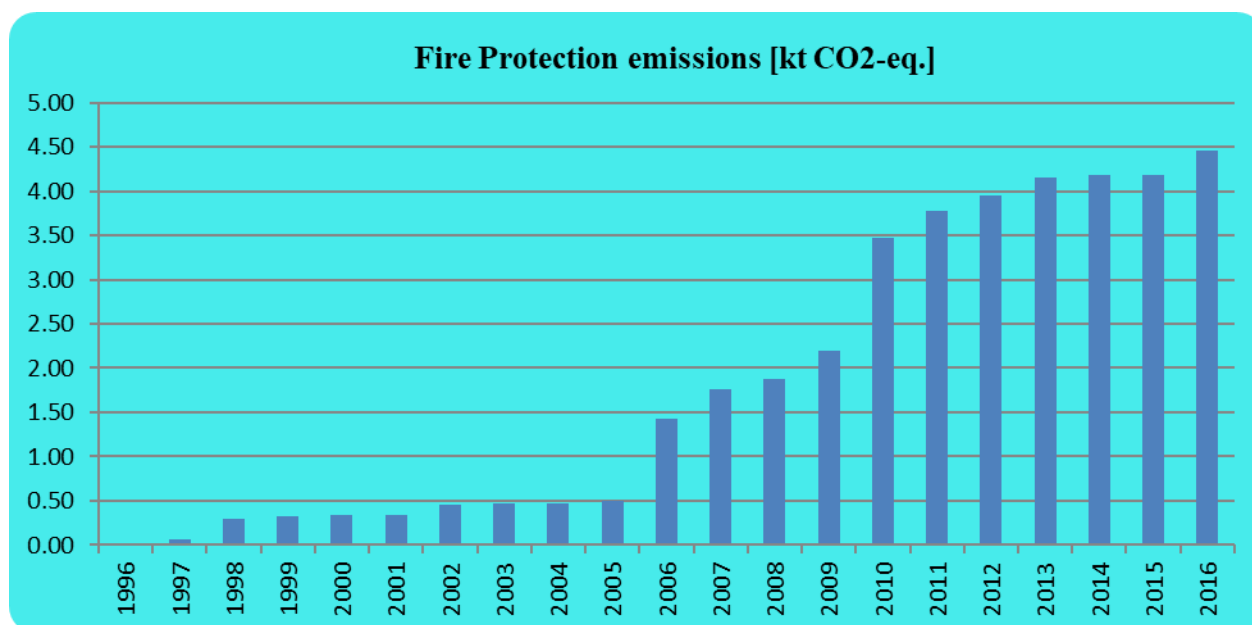
The emission estimates were prepared using the default emission factors from the 2000 IPCC GPG and 2006 IPCC Guidelines. For open-cell flexible foam was applied a 100% loss in the first year, while for closed-cell spray foam is assumed 15% loss for the first year and 1.5% per annum thereafter.

#### 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 28 t in 2016 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 2016 year are estimated to be about 4.46 kt CO<sub>2</sub>eq (Figure 4.28).

*Figure 4.28 Actual emissions of the Fire Protection for 1989–2016 period**Table 4.53 The quantity of banked HFC of the Fire Protection for 1989–2016 period*

Year	HFCs placed on the market [t]	Quantity of banks [t]	Operation emissions [kg HFC]	Actual emissions [kt CO <sub>2</sub> eq.]
1989	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00
2000	0.08	2.07	103.61	0.33
2005	0.19	3.10	155.12	0.50
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

Year	HFCs placed on the market [t]	Quantity of banks [t]	Operation emissions [kg HFC]	Actual emissions [kt CO <sub>2</sub> eq.]
2014	0.17	25.95	1,297.34	4.18
2015	0.00	25.95	1,297.34	4.18
2016	1.78	27.73	1,386.31	4.46

### *Activity data*

For the estimate of this subcategory was used data from the Ministry of Interior Affairs regarding all fire protection installations containing F-gases. Only the use of HFC-227ea (FM-200) was reported, while the reported quantities vary from 18 kg to 6,500 kg per installation. For each installation was provided the nameplate capacity and the year of installation. In some cases the installation capacity was provided in liters – in order to calculate the mass of the F-gas was used a density of 1.3886 kg/l.

### *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.

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<sup>1</sup>[http://www2.dupont.com/FE/en\\_US/assets/downloads/pdf\\_fm/k17649\\_FM-200\\_physical\\_properties\\_si.pdf](http://www2.dupont.com/FE/en_US/assets/downloads/pdf_fm/k17649_FM-200_physical_properties_si.pdf)



#### 4.7.2.4 Aerosols/Metered Dose Inhalers (CRF 2.F.4)

##### **Methodology**

The research did not reveal any aerosol producers from Romania. This was confirmed by reviewing international sources (list of members of the European Aerosol Federation<sup>2</sup>, FEA Statistics Report for 2008-2012<sup>3</sup>, Aerosol Europe Market survey of European producers<sup>4</sup>). According to information from European Aerosol Federation, the European aerosol industry has primarily shifted to flammable liquefied propellants (hydrocarbons and dimethyl ether), although there are still some use of HFCs, where the use of non-flammable liquefied propellant is required, but this usually excludes the most widespread aerosol types like personal care products and household products. Since the research did not identify any evidence for the existence of Romanian aerosols producers, emissions from manufacturing are not occurring. In Romania, HFCs are mostly used as propellants in aerosol sprays for drug application in asthma therapy (e.g. metered dose inhalers). Generally, HFC-134a and HFC-227ea could be used as propellants, although the research showed only the use of HFC-134a. 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 36.67 kt CO<sub>2</sub>eq (see Table 4.54).

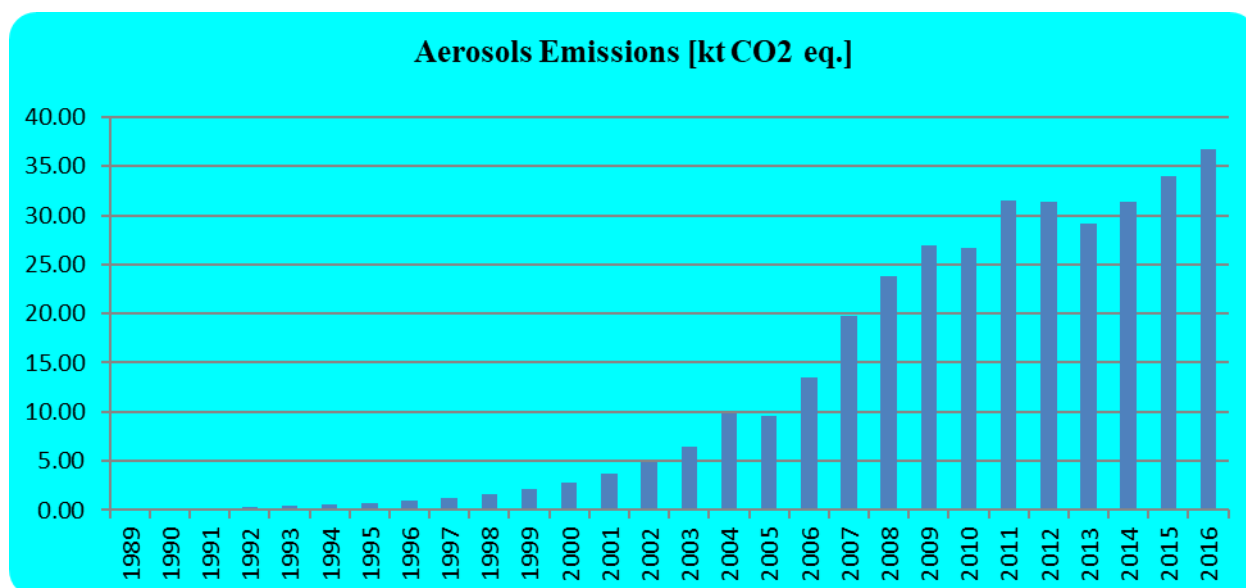
Since for this subsector the accumulation of banks is limited to one year after the production of the aerosol, there are no large banked quantities accumulated. Although the 2000 IPCC GPG does not distinguish between different methodological tiers, it defines two possible approaches whether the estimates 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.

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<sup>2</sup> <http://www.aerosol.org/about-fea/members>

<sup>3</sup> <http://www.aerosol.org/publications-news/publications/statistics/statistics-2>

<sup>4</sup> [http://www.aerosoleurope.de/wp-content/uploads/MarketSurvey\\_AE0211.pdf](http://www.aerosoleurope.de/wp-content/uploads/MarketSurvey_AE0211.pdf)

**Figure 4.29 Actual emissions of the Aerosols/Metered Dose Inhalers for 1989–2016 period****Table 4.54 The quantity of banked HFC of the Aerosols/Metered Dose Inhalers for 1989–2016 period**

Year	HFCs placed on the market [t]	Quantity of banks [t]	Initial emissions [kg HFC]	Operation emissionsm [kg HFC]	Actual emissions [kt CO <sub>2</sub> eq.]
1989	0.11	0.05	54.59	54.59	0.16
1990	0.14	0.07	72.11	54.59	0.18
1995	0.57	0.29	285.74	218.10	0.72
2000	2.25	1.13	1,127.38	858.22	2.84
2005	4.56	2.28	2,279.06	4,374.64	9.51
2007	13.33	6.66	6,663.40	7,175.09	19.79
2008	20.03	10.02	10,016.62	6,663.40	23.85
2009	17.71	8.86	8,855.65	10,016.62	26.99
2010	19.60	9.80	9,798.32	8,855.65	26.68
2011	24.41	12.20	12,203.56	9,798.32	31.46
2012	19.56	9.78	9,779.65	12,203.56	31.44

<b>Year</b>	<b>HFCs placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [kg HFC]</b>	<b>Operation emissionsm [kg HFC]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>2013</b>	21.16	10.58	10,579.09	9,779.65	29.11
<b>2014</b>	22.66	11.33	11,328.28	10,579.09	31.33
<b>2015</b>	24.82	12.41	12,410.87	11,328.28	33.95
<b>2016</b>	26.46	13.23	13,229.24	12,410.87	36.67

### *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 from 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 assess 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, no 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<sub>6</sub>), 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 1989–2016.

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

Following these activities there were no nonconformities recorded.

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



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

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

- **activity data:**
  - Aerosols/Metered Dose Inhalers (CRF 2.F.4)

Recalculation of the HFC emissions have been made for the 2013-2014 period. Recalculations were made as a result of due to the changes in activity data for 2013 year.

***Table 4.55 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 2017	NGHGI 2018	Differences [%]
	HFC emissions [kt CO2 equivalent]		
1989	0.16	0.16	0.00
1990	0.18	0.18	0.00
1995	2.53	2.53	0.00
2000	70.82	70.82	0.00
2005	368.91	368.91	0.00
2007	665.63	665.63	0.00
2008	946.95	946.95	0.00
2009	924.42	924.42	0.00
2010	982.46	982.46	0.00
2011	1,092.14	1,092.14	0.00
2012	1,197.29	1,197.29	0.00
2013	1,298.44	1,298.45	0.00
2014	1,373.08	1,373.10	0.00
2015	1,636.76	1,636.76	0.00
2016		1,894.11	

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

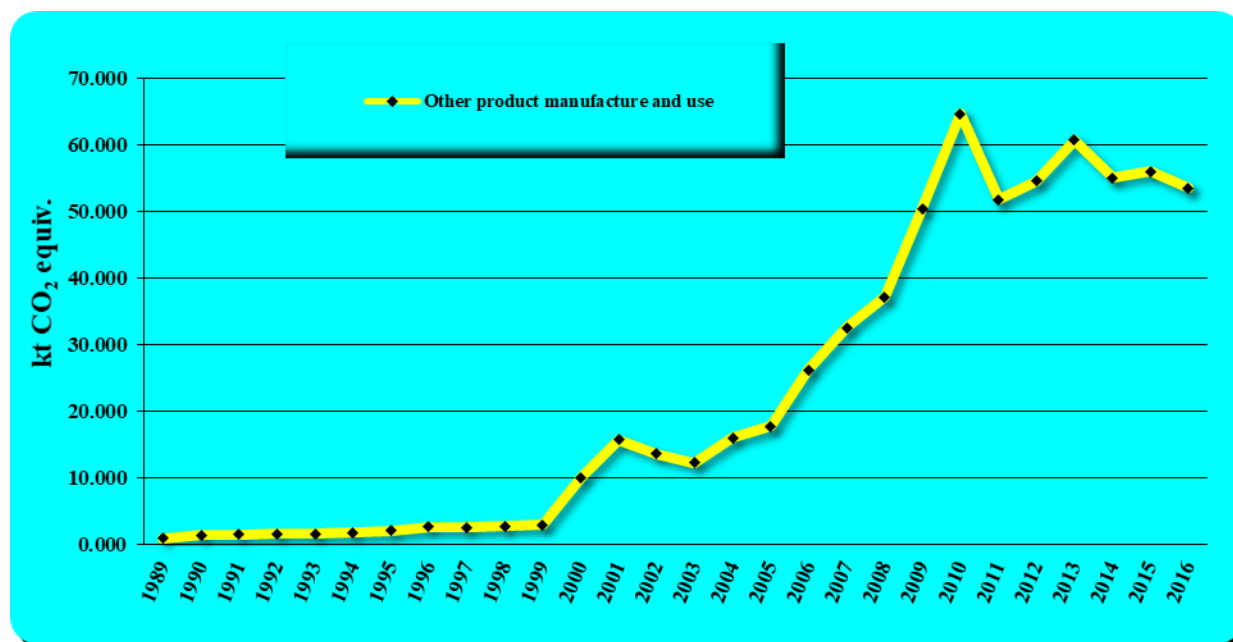
More detailed data will try to be obtained, in respect to the 2006 IPCC GL provisions.

### 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<sub>6</sub> and PFCs from other product use (CRF 2.G.2), N<sub>2</sub>O 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 1995–2016 period**

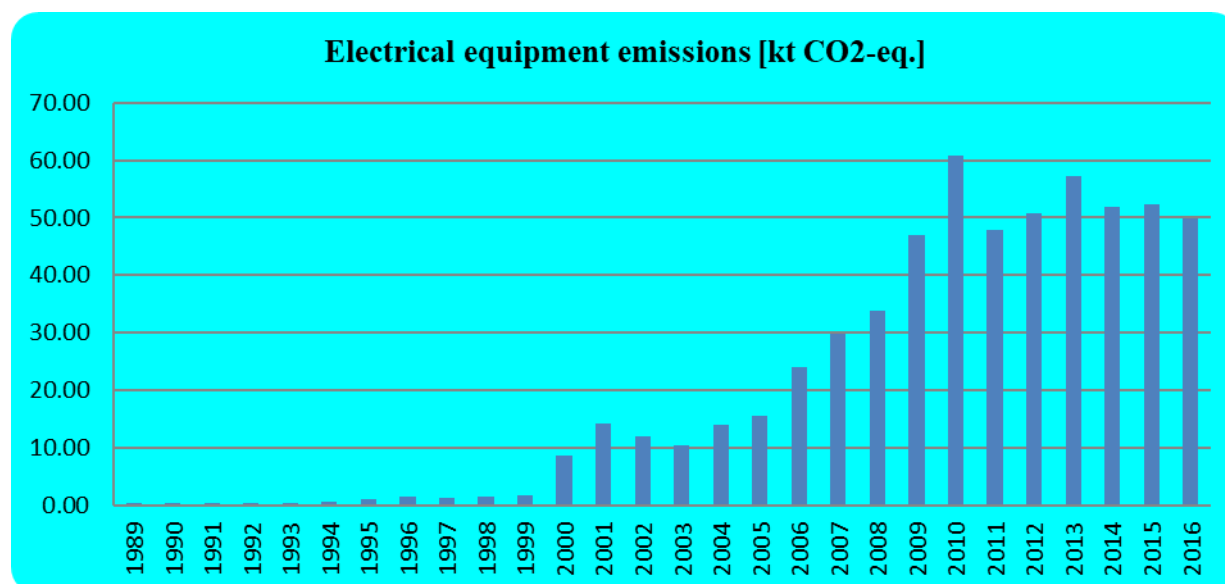


#### *4.8.2 Methodological issues*

##### *4.8.2.1 Electrical Equipment (CRF 2.G.1)*

#### **Methodology**

Sulphur hexafluoride (SF<sub>6</sub>) 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<sub>6</sub> 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<sub>6</sub> are contained in closed pressure equipment (around 67.4% of the total quantity or 78.5 t in 2016 year), while the rest is banked in sealed pressure equipment (38 t in 2016 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 49.88 kt CO<sub>2</sub>eq. in 2016 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 1989–2016 period**Table 4.56 The quantity of banked HFC of the Electrical Equipment for 1989–2016 period*

Year	SF <sub>6</sub> placed on the market [t]	Quantity of banks [t]	Initial emissions [kg SF <sub>6</sub> ]	Operation emissions [kg SF <sub>6</sub> ]	Disposal emissions [kg SF <sub>6</sub> ]	Actual emissions [kt CO <sub>2</sub> eq.]
1989	0.00	0.80	0.00	20.83	0.00	0.47
1990	0.00	0.80	0.00	20.83	0.00	0.47
1995	0.17	1.10	14.28	28.52	0.00	0.98
2000	3.06	5.44	249.26	130.80	0.00	8.68
2005	2.32	20.34	171.09	461.73	49.20	15.67
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

<b>Year</b>	<b>SF<sub>6</sub> placed on the market [t]</b>	<b>Quantity of banks [t]</b>	<b>Initial emissions [kg SF<sub>6</sub>]</b>	<b>Operation emissions [kg SF<sub>6</sub>]</b>	<b>Disposal emissions [kg SF<sub>6</sub>]</b>	<b>Actual emissions [kt CO<sub>2</sub>eq.]</b>
<b>2014</b>	5.38	107.78	212.74	2,039.89	18.48	51.78
<b>2015</b>	6.20	113.98	165.07	2,098.90	28.61	52.27
<b>2016</b>	2.51	116.48	46.58	2,117.07	24.24	49.88

### *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<sub>6</sub> 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<sub>6</sub> and PFCs from other product use (CRF 2.G.2)*

Other emissions are not known to be occurring.

#### *4.8.2.3 N<sub>2</sub>O from product uses (CRF 2.G.3)*

N<sub>2</sub>O from product uses is not a key category. Evaporative emissions of nitrous oxide (N<sub>2</sub>O) 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<sub>2</sub>O 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 reported 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 2007-2016 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 1989–2016.



#### 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.

#### 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<sub>2</sub>O from product uses (CRF 2.G.3).

**Table 4.57 The effects of recalculations in Other Product Manufacture and Use Sector**

The effects of recalculations in Other Product Manufacture and Use Sector			
Years	NGHGI 2017	NGHGI 2018	Differences
	Emissions (kt CO <sub>2</sub> equivalent)		[%]
<b>1989</b>	0.98	0.98	0.00
<b>1990</b>	1.45	1.45	0.00
<b>1995</b>	2.15	2.15	0.00
<b>2000</b>	10.08	10.08	0.00
<b>2005</b>	17.78	17.83	0.26
<b>2007</b>	32.56	32.65	0.27

The effects of recalculations in Other Product Manufacture and Use Sector			
Years	NGHGI 2017	NGHGI 2018	Differences
	Emissions (kt CO <sub>2</sub> equivalent)		[%]
2008	37.13	37.22	0.23
2009	50.43	50.52	0.18
2010	64.62	64.72	0.15
2011	51.79	51.83	0.09
2012	54.55	54.60	0.09
2013	60.74	60.84	0.15
2014	55.05	55.14	0.18
2015	56.01	56.07	0.11
2016		53.55	

Recalculation have been made for the 2004-2015 period. The recalculations were made as a result of the improvement in activity data (two new operators have sent data on the use of nitrous oxide in medical applications for those years). (CRF Category 2.G.3.a).

*Table 4.58 The effects of recalculations in N<sub>2</sub>O from Product Uses Sub-sector*

The effects of recalculations in N <sub>2</sub> O from Product Uses Sub-sector			
Years	NGHGI 2017	NGHGI 2018	Differences
	N <sub>2</sub> O emissions [kt CO <sub>2</sub> equivalent]		[%]
1989	0.51	0.51	0.00
1990	0.98	0.98	0.00
1995	1.17	1.17	0.00
2000	1.40	1.40	0.00
2005	2.12	2.16	2.18
2007	2.68	2.77	3.33
2008	3.30	3.39	2.55
2009	3.40	3.49	2.67

<b>The effects of recalculations in N<sub>2</sub>O from Product Uses Sub-sector</b>			
<b>Years</b>	<b>NGHGI 2017</b>	<b>NGHGI 2018</b>	<b>Differences</b>
	<b>N<sub>2</sub>O emissions [kt CO<sub>2</sub> equivalent]</b>		<b>[%]</b>
<b>2010</b>	3.92	4.01	2.40
<b>2011</b>	3.96	4.00	1.17
<b>2012</b>	3.79	3.84	1.32
<b>2013</b>	3.54	3.63	2.59
<b>2014</b>	3.27	3.36	2.96
<b>2015</b>	3.74	3.80	1.71
<b>2016</b>		3.67	

*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<sub>4</sub> emissions from enteric fermentation;
- CH<sub>4</sub> and N<sub>2</sub>O emissions from manure management;
- CH<sub>4</sub> emissions from rice cultivation;
- N<sub>2</sub>O emissions from agricultural soils;
- CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub> and CO emissions from field burning of agricultural residues;
- CO<sub>2</sub> emissions from Lime application;
- CO<sub>2</sub> emissions from Urea application.

The direct GHGs reported within this sector are CH<sub>4</sub>, N<sub>2</sub>O and CO<sub>2</sub> while indirect gases comprise NO<sub>x</sub> and CO.

Domestic livestock are the major source of CH<sub>4</sub> emissions from agriculture, both from enteric fermentation and manure management. Manure management also generates N<sub>2</sub>O 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 <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>
<b>3. A Enteric fermentation</b>			
<b>3.A.1 Cattle</b>	✓	NA	NA
3.A.1.A.1. Dairy cattle	✓	NA	NA
3.A.1.A.2. Non-dairy cattle	✓	NA	NA
<b>3.A.2 Sheep</b>	✓	NA	NA

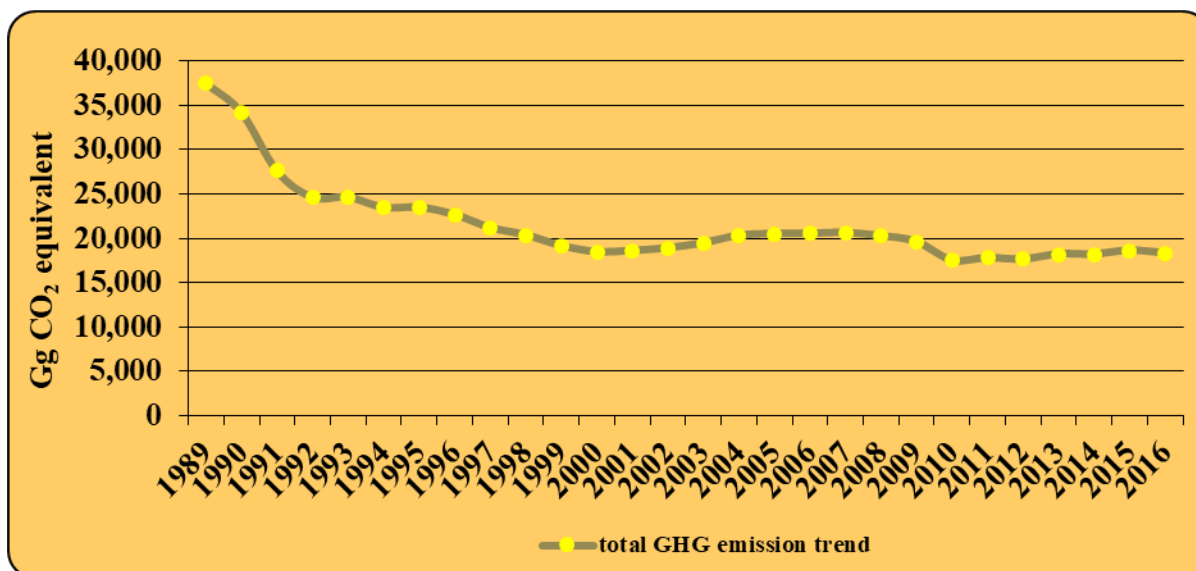
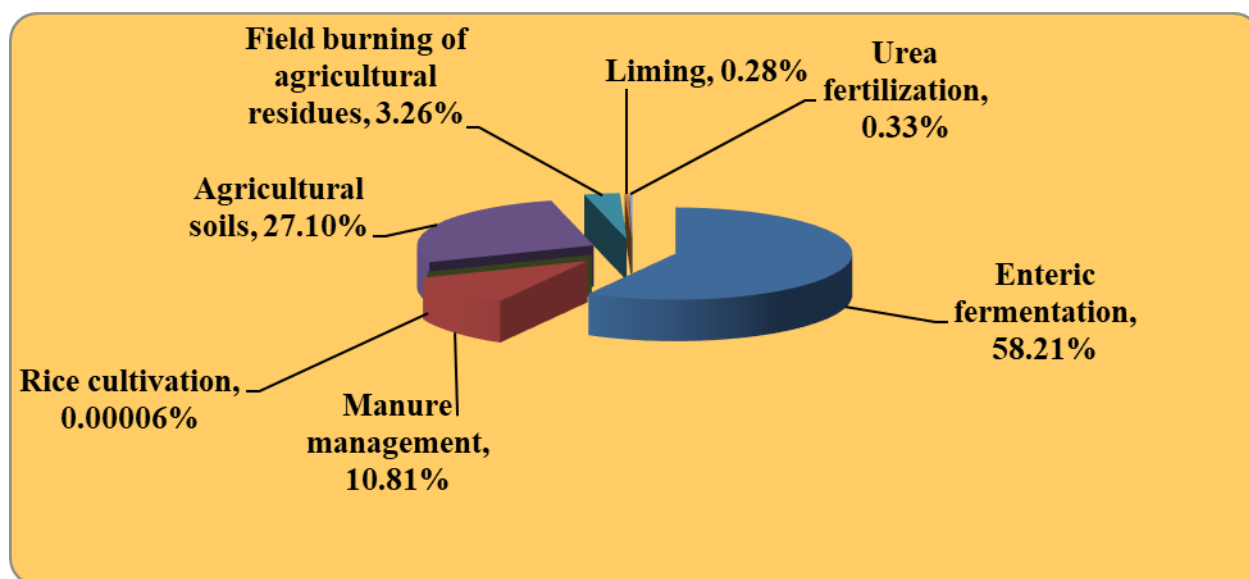
IPCC category	Emissions estimation status		
	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>
<b>3.A.3 Swine</b>	✓	NA	NA
<b>3.A.4 Other livestock</b>			
3.A.4.1 Rabbits	NO	NA	NA
3.A.4.2 Buffalo	✓	NA	NA
3.A.4.3 Camels	NO	NO	NO
3.A.4.4 Goats	✓	NA	NA
3.A.4.5 Horses	✓	NA	NA
3.A.4.6 Mules and Asses	✓	NA	NA
3.A.4.7 Poultry	✓	NA	NA
<b>3.B Manure management</b>			
<b>3.B.1. CH<sub>4</sub> emissions</b>	✓	NA	NA
<b>3.B.1.1 Cattle</b>	✓	NA	NA
3.B.1.1.A.1. Dairy cattle	✓	NA	NA
3.B.1.1.A.2. Non-dairy cattle	✓	NA	NA
<b>3.B.1.2. Sheep</b>	✓	NA	NA
<b>3.B.1.3. Swine</b>	✓	NA	NA
<b>3.B.1.4 Other livestock</b>	✓	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
<b>3.B.2. N<sub>2</sub>O and NMVOC emissions</b>	NA	✓	NA
<b>3.B.2.1 Cattle</b>	NA	✓	NA
3B.2.1.A.1. Dairy cattle	NA	✓	NA
3B.2.1.A.2. Non - dairy cattle	NA	✓	NA

IPCC category	Emissions estimation status		
	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>
<b>3.B.2.2. Sheep</b>	NA	✓	NA
<b>3.B.2.3. Swine</b>	NA	✓	NA
<b>3.B.2.4. Other livestock</b>	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
<b>3.B.2.5. Indirect N<sub>2</sub>O Emissions</b>	NA	✓	NA
<b>3.B.2.6. Emissions per MMS</b>	NA	✓	NA
<b>3.C Rice cultivation</b>			
<b>3.C.1 Irrigated</b>	✓	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
<b>3.C.2 Rainfed</b>	NO	NA	NA
<b>3.C.3 Deep water</b>	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
<b>3.C.4 Other</b>	NO	NA	NA
<b>3.D Agricultural soils</b>			
<b>3.D.1 Direct soil emissions</b>	NA	✓	NA
3.D.1.1. Inorganic N Fertilizers	NA	✓	NA
3.D.1.2. Organic N Fertilizers	NA	✓	NA
3D.1.2.a. Animal Manure Applied to Soils	NA	✓	NA

IPCC category	Emissions estimation status		
	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>
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
<b>3.D.2. Indirect N<sub>2</sub>O Emissions from Managed Soils</b>	NA	✓	NA
3.D.2.1.Atmospheric Deposition	NA	✓	NA
3.D.2.2. Nitrogen Leaching and Run-off	NA	✓	NA
<b>3.E Prescribed burning of savannas</b>	NO	NO	NO
<b>3.F Field burning of agricultural residues</b>	✓	✓	NA
<b>3.G. Liming</b>	NA	NA	✓
<b>3.H. Urea Application</b>	NA	NA	✓
<b>3.I. Other Carbon-containing Fertilizers</b>	NA	NA	✓

### Observations

1) In respect to the IPCC GPG 2006 provisions, N<sub>2</sub>O 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 1989–2016 period**Figure 5.2 Contribution of the sub-sectors in the total GHG emissions from Agriculture, in 2016 year*

Another source of methane is represented by anaerobic decomposition of organic material in flooded rice fields. Microbiological processes in soil lead to N<sub>2</sub>O emissions.



Two N<sub>2</sub>O 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<sub>4</sub>, CO, N<sub>2</sub>O and NO<sub>x</sub> emissions for 1989-2016 period.

Emissions from prescribed burning of savannas do not occur in Romania.

The Agriculture Sector accounted for 16.28% of the total GHG emissions in 2016, reaching 18,320.20 kt CO<sub>2</sub> equivalent (Table 5.2).

Within the GHG emissions from the agriculture sector, the CH<sub>4</sub> emissions have the largest contribution (in 2016, CH<sub>4</sub> emissions contribution is 69.76% to the total Agriculture Sector's CO<sub>2</sub> equivalent emissions), followed by the N<sub>2</sub>O emissions (that account for the remaining 31.32%).

Over the period 1989 – 2016, the GHG emissions resulted from Agriculture Sector decreased by 46.46% (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 occurred, 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 2016 there were registered 339,036 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 sheep'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 grown in farms.

Poultry for meat number decreased from 1989 to 1994, after which they slightly increased, the egg poultry decreased sharply in 1994, then began 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 2004-2016 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 2015 year, in 2016 were slowly increased some livestock categories for example: buffaloes, sheeps, goats, horses and rabbits.
- ❖ The rice cultivation generated in 2016 a significantly reduced emission compared to the base year 1989 due to the decrease of areas (77.03% decrease comparing with the base year).
- ❖ In case of agricultural soils, the emissions decreased over the period (47.79% decrease in 2016 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<sub>2</sub>O 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<sub>4</sub> emissions decreased in 2016 with 52.60% compared to basic (see Annex 3.5 - sheet *Distribution of N<sub>2</sub>O and CH<sub>4</sub> 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<sub>2</sub>O emissions from the Agriculture Sector decreased in 2016 with 47.56% comparing with the base year (see Annex 3.3 - sheet *Distribution of N<sub>2</sub>O and CH<sub>4</sub> emission*). The reasons for this decrease are:
  - ❖ the decrease of the amount of chemical fertilizers applied to soils;
  - ❖ the decline of the domestic livestock (the details are presented above);
  - ❖ the decrease of the crop productions level.

In the general context of the transition of the economy to a market based approach, the activity data level decreased substantially in the last years of the characterized period in comparison to the base year.

The livestock number decreased in the last years of the characterized period in comparison to 1989 mainly due to:

- ❖ the import of animals;
- ❖ the draught which affected the crop production levels and the crop production prices;
- ❖ state incentives in some periods;
- ❖ closing of the old/opening new facilities due to the restructuration of the economy.

The crop productions level decreased in the late years of the analyzed period in comparison to 1989 mainly due to the change in agricultural land property regime and to the transition to the market economy. Reasons for the inter-annual changes in crop production levels include:

- ❖ existence of draught periods;
- ❖ existence if state incentives for some periods;
- ❖ changes in the land property regime, including the disaggregation of large farms before 1990 and crystallization of new large farms in the late years.

The livestock number was decreased in the 2010 year comparative with the 2009 year due to:

- ❖ the deficiency precipitation that which led to decreased of production needed for feeding;
- ❖ the increases of price per food.

The crop productions of the N fixing for all plants decreased in 2012 compared with 2011 due to drought.

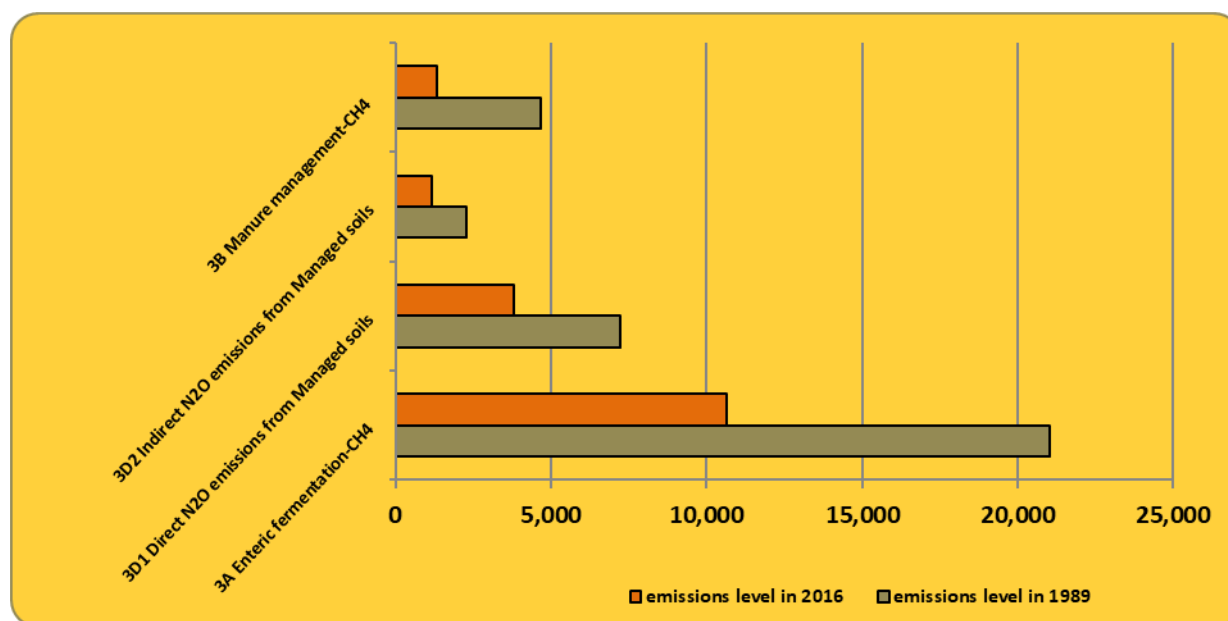
**Table 5.2 Contribution of Agriculture sector in total GHG emissions, in 1989-1990, 1995, 2000, 2005, 2007–2016**

<b>Year</b>	<b>Total GHG emissions [kt]</b>	<b>GHG emissions from Agriculture [kt]</b>	<b>Contribution of Agriculture in total GHG emissions [%]</b>	<b>Methane emissions from Agriculture [kt]</b>	<b>Contribution of methane emissions in total GHG emissions from Agriculture [%]</b>	<b>Nitrous oxide emissions from Agriculture [kt]</b>	<b>Contribution of nitrous oxide emissions in total GHG emissions from Agriculture [%]</b>
<b>1989</b>	302,630.63	37,508.85	12.39	26,256.03	70.00	10,986.52	29.29
<b>1990</b>	246,747.86	34,222.10	13.87	23,791.49	69.52	10,248.09	29.95
<b>1995</b>	180,478.41	23,484.56	13.01	16,483.46	70.19	6,903.39	29.40
<b>2000</b>	140,733.62	18,456.03	13.11	13,359.96	72.39	4,993.17	27.05
<b>2005</b>	147,827.94	20,505.81	13.87	14,124.64	68.88	6,242.63	30.44
<b>2007</b>	152,984.04	20,613.75	13.47	15,145.94	73.47	5,350.38	25.96
<b>2008</b>	148,078.36	20,261.46	13.68	14,435.09	71.24	5,689.39	28.08
<b>2009</b>	127,661.72	19,605.96	15.36	13,973.41	71.27	5,509.49	28.10
<b>2010</b>	122,182.25	17,505.79	14.33	12,168.56	69.51	5,230.02	29.88
<b>2011</b>	127,875.46	17,774.04	13.90	12,142.80	68.32	5,540.59	31.17
<b>2012</b>	124,847.08	17,623.42	14.12	12,527.18	71.08	5,019.61	28.48
<b>2013</b>	115,262.27	18,193.88	15.78	12,380.27	68.05	5,723.71	31.46
<b>2014</b>	115,371.21	18,190.23	15.77	12,549.87	68.99	5,558.21	30.56
<b>2015</b>	116,211.32	18,611.87	16.02	12,780.08	68.67	5,737.45	30.82
<b>2016</b>	112,542.36	18,320.20	16.28	12,445.42	67.93	5,761.54	31.45

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, 2016**

Key categories	GHG	Criteria	Contribution in total GHG emissions [%]
3.A Enteric fermentation	CH <sub>4</sub>	L,T (Tier 1, excluding and including LULUCF)	<b>9.47</b>
3.D.1 Direct N <sub>2</sub> O emissions from Managed soils	N <sub>2</sub> O	L,T (Tier 1, excluding and including LULUCF)	<b>3.37</b>
3B Manure management	CH <sub>4</sub>	L,T (Tier 1, excluding and including LULUCF)	<b>1.19</b>
3.D.2 Indirect N <sub>2</sub> O emissions from Managed soils	N <sub>2</sub> O	L,T (Tier 1, excluding and including LULUCF)	<b>1.03</b>

**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<sub>4</sub>.

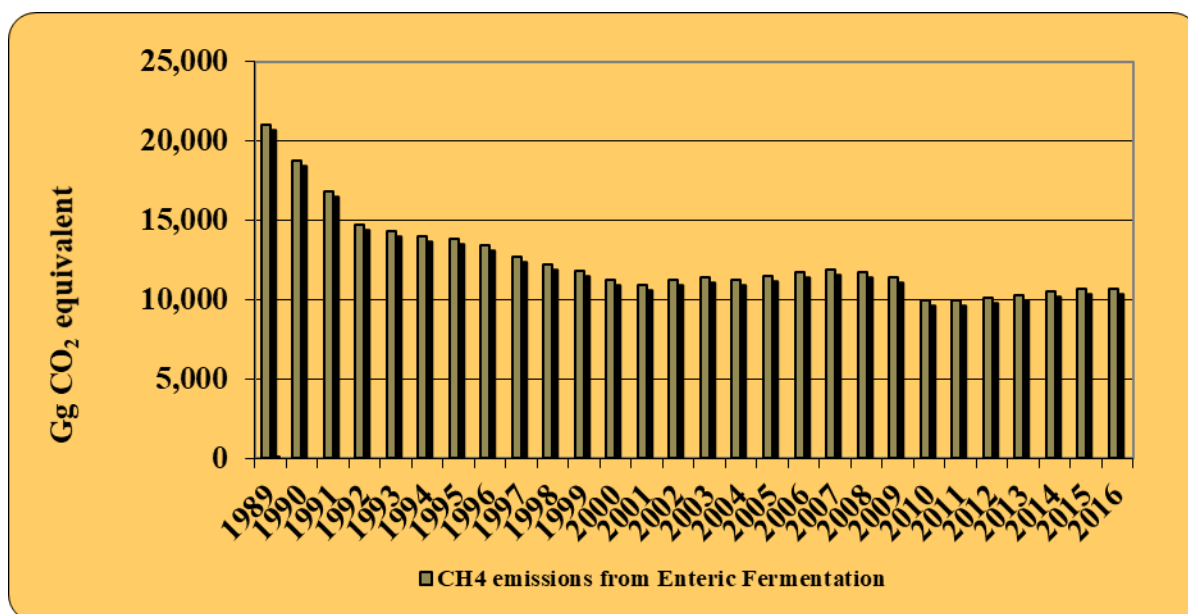
#### ***Enteric Fermentation:***

- ❖ is the main source of CH<sub>4</sub> emissions in the Agriculture sector (in 2016, CH<sub>4</sub> emissions from Enteric Fermentation represented 85.68% of total CH<sub>4</sub> emissions in the Agriculture sector);
- ❖ is the main source in the Agriculture sector (in 2016, CH<sub>4</sub> emissions from Enteric Fermentation as CO<sub>2</sub> equivalent represented 58.20% from Total Agriculture emissions);
- ❖ contributed with 9.47% to Total GHG emissions of Romania.

Compared to 1989, total CH<sub>4</sub> emissions from Enteric Fermentation decreased with 49.28 % in 2016 (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 <i>cattle</i> categories: <i>dairy cows</i> and <i>non-dairy cattle</i> .	AD: NIS and expert judgment, 1989-2003; NIS, 2004-2016 EF: Country specific, expert judgment
3.A.2	Sheep	Includes livestock data from three different sheep: <i>Ewes of milk and fitted, reproducers rams</i> and <i>other sheep</i>	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016; EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment



Source indicative	Source (livestock) type	Observation	Data source
3A3	Swine	Includes livestock data from five different <i>swine: pigs under 20 kg, pigs between 20 and 50 kg, pigs fattening, boars, breeding sows</i>	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016 EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	Buffalo	Includes livestock data from two different <i>buffalo: buffalo milk and other buffalo</i>	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016; EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	Goats	Includes livestock data from two different <i>goats: Female goats for milk and females by first mount and other goats</i>	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016; EF: IPCC 2006, IPCC GPG 2000,
3.A.4	Horses		AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016; EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	Mules and asses		AD: FAO, 2011, 2016; EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment

Source indicative	Source (livestock) type	Observation	Data source
3.A.4	Poultry	Includes livestock data from two different <i>poultry: adult poultry for eggs, poultry for meat</i>	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016 EF: IPCC 2006, IPCC GPG 2000, IPCC 1996, Country specific, expert judgment
3.A.4	Rabbits		AD: NIS, 1989-2016 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***

$$GE \text{ (kcal/kg)} = 5.72 \cdot PB + 9.5 \cdot GB + 4.79 \cdot CelB + 4.17 \cdot SEN$$

***(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	x1	x2	x3	x4
<b>Energy equivalent (e) to:</b>				
Cattle (Non dairy)	5.79	8.15	4.42	4.06

Specification	Digestible PB	Digestible GB	Digestible CelB	Digestible SEN
Symbol	x <sub>1</sub>	x <sub>2</sub>	x <sub>3</sub>	x <sub>4</sub>
<b>Energy equivalent (e) to:</b>				
cattle)				
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 calorificity 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 calorificity 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 1989-1990, 1995, 2000, 2005, 2007–2016 for dairy cows and, respectively, buffaloes.

**Table 5.6 Milk production in cows and and buffalo in the period 1989-1990, 1995, 2000, 2005, 2007–2016 (NIS)**

<b>Year</b>	<b>Dairy cattle production (thousand hl)</b>	<b>Milk buffalo production (thousand hl)</b>
<b>1989</b>	40,477	717
<b>1990</b>	39,698	613
<b>1995</b>	52,431	399
<b>2000</b>	48,191	327
<b>2005</b>	54,976	357
<b>2007</b>	54,517	358
<b>2008</b>	52,761	327
<b>2009</b>	48,234	304
<b>2010</b>	42,585	239
<b>2011</b>	43,728	218
<b>2012</b>	41,823	212
<b>2013</b>	42,381	210

Year	Dairy cattle production (thousand hl)	Milk buffalo production (thousand hl)
2014	43,713	302
2015	42,401	262
2016	41,801	218

- ❖ *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, calorificity is 4122.97 kcal, equivalent to 17.25 MJ/1 kg ration. For an increase of 35 g, specific to this type of exploitation, 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.

Weight 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<sub>4</sub>/head/year) used for calculation of methane emissions from enteric fermentation of livestock and data necessary for their calculation, in the 1989-2016 period**

Source indicative	Livestock (source) type	Emission Factors [kg CH <sub>4</sub> /head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Y <sub>m</sub> fraction)
<b>3.A.1</b>	<b>CATTLE</b>			
<b>3.A.1.2</b>	<i>Non dairy cattle</i>			
	Calves for slaughter younger than 1 year	60.99	143.07	0.065
	Young cattle of breeding under 1 year	49.24	115.5	0.065
	Young cattle of breeding between 1 and 2 years	62.59	146.83	0.065
	Young cattle of slaughter between 1 and 2 years	94.78	222.33	0.065
	Cattle 2 years and over Breeding bulls	103.03	241.68	0.065
	Cattle 2 years and over Heifers for breeding	90.00	211.12	0.065
	Males and females for sacrificed	71.07	166.72	0.065

Source indicative	Livestock (source) type	Emission Factors [kg CH <sub>4</sub> /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)
	older than 2 years			
	Cattle for work	119.27	303.08	0.06
<b>3.A.2</b>	<b><i>SHEEP</i></b>			
	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
<b>3.A.3</b>	<b><i>SWINE</i></b>			
	Pigs under 20 kg	0.69	8.18	0.013
	Pigs between 20 and 50 kg	1.15	13.49	0.013
	Pigs fattening	1.84	46.86	0.006
	Boars	1.78	45.32	0.006
	Breeding sows	1.78	45.34	0.006
<b>3.A.4.1</b>	<b><i>BUFFALO</i></b>			
	Female buffalo	114.99	269.74	0.065
	Other buffalo	54.93	128.85	0.065
<b>3.A.4.3</b>	<b><i>GOATS</i></b>			
	Female goats for milk and females by first mount	17.34	52.88	0.05
	Other goats	16.15	49.25	0.05
<b>3.A.4.4</b>	<b><i>HORSES</i></b>	37.02	225.79	0.025
<b>3.A.4.5</b>	<b><i>MULES AND ASSES</i></b>	29.70	181.18	0.025

Source indicative	Livestock (source) type	Emission Factors [kg CH <sub>4</sub> /head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Y <sub>m</sub> fraction)
3.A.4.6	<b>POULTRY</b>			
	Adult poultry for eggs	0	1.83	0
	Poultry for meat	0	1.3	0

*Table 5.8 The factors emission (kg CH<sub>4</sub>/head/year) used for calculation of methane emissions from enteric fermentation of dairy cattle and data necessary for their calculation, , in the 1989-1990, 1995, 2000, 2005,2007–2016 period*

Years	Emission Factors [kg CH <sub>4</sub> /head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Y <sub>m</sub> fraction)
<b>3A.1.1 Dairy cattle</b>			
<b>1989</b>	87.64	205.57	0.065
<b>1990</b>	89.55	210.05	0.065
<b>1995</b>	104.97	246.23	0.065
<b>2000</b>	108.60	254.75	0.065
<b>2005</b>	112.81	264.61	0.065
<b>2007</b>	113.76	266.84	0.065
<b>2008</b>	114.79	269.25	0.065
<b>2009</b>	113.00	265.07	0.065
<b>2010</b>	115.42	270.74	0.065
<b>2011</b>	117.41	275.40	0.065
<b>2012</b>	115.80	271.62	0.065

Years	Emission Factors [kg CH <sub>4</sub> /head/year]	Gross energy intake (GE) (Mj/head/day)	Methane conversion rate which is the fraction of gross energy in feed converted to methane (Y <sub>m</sub> fraction)
<b>3A.1.1 Dairy cattle</b>			
<b>2013</b>	116.06	272.24	0.065
<b>2014</b>	116.69	273.73	0.065
<b>2015</b>	115.33	270.53	0.065
<b>2016</b>	113.92	267.22	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 1989-2016 period**

Source indicative	Livestock (source) type	Energy digestible DE (Mj/day)	Percentage of digestible energy DE(%)	Animal weight (kg)
<b>3.A.1</b>	<b>CATTLE</b>			
<b>3.A.1.1</b>	<i>Dairy cattle</i>	-	60	550
<b>3.A.1.2</b>	<i>Non dairy cattle</i>			
	Calves for slaughter younger than 1 year	81.23	56.77	250
	Young cattle of breeding under 1	65.8	56.97	250

Source indicative	Livestock (source) type	Energy digestible DE (Mj/day)	Percentage of digestible energy DE(%)	Animal weight (kg)
	year			
	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
<b>3.A.2</b>	<b><i>SHEEP</i></b>			
	Ewes of milk and fitted	19.7	44.57	60
	Reproducers rams	30.07	59.86	77
	Other sheep	20.84	46.04	48
<b>3.A.3</b>	<b><i>SWINE</i></b>			
	Pigs under 20 kg	6.7	82.88	14
	Pigs between 20 and 50 kg	11.7	86.75	35
	Pigs fattening	40.66	86.77	110
	Boars	39.3	86.72	270

Source indicative	Livestock (source) type	Energy digestible DE (Mj/day)	Percentage of digestible energy DE(%)	Animal weight (kg)
	Breeding sows	37.7	83.14	125
<b>3.A.4.1</b>	<b><i>BUFFALO</i></b>			
	Female buffalo	145	53.75	500
	Other buffalo	71.3	55.34	400
<b>3A.4.3</b>	<b><i>GOATS</i></b>			
	Female goats for milk and females by first mount	23.91	45.21	48
	Other goats	20.82	42.27	50
<b>3.A.4.4</b>	<b><i>HORSES</i></b>	121.84	53.96	500
<b>3.A.4.5</b>	<b><i>MULES AND ASSES</i></b>	99.2	54.75	300
<b>3.A.4.6</b>	<b><i>POULTRY</i></b>			
	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.

**2004-2016**

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 1989-2016, 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 2004-2016. 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 1989-2016 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 2016), 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.

**2004-2016**

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 1989-2016 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*

No recalculation was made against the last variant.

#### *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*

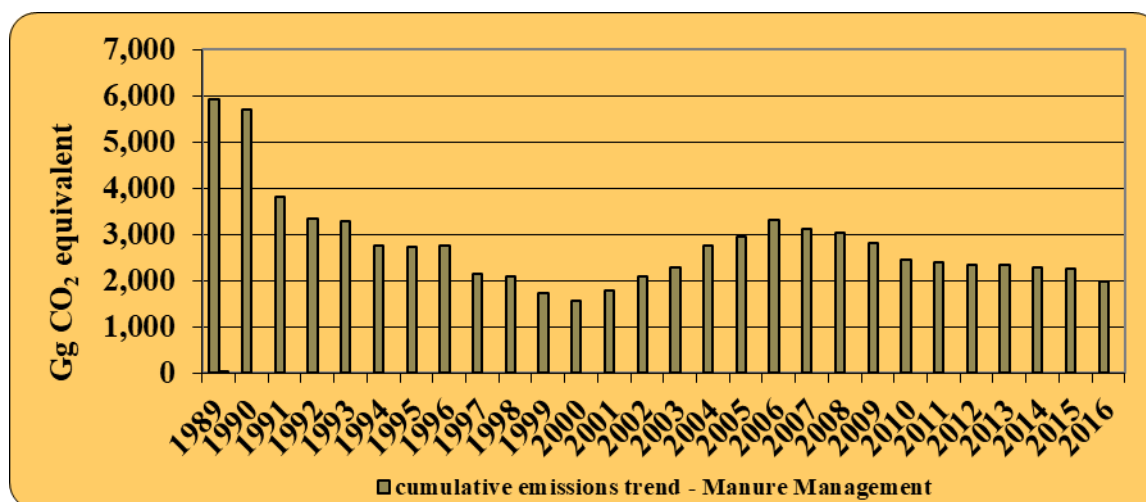
Managing a large number of animals in a confined area creates conditions for CH<sub>4</sub> emissions due to the anaerobic decomposition of manure. A part of the nitrogen from manure is converted to N<sub>2</sub>O during storage of manure.

***Manure Management:***

- ❖ is the second source of CH<sub>4</sub> and the third source of N<sub>2</sub>O emissions in the Agriculture sector (in 2016, CH<sub>4</sub> emissions from Manure Management represented 10.79% of total CH<sub>4</sub> emissions while N<sub>2</sub>O accounted for 11.05% of total N<sub>2</sub>O emissions in the Agriculture sector);
- ❖ is the third source in the Agriculture sector (in 2016, CH<sub>4</sub> and N<sub>2</sub>O emissions from Manure Management as CO<sub>2</sub> 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<sub>4</sub> 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 5.10. And the of N<sub>2</sub>O 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 5.10 Observations on source category 4B – “Manure Management”*

Source indicative	Source type	Observation	Data source
<i>Observations on source category 3B – “Manure Management – CH<sub>4</sub> and N<sub>2</sub>O emissions”</i>			
<b>3.B.1.1</b>	<b>Cattle</b>	Includes livestock data from nine different cattle categories: dairy cows and non-dairy cattle	AD: NIS and expert judgment, 1989-2003; NIS, 2004-2016 EF: Country specific, expert judgment, IPCC 2006
<b>3.B.1.2</b>	<b>Sheep</b>	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, 2004-2016; EF: IPCC 2006, expert judgment

Source indicative	Source type	Observation	Data source
<i>Observations on source category 3B – “Manure Management – CH<sub>4</sub> and N<sub>2</sub>O emissions”</i>			
<b>3.B.1.3</b>	<b>Swine</b>	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, 2004-2016 EF: IPCC 2006, expert judgment
<b>3B.1.4.1</b>	<b>Rabbits</b>		AD: NIS, 1989-2016; EF: IPCC 2006
<b>3.B.1.4.2</b>	<b>Buffalo</b>	Includes livestock data from two different buffalo: buffalo milk and other buffalo	AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016; EF: IPCC 2006, expert judgment
<b>3.B.1.4.3</b>	<b>Goats</b>	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, 2004-2016; EF: IPCC 2006, expert judgment
<b>3.B.1.4.4</b>	<b>Horses</b>		AD: SY, other correspondence, NIS and expert judgment, 1989-2003; NIS, 2004-2016; EF: IPCC 2006, expert judgment
<b>3.B.1.4.4</b>	<b>Mules and asses</b>		AD: FAO, 2011; EF: IPCC 2006, expert judgment
<b>3.B.1.4.5</b>	<b>Poultry</b>	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, 2004-2016 EF: IPCC 2006, expert judgment



Source indicative	Source type	Observation	Data source
<i>Observations on source category 3B – “Manure Management – CH<sub>4</sub> and N<sub>2</sub>O emissions”</i>			
<b>3.B.2.1</b>	<b>Cattle</b>	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
<b>3.B.2.2</b>	<b>Sheep</b>	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

Source indicative	Source type	Observation	Data source
<i>Observations on source category 3B – “Manure Management – CH<sub>4</sub> and N<sub>2</sub>O emissions”</i>			
<b>3.B.2.3</b>	<b>Swine</b>	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
<b>3.B.2.4.1</b>	<b>Buffalo</b>	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

Source indicative	Source type	Observation	Data source
<i>Observations on source category 3B – “Manure Management – CH<sub>4</sub> and N<sub>2</sub>O emissions”</i>			
<b>3.B.2.4.3</b>	<b>Goats</b>	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
<b>3.B.2.4.4</b>	<b>Horses</b>	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

Source indicative	Source type	Observation	Data source
<i>Observations on source category 3B – “Manure Management – CH<sub>4</sub> and N<sub>2</sub>O emissions”</i>			
<b>3.B.2.4.5</b>	<b>Mules and asses</b>	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
<b>3.B.2.4.6</b>	<b>Poultry</b>	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

Source indicative	Source type	Observation	Data source
<i>Observations on source category 3B – “Manure Management – CH<sub>4</sub> and N<sub>2</sub>O emissions”</i>			
<i>Observations on source category 3B – “Manure Management – N<sub>2</sub>O indirect emissions”</i>			
<b>3.B.2.5</b>	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<sub>4</sub> 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 ( $B_0$  – maximum  $\text{CH}_4$  producing capacity for manure produced by an animal within defined population  $i$ ,  $\text{m}^3/\text{kg}$  of VS and MCF -  $\text{CH}_4$  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,  $B_0$ , 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  $B_0$  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 5.11.

In the Table 5.11 are summarized the values used in the calculation of emissions factors for 1989-2016 period for each livestock (non dairy cattle, sheep, goats, swine, horses, mules and asses and poultry). In the table 5.12 are summarized the values used in the calculation of emissions factors for 1989-2016 period for dairy cattle and in the Table 5.13 are summarized the MCF ( $\text{CH}_4$  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  $\text{CH}_4$  producing capacity for manure produced by an animal within defined population  $i$ ,  $\text{m}^3/\text{kg}$  of VS ( $B_0$ ) are 8 respectively 0.24.

**Table 5.11 The values used in the calculation of emissions factors from Manure management for 1989-2016**

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 <sub>4</sub> producing capacity for manure produced by an animal within defined population <i>i</i> , m <sup>3</sup> /kg of VS (B <sub>0</sub> )	Urinary energy expressed as fraction of GE
<b>3.B.1</b>	<b>CATTLE</b>				
<b>3.B.1.2</b>	<b>Non dairy cattle</b>				
	Calves for slaughter younger than 1 year	8	3.37	0.17	5.72
	Young cattle of breeding under 1 year	8	2.71	0.17	4.62
	Young cattle of breeding between 1 and 2 years	8	3.55	0.17	5.87
	Young cattle of slaughter between 1 and 2 years	8	3.92	0.17	8.89
	Cattle 2 years and over - Breeding bulls	8	5.90	0.17	9.66



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 <sub>4</sub> producing capacity for manure produced by an animal within defined population <i>i</i> , m <sup>3</sup> /kg of VS (B <sub>0</sub> )	Urinary energy expressed as fraction of GE
	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
<b>3.B.2</b>	<b><i>SHEEP</i></b>				
	Ewes of milk and fitted	8	1.26	0.13	1.71
	Reproducers rams	8	1.10	0.13	2.00
	Other sheep	8	1.30	0.13	1.81
<b>3.B.3</b>	<b><i>SWINE</i></b>				
	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

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 <sub>4</sub> producing capacity for manure produced by an animal within defined population <i>i</i> , m <sup>3</sup> /kg of VS (B <sub>0</sub> )	Urinary energy expressed as fraction of GE
<b>3.B.4.1</b>	<b><i>BUFFALO</i></b>				
	Buffalo milk	8	6.76	0.1	10.78
	Other buffalo	8	3.12	0.1	5.15
<b>3.B.4.3</b>	<b><i>GOATS</i></b>				
	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
<b>3.B.4.4</b>	<b><i>HORSES</i></b>	8	5.87	0.26	9.03
<b>3.B.4.5</b>	<b><i>MULES AND ASSES</i></b>	8	4.64	0.26	7.24
<b>3.B.4.6</b>	<b><i>POULTRY</i></b>				
	Adult poultry for eggs	8	0.02	0.24	0.03
	Poultry for meat	8	0.02	0.24	0.02

**Table 5.12** *The values used in the calculation of emissions factors from Manure management for 1989-1990, 1995, 2000, 2005, 2007–2016 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
<b>3.B.1.1 Dairy cattle</b>		
<b>1989</b>	4.51	8.22
<b>1990</b>	4.60	8.40
<b>1995</b>	5.40	9.84
<b>2000</b>	5.58	10.19
<b>2005</b>	5.80	10.58
<b>2007</b>	5.85	10.67
<b>2008</b>	5.90	10.77
<b>2009</b>	5.81	10.60
<b>2010</b>	5.94	10.82
<b>2011</b>	6.04	11.01
<b>2012</b>	5.95	10.86
<b>2013</b>	5.97	10.88
<b>2014</b>	6.00	10.94
<b>2015</b>	5.93	10.82
<b>2016</b>	5.86	10.68

**Table 5.13 The values MCF used in calculation of emissions factor for each manure system management for all livestock in the 1989-2016 period**

The period 1989-2016	CH <sub>4</sub> 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 1989-2016 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 1989-2016 period (from 0.3 to 0.58 kg CH<sub>4</sub>/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<sub>4</sub> 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 above.

***Activity data***

They were used the same activity data as for calculation of CH<sub>4</sub> emissions from enteric fermentation. Data are presented in Chapter 5.2.2.

**N<sub>2</sub>O emissions****Direct N<sub>2</sub>O 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) (N<sub>ex</sub>), 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<sub>3</sub> - 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<sub>2</sub>O 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) (N<sub>ex</sub>), 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<sub>3</sub> (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<sub>2</sub>O emission factors used in the calculation the emissions N<sub>2</sub>O from manure management are presented in Table 5.14 depending to manure management system.

**Table 5.14 N<sub>2</sub>O emission factors [kg N<sub>2</sub>O-N/kg N excreted] for animal waste per AWMS**

<b>AWMS (source) type</b>	<b>Emission factor EF<sub>3</sub> [kg N<sub>2</sub>O-N/kg N excreted]</b>
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<sub>4</sub> 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***

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

The MS values were established by expert opinion in the context of the above study.

In the Table 5.15 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 5.15 Data necessary for calculating the rate of excretion of nitrogen, in the 1989-2016 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)
<b>3 B1</b>	<b>CATTLE</b>					
<b>3 B.1.1.a</b>	<i>Dairy cattle</i>	23.5	9	0.4031	0.58	53.63
<b>3 B1. 1.b</b>	<i>Non dairy cattle</i>					

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 Nex (kg N/animal/yr)
	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 for sacrificed older than 2 years	23.5	9	0.4031	0.58	53.63
	Cattle for work	23.5	9	0.4031	0.58	53.63
<b>3 B.1.2</b>	<b><i>SHEEP</i></b>					
	Ewes of milk and fitted	1.1	0.7	0.8	0.43	4.3



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 <sub>ex</sub> (kg N/animal/yr)
	Reproducers rams	1.183	0.7	0.8	0.43	4.55
	Other sheep	1.183	0.7	0.8	0.43	4.55
<b>3 B.1.3</b>	<b>SWINE</b>					
	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
<b>3 B.1.4.2</b>	<b>BUFFALO</b>					
	Female buffalo	23.5	9	0.4031	0.58	53.63
	Other buffalo	23.5	9	0.4031	0.58	53.63
<b>3 B.1.4.3</b>	<b>GOATS</b>					
	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
<b>3 B.1.4.4</b>	<b>HORSES</b>	16	3.6	0.6	1.55	55.4
<b>3 B.1.4.5</b>	<b>MULES AND</b>	11	2.2	0.6	1.55	36.53

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 <sub>ex</sub> (kg N/animal/yr)
	<i>ASSES</i>					
<b>3 B.1.4.6</b>	<b><i>POULTRY</i></b>					
	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<sub>4</sub> 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 1989-2016 is consistent.

### ***Direct N<sub>2</sub>O 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 1989-2016 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<sub>4</sub> emissions***

Was made recalculation at the level of the CH<sub>4</sub> emissions due to an errors of transcription for the 2015 year for swine.

The implications of all changes made on emission estimates are described in the Table 5.16.

***Table 5.16 Recalculations on CH<sub>4</sub> emission estimates***

<b>Year</b>	<b>2017 submission CH<sub>4</sub> (Gg) emissions</b>	<b>2018 submission CH<sub>4</sub> (Gg) emissions</b>	<b>Difference</b>
<b>2015</b>	64.1668	64.1205	-0.0462

### *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<sub>4</sub> 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

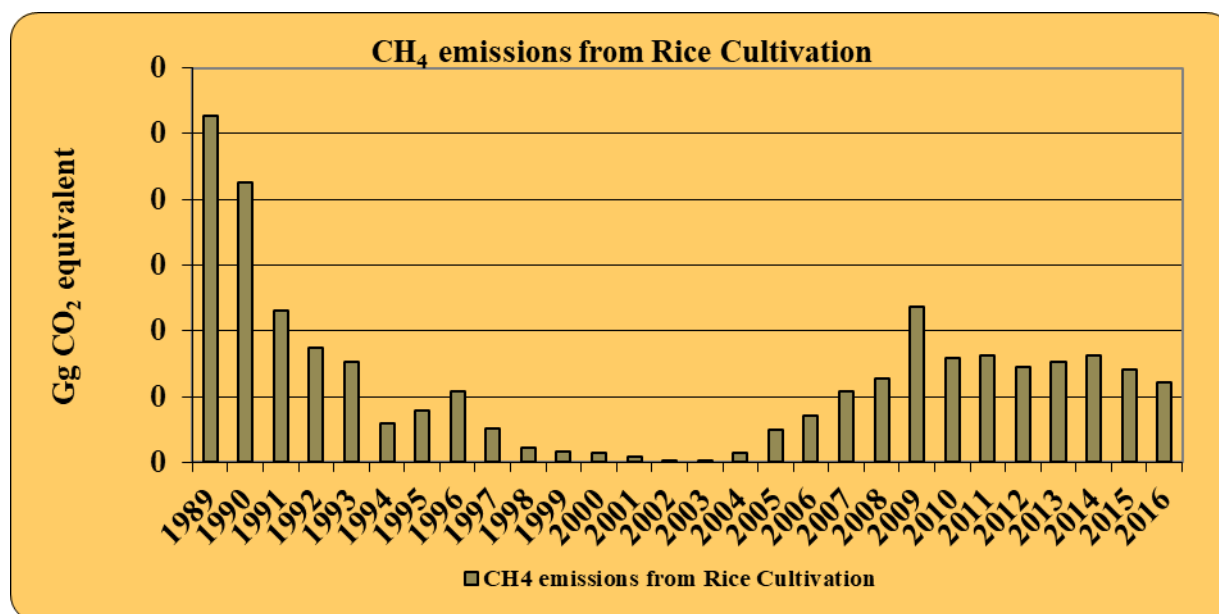
Anaerobic decomposition of organic material in flooded rice fields produces methane. Methane escapes to the atmosphere primarily by transport through the rice plants and its flux depends upon the input of organic carbon, water regimes, time and duration of drainage, soil type, etc.

#### ***Rice Cultivation:***

- ❖ is the smallest source of  $CH_4$  emissions in the Agriculture sector (in 2016,  $CH_4$  emissions from Rice Cultivation represented 0.00009% of total  $CH_4$  emissions in the Agriculture sector);
- ❖ is the smallest source in the Agriculture sector (in 2016,  $CH_4$  emissions from Rice Cultivation as  $CO_2$  equivalent represented 0.00006% from Total Agriculture emissions);
- ❖ contributed with 0.000010% 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 2016 the rice area cultivated is 9.2 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 5.17 Observations on source category 4C – “Rice Cultivation”**

Source indicative	Source type	Observation	Data source
3.C.1.2	Rice harvested area		AD: SY, NIS, 1989-2016; 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  $1.30 \text{ kg CH}_4 \text{ ha}^{-1} \text{ day}^{-1}$ ;
- ❖ 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 5.18.

***Table 5.18 Rice residues productivity values and default values for the scaling factor to account for the type and amount of amendment applied ( $SF_o$ ) for 1989-1990, 1995, 2000, 2005, 2007–2016 period***

<b>Year</b>	<b>Rice residues productivity [tones d.m./ha]</b>	<b>Scaling factor to account for the type and amount of amendment applied (<math>SF_o</math>)</b>
<b>1989</b>	1.07	1.5
<b>1990</b>	1.25	1.5
<b>1995</b>	2.92	1.8
<b>2000</b>	1.93	1.5
<b>2005</b>	2.75	1.8
<b>2007</b>	2.46	1.8
<b>2008</b>	3.70	1.8
<b>2009</b>	4.08	2.5

Year	Rice residues productivity [tones d.m./ha]	Scaling factor to account for the type and amount of amendment applied (SF <sub>O</sub> )
2010	3.72	1.8
2011	3.86	1.8
2012	3.37	1.8
2013	3.43	1.8
2014	2.66	1.8
2015	3.36	1.8
2016	3.46	1.8

### *Activity data*

Total rice cultivated area is provided by Romanian National Institute for Statistics (NIS) being released through Statistical Yearbook 1989-2016.

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 5.19.

***Table 5.19 Harvested area data series for 1989-2016***

Year	Harvested area [10 <sup>8</sup> m <sup>2</sup> ]
1989	4.93
1990	3.99
1995	0.62
2000	0.14
2005	0.39
2007	0.84
2008	0.99
2009	1.33
2010	1.24



Year	Harvested area [ $10^8 \text{ m}^2$ ]
2011	1.27
2012	1.13
2013	1.19
2014	1.27
2015	1.11
2016	0.94

#### 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 1989-2016 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 2016,  $N_2O$  Direct soil emissions represented 65.89% of total  $N_2O$  emissions in the Agriculture sector);
- ❖ is the first source in the Agriculture sector (in 2016,  $N_2O$  Direct soil emissions as  $CO_2$  equivalent represented 20.72% from Total Agriculture emissions);
- ❖ contributed with 3.37% 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.

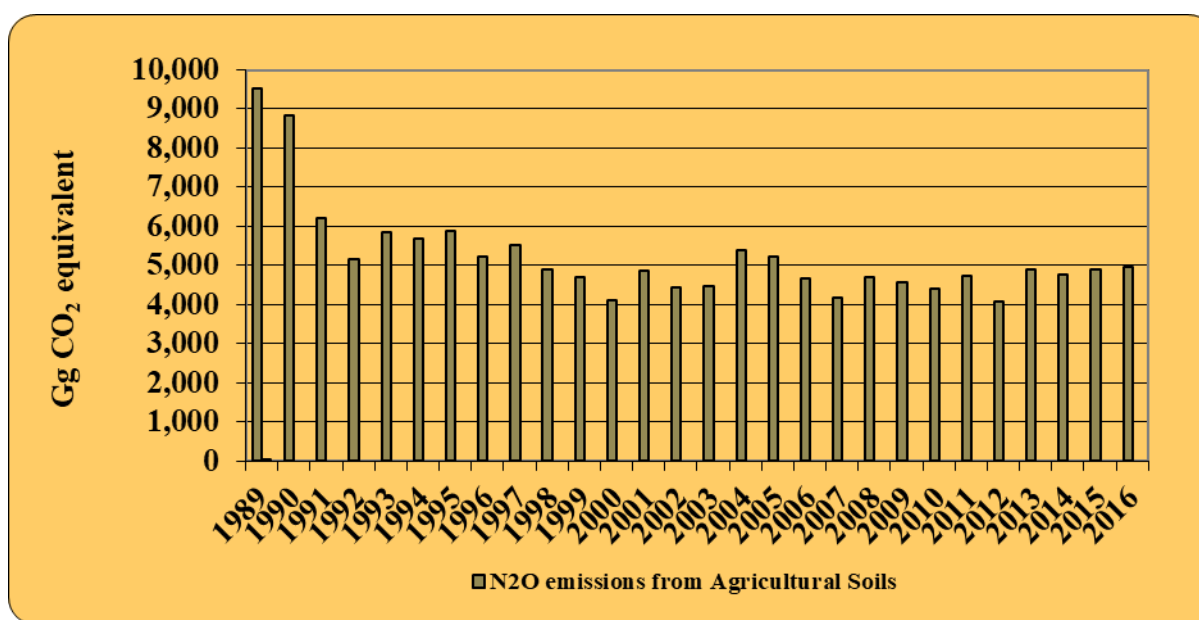
The amount of N<sub>2</sub>O emissions from application of synthetic fertilizers have decreased from 9.41 kt N<sub>2</sub>O in 1989, to 4.87 kt N<sub>2</sub>O in 2016.

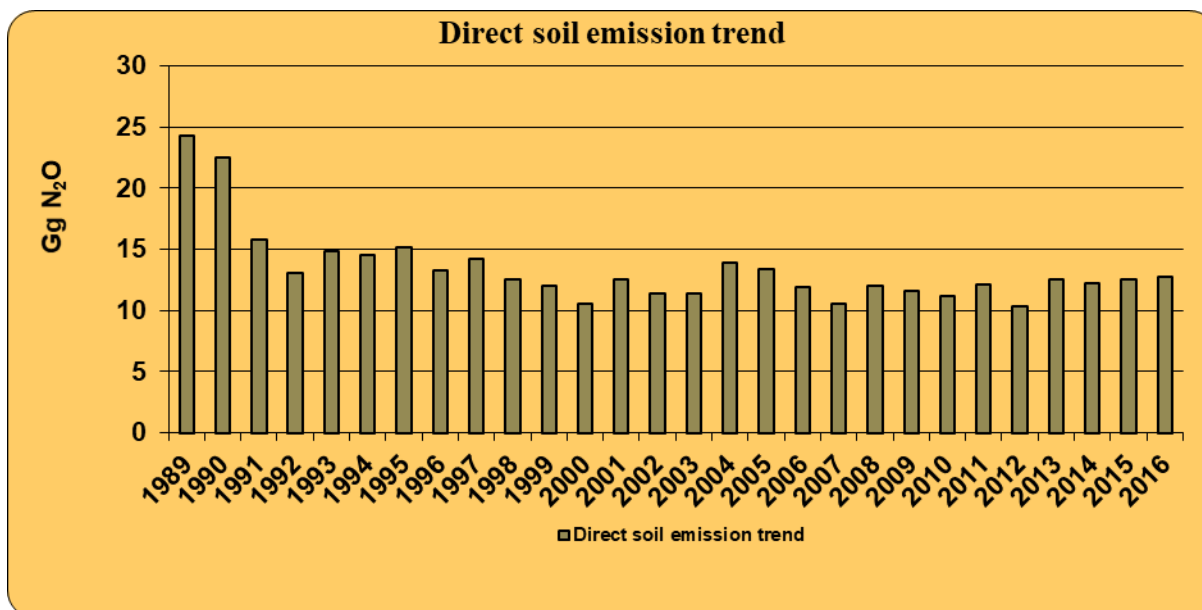
The quantity of synthetic fertilizer has decreased considerably after the 1989 year from 665,300 tonnes/year to 344,311 tonnes/year. This decrease is reflected in the decrease of the nitrogen fraction volatilized into the atmosphere as N<sub>2</sub>O. The main cause was a decrease of crop production and the inability of farmers to use the agricultural technology correctly.

The amount of N<sub>2</sub>O 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<sub>2</sub>O in 1989, to 2.27 kt N<sub>2</sub>O in 2016.

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<sub>2</sub>O emissions trends – Agricultural Soils*

**Table 5.20 Observations on source category 3D – “Managed Soils”**

Source indicative	Source (livestock) type	Observation	Data source
<b>3.D.1, 3.D.2</b>	Amount of N synthetic fertilizer used		AD: SY, NIS, 1989-2016; EF: IPCC 2006
<b>3.D.1.2.a, 3.D.1.3, 3.D.2</b>	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, 2004-2016; The study „ <i>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</i> “ EF: IPCC 2006, Country specific, expert judgment
<b>3.D.1.4</b>	Production crops	Includes following crops: <i>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</i>	AD: SY, other correspondence, NIS, 1989 -2016; The study „ <i>Elaboration of national emission factors /other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and</i>

Source indicative	Source (livestock) type	Observation	Data source
		<i>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.</i>	Waste, to allow for the higher tier calculation methods“. EF: IPCC 2006
	Area crop	Includes following crops: <i>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.</i>	AD: NIS, 1989 -2016; EF: IPCC 2006

Source indicative	Source (livestock) type	Observation	Data source
	Area burnt	Includes following crops: <i>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.</i>	AD: NIS, 1989 -2016; expert judgment EF: IPCC 2006
3.D.1.6	Area of cultivated organic soils		AD: The Report of National Research Institute for Soil Agrochemical and Environment Protection EF: IPCC 2006



### 5.5.2 Methodological issues

#### *N<sub>2</sub>O 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<sub>2</sub>O-N/kg N);
- ❖  $EF_2 = 8$  (value specific to Middle-Latitude Organic Soils; kg N<sub>2</sub>O-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<sub>3</sub> and NO<sub>x</sub> (F<sub>SN</sub>)**

The amount of synthetic fertilizer applied to soils data are provided by Romanian National Institute for Statistics (NIS) being released through Statistical Yearbook 1989-2016.

Data series are presented in Table 5.21.

Default value of **Frac<sub>GASF</sub>** 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  $F_{ON}$  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 ( $F_{racLossMS}$ ) is used the default value from IPCC 2006 (Table 10.23), and the amount of nitrogen from bedding ( $N_{bedding}$ ) is used the value 0, it is not known organic bedding.

For fractions of managed manure used for feed ( $F_{racFEED}$ ), fraction of managed manure used for fuel ( $F_{racFUEL}$ ) and fraction of managed manure used for construction ( $F_{racCNST}$ ) 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 5.21 Activity data series used for calculation of  $F_{SN}$ , , for 1989-1990, 1995, 2000, 2005,2007–2016 period**

Year	Amount of synthetic fertilizer applied to soil [thousands tonnes/year]
1989	665.3
1990	656.0
1995	306.0
2000	239.0

Year	Amount of synthetic fertilizer applied to soil [thousands tonnes/year]
2005	299.0
2007	265.0
2008	279.8
2009	296.0
2010	306.0
2011	313.0
2012	289.9
2013	344.0
2014	303.0
2015	357.0
2016	344.1

#### 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 1989-2016 and data base. Crop production of nitrogen fixing crop are presented in Table 5.22.

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 fodder total* (the sum plant used silage with annual green fodder).

**Table 5.22 The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989-1990, 1995, 2000, 2005, 2007–2016 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
<b>1989</b>	98,500	143,600	255,900	303,900	9,705,200	6,096,600	15,801,800	11,131,700
<b>1990</b>	49,395	57,542	112,116	141,173	6,882,641	7,520,906	14,403,547	8,057,219
<b>1995</b>	54,262	41,769	97,017	107,861	4,127,358	1,892,078	6,019,436	7,081,202
<b>2000</b>	14,159	21,803	36,929	69,473	2,840,370	476,958	3,317,328	5,120,710
<b>2005</b>	39,096	41,733	80,913	312,781	IE	IE	2,454,958	6,274,555
<b>2007</b>	17,748	18,014	36,185	136,094	IE	IE	2,222,483	4,166,344
<b>2008</b>	36,917	25,157	62,466	90,579	IE	IE	2,860,655	5,505,795
<b>2009</b>	30,009	22,348	52,918	84,268	IE	IE	2,898,188	5,642,588
<b>2010</b>	39,677	21,059	61,344	149,940	IE	IE	3,041,978	5,799,305
<b>2011</b>	55,076	21,351	76,830	142,636	IE	IE	3,371,352	6,015,839
<b>2012</b>	45,878	16,603	62,934	104,330	IE	IE	3,043,519	4,836,406
<b>2013</b>	54,600	18,900	74,214	149,900	IE	IE	3,346,435	5,480,516
<b>2014</b>	51,000	19,700	71,400	202,900	IE	IE	3,389,600	6,071,232
<b>2015</b>	55,300	19,900	75,800	262,000	IE	IE	3,032,300	5,653,900
<b>2016</b>	78,808	19,087	99,312	263,380	IE	IE	2,715,401	5,505,202

**Table 5.22 (continued) The primary data on Crop production of nitrogen fixing crop obtained from the NIS, in the 1989-1990, 1995, 2000, 2005, 2007–2016 period**

Year	Crop production of nitrogen fixing crop (tonnes/year)		
	Clover in equivalent green fodder	Other perennial forage	Perennial forage
<b>1989</b>	2,937,100	3,988,200	18,057,000
<b>1990</b>	1,926,004	2,980,701	12,963,924
<b>1995</b>	2,367,015	2,761,694	12,209,911
<b>2000</b>	2,018,423	2,072,818	9,211,951
<b>2005</b>	1,601,385	2,251,574	10,127,514
<b>2007</b>	1,463,864	1,700,004	7,330,212
<b>2008</b>	1,751,484	2,016,050	9,273,329
<b>2009</b>	1,786,509	2,032,409	9,461,506
<b>2010</b>	1,949,735	2,224,993	9,974,033
<b>2011</b>	2,001,723	2,644,119	10,661,681
<b>2012</b>	1,598,254	2,047,590	8,482,250
<b>2013</b>	1,873,522	2,345,173	9,699,211
<b>2014</b>	1,888,412	2,534,297	10,493,941
<b>2015</b>	1,633,300	2,400,600	9,687,800
<b>2016</b>	1,521,715	2,328,189	9,355,106

**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 5.22 (NIS) for the calculation  $F_{CR}$  are used the data on Crop production of nitrogen fixing crop presented in the Table 5.22. 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 5.23 The data on Crop production of nitrogen fixing crop obtained through the dedicated study (tonnes/year), in the 1989-1990, 1995, 2000, 2005, 2007–2016 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
<b>1989</b>	98,500	143,600	13,800	303,900	11,131,700	2,937,100	4,740,540	1,595,280
<b>1990</b>	49,395	57,542	5,179	141,173	8,057,219	1,926,004	4,321,064	1,192,280
<b>1995</b>	54,262	41,769	986	107,861	7,081,202	2,367,015	1,805,831	1,104,678
<b>2000</b>	14,159	21,803	967	69,473	5,120,710	2,018,423	995,198.4	829,127.2
<b>2005</b>	39,096	41,733	84	312,781	6,274,555	1,601,385	736,487.4	900,629.6
<b>2007</b>	17,748	18,014	423	136,094	4,166,344	1,463,864	666,744.9	680,001.6
<b>2008</b>	36,917	25,157	392	90,579	5,505,795	1,751,484	858,196.5	806,420
<b>2009</b>	30,009	22,348	561	84,268	5,642,588	1,786,509	869,456.4	812,963.6
<b>2010</b>	39,677	21,059	608	149,940	5,799,305	1,949,735	912,593.4	889,997.2
<b>2011</b>	55,076	21,351	403	142,636	6,015,839	2,001,723	1,011,406	1,057,648
<b>2012</b>	45,878	16,603	453	104,330	4,836,406	1,598,254	913,056	819,036
<b>2013</b>	54,600	18,900	714	149,900	5,480,516	1,873,522	1,003,930	938,069
<b>2014</b>	51,000	19,700	700	202,900	6,071,232	1,888,412	1,016,880	1,013,719

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
<b>2015</b>	55,300	19,900	600	262,000	5,653,900	1,633,300	909,690	960,240
<b>2016</b>	78,808	19,087	1,417	263,380	5,505,202	1,521,715	814,620	921,276

*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 5.24.

*Table 5.24 The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-1990, 1995, 2000, 2005,2007–2016 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
<b>1989</b>	0	0	3,436,300	167,800	6,761,800	7,600	70,100	18,379,300
<b>1990</b>	89,678	7,289,344	2,679,558	23,4025	6,809,604	3,500	66,460	17,173,539
<b>1995</b>	42,728	7,666,538	1,816,267	404,428	9,923,132	4,408	24,066	19,882,827
<b>2000</b>	21,802	4,434,438	867,018	243,830	4,897,603	1,479	3,551	10,477,506
<b>2005</b>	48,962	7,340,664	1,079,148	377,456	10,388,499	1,912	14,251	19,345,464
<b>2007</b>	20,583	3,044,465	531,420	251,633	3,853,918	1,193	27,518	7,814,825
<b>2008</b>	31,446	7,180,984	1,209,411	382,030	7,849,083	20,899	48,917	16,826,441
<b>2009</b>	32,959	5,202,526	1,182,062	295,832	7,973,258	14,440	72,418	14,872,952

Year	Productions of non-N-fixing crops (tonnes/year)							
	Rye	Wheat	Barley and two-row barley	Oats	Maize grains	Sorghum	Rice	Total Cereal grains
2010	34,281	5,811,810	1,311,035	304,462	9,042,032	18,677	61,588	1,6712,883
2011	31,382	7,131,590	1,329,692	375,855	11,717,591	39,696	65,261	20,842,160
2012	18,236	5,297,748	986,361	338,998	5,953,352	37,481	50,862	12,824,138
2013	23,812	7,296,400	1,542,200	373,800	11,305,100	49,800	54,600	20,897,100
2014	24,400	7,584,800	1,712,500	381,600	11,988,600	51,500	45,200	22,070,700
2015	24,300	7,962,400	1,623,200	344,200	8,984,700	31,700	49,800	19,286,200
2016	25,931	8,431,131	1,817,269	381,359	10,746,387	24,413	43,635	21,764,816

*Table 5.24 (continued) The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-1990, 1995, 2000, 2005, 2007–2016 period*

Year	Productions of non-N-fixing crops (tonnes/year)							
	Wheat and rye	Triticale	Rape	Sunflower	Flax for oil	Total Oilseed plants	Soy beans	In fiber-textile plants
1989	7,935,200	0	18,000	655,800	48,900	1,034,300	303,900	127,200
1990	7,379,022	0	10,860	556,242	28,040	739,319	141,173	53,192
1995	7,709,266	0	357	932,932	4,744	1,055,371	107,861	7,246
2000	4,456,240	7,431	76,126	720,871	994	868,531	69,473	881
2005	7,389,626	94,142	147,566	1,340,940	55	1,803,080	312,781	538
2007	3,065,048	81,768	361,500	546,922	394	1,046,558	136,094	72
2008	7,212,430	100,818	673,033	1,169,936	221	1,942,289	90,579	96
2009	5,235,485	97,251	569,611	1,098,047	1,099	1,764,047	84,268	0
2010	5,846,091	123,120	943,033	1,262,926	1,817	2,377,651	149,940	0



Year	Productions of non-N-fixing crops (tonnes/year)							
	Wheat and rye	Triticale	Rape	Sunflower	Flax for oil	Total Oilseed plants	Soy beans	In fiber-textile plants
2011	7,162,972	144,800	738,971	1,789,326	2,626	2,686,860	142,636	0
2012	5,315,984	133,931	157,511	1,398,203	3,553	1,667,601	104,330	20
2013	7,320,212	245,027	666,100	2,142,100	4,046	2,966,621	149,900	36
2014	7,609,200	275,219	1,059,100	2,189,300	2,600	3,460,600	202,900	0
2015	7,986,700	262,143	919,500	1,785,800	3,600	2,975,200	262,000	241
2016	8,457,062	287,326	1,292,779	2,032,340	3,159	3,596,831	263,380	79

*Table 5.24 (continued) The primary data on Crop production of non- nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-1990, 1995, 2000, 2005, 2007–2016 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
1995	5,862	21	13,358	1,823	12,114	11,156	3,019,921	2,654,610
2000	1,398	0	10,869	142	1,397	6,300	3,469,805	666,870
2005	4,698	0	3,682	194	3,297	6,712	3,738,594	729,658
2007	479	0	1,128	374	2,857	5,437	3,712,410	748,839
2008	181	0	2,366	257	7,488	3,170	3,649,020	706,660
2009	2	0	1,566	245	7,063	6,006	4,003,980	816,814
2010	45	0	2,971	232	15,828	5,392	3,283,866	837,895

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
2011	9	0	2,562	117	11,157	7,288	4,076,570	660,497
2012	0	0	1,341	173	4,293	5,793	2,465,150	719,788
2013	31	0	1,357	172	4,397	6,191	3,289,722	1,029,209
2014	2,253	0	1,405	268	4,219	6,290	3,519,329	1,398,570
2015	1,900	0	1,100	224	4,200	11,600	2,625,000	1,040,600
2016	3,673	0	1,656	208	5,627	5,668	2,689,733	1,012,186

*Table 5.24 (continued) The primary data on Crop production of non - nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-1990, 1995, 2000, 2005,2007–2016 period*

Year	Productions of non-N-fixing crops (tonnes/year)							
	Fodder roots	Tomatoes	Eggplant	Dry onion	Dry garlic	Cabbage	Green peppers	Cultivated mushrooms
1989	4,094,200	1,011,300	0	412,700	46,600	877,300	253,300	0
1990	2,575,013	813,561	51,951	225,440	30,611	551,914	182,033	0
1995	1,332,449	730,945	88,506	362,969	69,476	824,412	195,648	600
2000	800,587	628,675	94,823	296,297	68,338	731,897	174,836	3
2005	711,939	626,960	97,902	363,625	68,374	1,009,430	203,751	563
2007	594,956	640,785	63,716	324,993	49,948	893,153	184,939	1,083
2008	756,292	814,376	153,677	395,579	72,333	964,625	238,682	1,664
2009	567,499	755,596	168,588	378,106	63,245	1,001,940	245,661	7,317
2010	489,740	768,532	144,391	369,142	67,215	981,219	243,493	9,973
2011	555,341	910,978	160,010	394,305	66,602	1,025,293	253,505	7,661
2012	335,497	683,282	126,005	345,340	59,368	987,900	207,072	9,311

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
2016	335,811	627,177	116,225	325,074	54,389	992,398	201,881	14,519

*Table 5.24 (continued) The primary data on Crop production of non- nitrogen fixing crop obtained from the NIS (tonnes/year), in the 1989-1990, 1995, 2000, 2005,2007–2016 period*

Years	Productions of non-N-fixing crops (tonnes/year)						
	Root vegetables – Edible roots	Water melons and melons	Total vegetables	Annual green fodder	Plant used for silage	Annual green fodder new	Total Perennial forage
1989	251,900	215,700	4,195,600	9,705,200	6,096,600	15,801,800	18,057,000
1990	158,554	381,585	3,051,200	6,882,641	7,520,906	14,403,547	12,963,924
1995	281,339	639,352	3,868,500	4,127,358	1,892,078	6,019,436	12,209,911
2000	253,853	531,127	3,381,100	2,840,370	476,958	3,317,328	9,211,951
2005	229,569	691,760	3,624,612	IE	IE	2,454,958	10,127,514
2007	209,029	407,973	3,116,801	IE	IE	2,222,483	7,330,212
2008	265,999	562,260	3,819,890	IE	IE	2,860,655	9,273,329
2009	238,748	652,844	3,901,862	IE	IE	2,898,188	9,461,506
2010	241,578	662,863	3,863,617	IE	IE	3,041,978	9,974,033
2011	275,145	645,486	4,176,298	IE	IE	3,371,352	10,661,681
2012	275,145	554,588	3,535,316	IE	IE	3,043,519	8,482,250
2013	242,265	634,786	3,960,990	IE	IE	3,346,435	9,699,211
2014	251,589	530,677	3,802,494	IE	IE	3,389,600	10,493,941
2015	227,004	506,000	3,629,600	IE	IE	3,032,300	9,687,800

Years	Productions of non-N-fixing crops (tonnes/year)						
	Root vegetables – Edible roots	Water melons and melons	Total vegetables	Annual green fodder	Plant used for silage	Annual green fodder new	Total Perennial forage
<b>2016</b>	219,232	477,556	3,358,389	IE	IE	2,715,401	9,355,106

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 5.24 (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 5.24.

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 5.24).

By expert opinion, the values for other grains were obtained from the difference between total cereal grains and the sum wheat and rye, barley and two-row barley, oats, maize, sorghum, rice and triticale.

The values for other oilseed plants (castor) were obtained from the difference between total oilseed plants and the sum rape, sunflower, flax for oil and soya beans.

By expert opinion, the values of *other textile plants* were taken from *castor*.

In the context of the study above, by expert opinion were taken from *sorghum for brooms*.

The values for *other vegetable* were obtained from the difference between *total vegetables* and

the sum *tomatoes, eggplant, dry onion, dry garlic, cabbage, green peppers, cultivated mushrooms, root vegetables – edible roots, water melons and melons.*

In the context of the study above, by expert opinion, were considered that the *annual green fodder new* the values of *annual grasses* represent 70%.

The productions of *annual green fodder new* were obtained from the of sum *annual green fodder* and *plant used for silage*. In the context of the study above, by expert opinion, were considered that the *other perennial forage* the values of *other perennial grasses* represent 60%.

The values for *other perennial forage* were obtained from the difference between *total perennial forage* and the sum *the lucerne in equivalent green fodder* and *clover in equivalent green fodder*.

The values associated the nitrogen fixing crop used in the calculation  $F_{CR}$  are presented in the Table 5.25.

*Above-ground residues dry matter (AG<sub>DM</sub>)* has calculated with the formula in Table 11.2 in IPCC 2006, pg.11.17 using the default value for  $AG_{DMslope}$  and  $AG_{DMintercept}$  in the same table and for the N content of above-ground residues for crop ( $N_{AG}$ ), N content of below-ground residues for crop ( $N_{BG}$ ) and ratio of below-ground residues above-ground biomass ( $R_{BG-BIO}$ ), dry matter has fraction ( $Frac_{DM}$ ) used the default value in Table 11.2 (IPCC 2006).

Data on **Area crops** (ha) and **Area burnt** were presented in Anexe 3.5.

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 5.25 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 1989-2016 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
$Frac_{DM}$	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 5.26 are presented the values associated the nitrogen non fixing crop used in the calculation  $F_{CR}$ .

**Table 5.26** *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 1989-2016 period*

Parameters	<i>The values associated the nitrogen non fixing crop in the calculation <math>F_{CR}</math></i>							
	Rye	Wheat	Barley and two-row barley	Oats	Maize grains	Sorghum	Rice	Other cereals
<b><math>AG_{DM}</math> slope</b>	1.09	1.51	0.98	0.91	1.03	0.88	0.95	1.43
<b><math>AG_{DM}</math> intercept</b>	0.88	0.52	0.59	0.89	0.61	1.33	2.46	0.14
<b><math>R_{BG-BIO}</math> (kg d. m.)</b>	0	0.24	0.22	0.25	0.22	0	0.16	0
<b><math>N_{AG}</math> (kg d.m.)</b>	0.005	0.01	0.007	0.007	0.006	0.007	0.007	0.007
<b><math>N_{BG}</math></b>	0.011	0.01	0.01	0.01	0.01	0.01	0	0
<b><math>Frac_{Remove}</math></b>	0	0.25	0	0.20	0.20	0	0	0
<b><math>Frac_{DM}</math></b>	0.88	0.89	0.89	0.89	0.87	0.89	0.89	0.9
<b><math>Frac_{RENEW}</math></b>	1	1	1	1	1	1	1	1

**Table 5.26 (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 1989-2016 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
<b><math>AG_{DM}</math> slope</b>	0.93	0.93	0.93	0.93	0	0	0	0
<b><math>AG_{DM}</math> intercept</b>	1.35	1.35	1.35	1.35	0	0	0	0
<b><math>R_{BG-BIO}</math> (kg d. m.)</b>	0.19	0.19	0.19	0.19	0	0	0	0
<b><math>N_{AG}</math> (kg d.m.)</b>	0.008	0.008	0.008	0.008	0	0	0	0
<b><math>N_{BG}</math></b>	0.01	0.01	0.01	0.01	0	0	0	0
<b><math>Frac_{Remove}</math></b>	0.40	0.40	0.10	0	0.30	0.30	0.30	0
<b><math>Frac_{DM}</math></b>	0.91	0.91	0.91	0.91	0.85	0.85	0.85	0.85
<b><math>Frac_{RENEW}</math></b>	1	1	1	1	1	1	1	1



**Table 5.26 (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 1989-2016 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
<b><math>AG_{DM}</math> slope</b>	0	0	0.88	0.1	1.07	1.07	0.1	0.1	0
<b><math>AG_{DM}</math> intercept</b>	0	0	1.33	1.06	1.54	1.54	1.06	1.06	0
<b><math>R_{BG-BIO}</math> (kg d. m.)</b>	0	0	0	0.2	0.2	0.2	0.2	0.2	0
<b><math>N_{AG}</math> (kg d.m.)</b>	0	0	0.007	0.019	0.016	0.016	0.019	0.019	0
<b><math>N_{BG}</math></b>	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0
<b><math>Frac_{Remove}</math></b>	0	0	0.10	0	0.40	0	0	0	0
<b><math>Frac_{DM}</math></b>	0.85	0.85	0.89	0.22	0.94	0.94	0.85	0.22	0.85
<b><math>Frac_{RENEW}</math></b>	1	1	1	1	1	1	1	1	1

**Table 5.26 (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 1989-2016 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
<b><math>AG_{DM}</math> slope</b>	0	0	0.1	0	1.07	0	0.1	0.3	0.3
<b><math>AG_{DM}</math> intercept</b>	0	0	1.06	0	1.54	0	1.06	0	0
<b><math>R_{BG-BIO}</math> (kg d. m.)</b>	0	0	0.2	0	0.2	0	0.2	0.8	0.8
<b><math>N_{AG}</math> (kg d.m.)</b>	0	0	0.019	0	0.016	0	0.019	0.015	0.015
<b><math>N_{BG}</math></b>	0	0	0.01	0	0.01	0	0.01	0.01	0.01
<b><math>Frac_{Remove}</math></b>	0	0	0	0	0.10	0	0	0	0
<b><math>Frac_{DM}</math></b>	0.85	0.85	0.22	0.85	0.94	0.85	0.22	0.90	0.90
<b><math>Frac_{RENEW}</math></b>	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 1989-2016 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<sub>CDM</sub>**

Were used the default values from the Table 11.2 (IPCC 2006) and the national values based on data presented in national bibliography.

### **Frac<sub>Renew</sub>**

By expert opinion, fraction of total area under crop that is 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 through 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 through 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 (**FracPRP**) were used the same livestock population numbers as for calculation of CH<sub>4</sub> emissions from enteric fermentation and annual average N excretion per head and fraction of total annual N excretion for each livestock as for calculation of N<sub>2</sub>O 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<sub>CR</sub>); 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 1989-2016 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  $\text{NH}_3$  and  $\text{NO}_x$ , specific to synthetic fertilizers nitrogen adjusted for volatilization ( $\text{Frac}_{\text{GASF}}$ );
- ❖ fraction that volatilizes as  $\text{NH}_3$  and  $\text{NO}_x$ , specific to animal manure nitrogen used as fertilizer, adjusted for volatilization ( $\text{Frac}_{\text{GASM}}$ );
- ❖ national values for activity data in totality;
- ❖ fraction of N input that is last through leaching and runoff ( $\text{Frac}_{\text{LEACH}}$ ).

## **5.6 Prescribed Burning of Savannas (CRF 3.E)**

Prescribed Burning of Savannas does not occur in Romania.

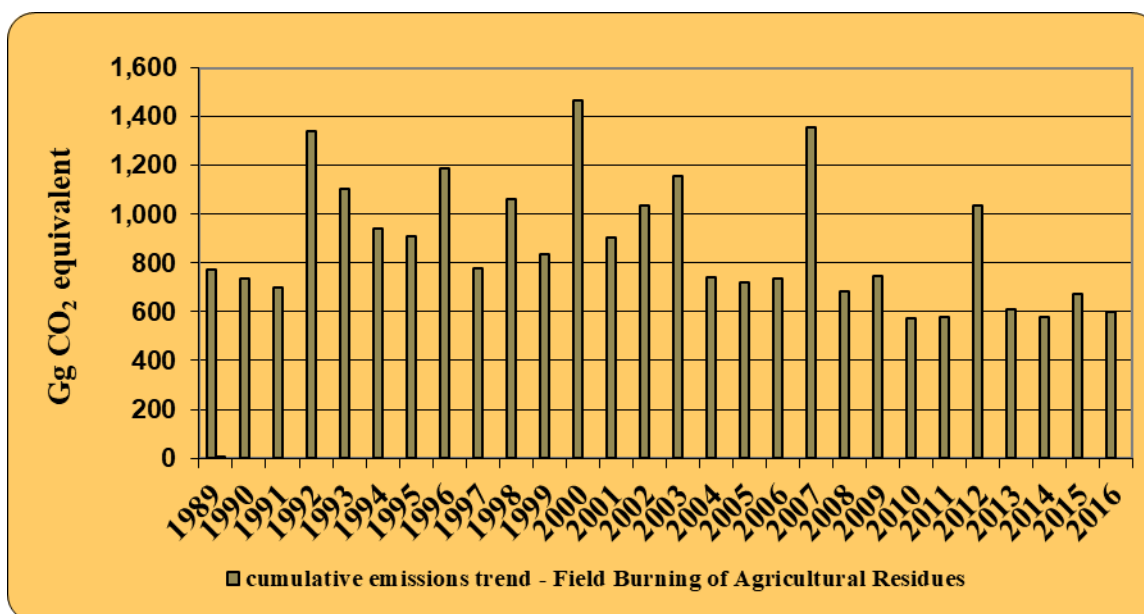
## **5.7 Field Burning of Agricultural Residues (CRF 3.F)**

### *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 2016 are lower than emissions in 1989 with 22.90%, due to the lower agricultural yields.

**Figure 5.9 Cumulative emissions trend - Field Burning of Agricultural Residues****Table 5.27 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, 1989-2016; the study „ <i>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</i> “ EF: IPCC 2006.

### 5.7.2 Methodological issues

#### **Methodology**

Due to the fact that CH<sub>4</sub> and N<sub>2</sub>O 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 5.28 Default emission ratios for agricultural residue burning of residues calculations**

Gas	Default IPCC 1996 emission ratios
Methane (CH <sub>4</sub> )	2.7
Nitrous oxide (N <sub>2</sub> O)	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<sub>2</sub>O 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 1989-2016 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.

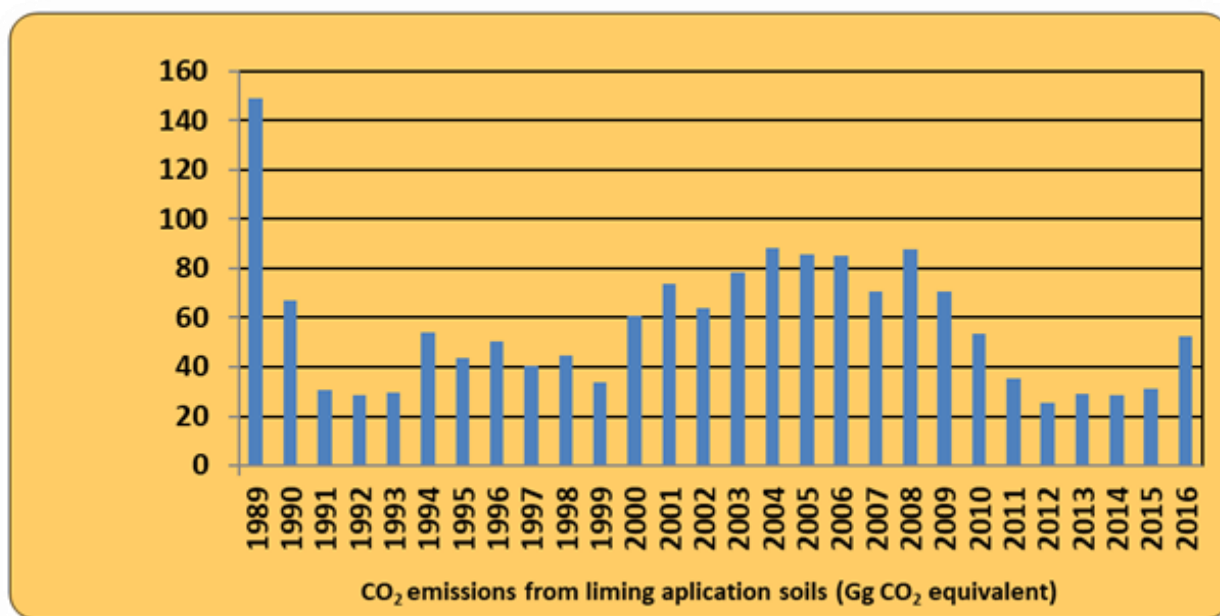
## **5.8 Liming (CRF 3G)**

### *5.8.1 Category description*

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (calcil limestone  $\text{CaCO}_3$  or dolomite  $\text{CaMg}(\text{CO}_3)_2$  leads to  $\text{CO}_2$  emissions as the carbonate limes dissolve and release bicarbonate ( $2\text{HCO}_3$ ), which evolves into  $\text{CO}_2$  and water ( $\text{H}_2\text{O}$ ). The

emissions decreasing until 1993 then begin to fluctuate in according with the decreasing and increasing of annual amount of calcic limestone  $\text{CaCO}_3$ .

**Figure 5.10  $\text{CO}_2$  emissions from liming application soils**



### 5.8.2 Methodological issues

#### **Methodology**

Was applied the method of tier 1 applying the equation 11.12 from IPCC 2006, pg.11.27.

#### **Emission factor**

Were used default emissions factors from IPCC 2006 of 0.12 for limestone and 0.13 for dolomite.

#### **Activity data**

Annual amount of calcic limestone or dolomite have been provided by Ministry of Agriculture and Rural Development.

### *5.8.3 Uncertainties and time-series consistency*

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

- AD: 25 %;
- EF: 40 %;

Uncertainties were taken from IPCC 2006.

- 47.17 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation 3.1, page 3.2.8 from Chapter 3, Volume 1 of the IPCC 2006.

### *5.8.4 Category-specific QA/QC and verification, if applicable*

All quality control activities described in the QA/QC Programme were performed. A 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.

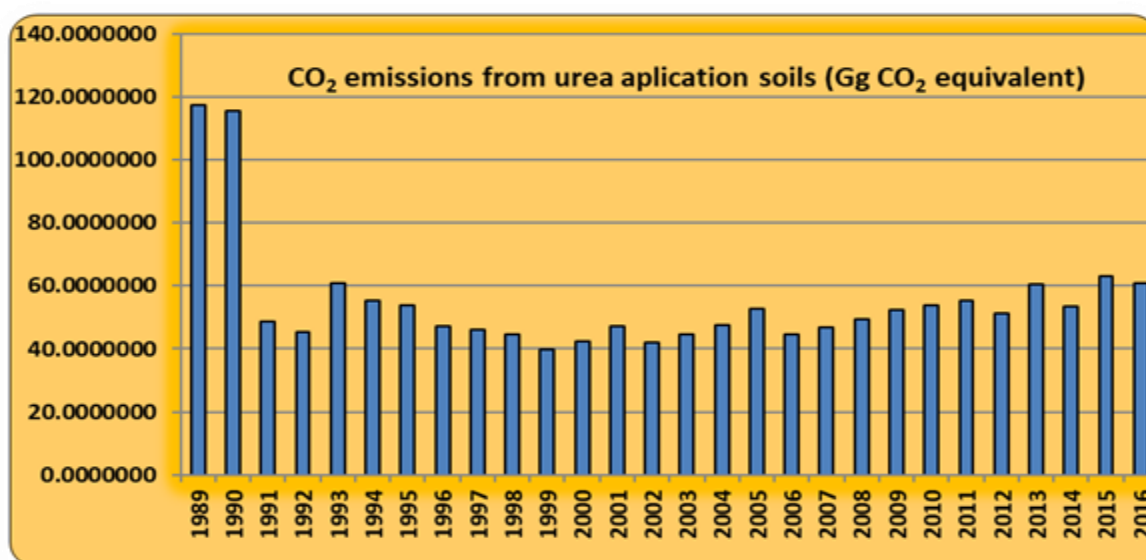
## 5.9 Urea fertilization (CRF 3H)

### 5.9.1 Category description

Adding urea to soils during fertilisation leads to a loss of CO<sub>2</sub> that was fixed in the industrial production process. Urea is converted into ammonium (NH<sub>4</sub>), hydroxyl in and bicarbonate that is formed evolves into CO<sub>2</sub> and water. This source is included because the CO<sub>2</sub> 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<sub>2</sub> emissions from Urea fertilization*



### 5.9.2 Methodological issues

#### Methodology

Was applied 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 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.

*5.9.5 Category-specific recalculation, including change made in response to the review process and impact on emission trend*

No recalculation was made.

*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**

According with the latest data provided by NIS, agricultural lands, including arable, orchards, vineyards, pastures and hayfields makes up 61.37% of Romania's total national area. Forests cover 28.24% while constructed areas and road/railways, cover some 4.81%, humid areas, water and lakes some 3.48% and other land 2.07%. The official statistics provide 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) - 2016**

IPCC Subcategories	Emission ("+") / removal ("-"), in kt CO <sub>2</sub> eq														
	BY(1989)	1990	1995	2000	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
<b>4.A.1. Forest land remaining Forest Land</b>	- 18356.7 6	- 21164.3 8	- 24205.1 6	- 23997.5 1	- 22696.1 1	- 21144.4 3	- 21382.6 4	- 21327.0 9	- 21269.4 0	- 21564.3 0	- 21581.0 6	- 21597.8 2	- 21614.5 8	- 18596.0 6	- 19677.3 0
<b>4.A.2. Land converted to Forest Land</b>	-3685.12	-3873.72	-3873.69	-3873.64	-3873.64	-3873.64	-3873.64	-3873.64	-3873.64	-3873.64	-3873.64	-3873.64	-3873.64	-4250.84	-4250.84
<b>4.B.1. Cropland remaining Cropland</b>	-3040.40	-3015.33	-2768.42	-2804.83	-2841.26	-2855.82	-2863.10	-2870.38	-2877.66	-2884.94	-2892.22	-2899.50	-2906.78	-2914.06	-2921.34
<b>4.B.2. Land converted to Cropland</b>	728.23	743.63	743.65	743.65	743.65	743.65	743.65	743.65	743.65	743.65	743.65	743.65	743.65	774.46	774.46
<b>4.C.1. Grassland remaining Grassland</b>	-1161.24	-1222.11	-1222.05	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98	-1221.98
<b>4.C.2. Land converted to Grassland</b>	1457.79	1423.26	1423.24	1423.24	1423.24	1423.24	1423.24	1423.24	1423.24	1423.24	1423.24	1423.24	1423.24	1354.17	1354.17
<b>4.D.1. Wetlands remaining Wetlands</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>4.D.2. Land converted to Wetlands</b>	1499.77	1515.65	1515.65	1515.66	1515.66	1515.66	1515.66	1515.66	1515.66	1515.66	1515.66	1515.66	1515.66	1502.16	1502.16
<b>4.E.1. Settlements remaining Settlements</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>4.E.2. Land converted to Settlements</b>	3590.56	3699.65	3699.64	3699.64	3699.64	3699.64	3699.64	3699.64	3699.64	3699.64	3699.64	3699.64	3699.64	3853.52	3853.52
<b>4.F.1. Other land remaining Other Land</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>4.F.2. Land converted to Other Land</b>	794.13	810.68	810.67	810.67	810.67	810.67	810.67	810.67	810.67	810.67	810.67	810.67	810.67	843.78	843.78
<b>4G. Harvested Wood Products</b>	-1704.22	-843.92	668.53	-910.12	-2199.52	-2411.51	-2598.33	-2565.68	-3807.07	-4000.00	-5710.84	-6279.00	-5914.85	-6725.43	-6576.32
<b>CH<sub>4</sub> emissions</b>	0.09	0.41	0.19	3.33	0.20	2.70	0.78	0.90	0.19	1.12	1.19	1.26	1.10	1.10	1.10
<b>N<sub>2</sub>O emissions</b>	1240.86	1331.75	1560.31	1722.72	1815.83	1835.48	1840.23	1842.96	1842.73	1843.03	1843.05	1843.08	1843.02	2017.64	2017.64

CO<sub>2</sub> removals have increased in forestland while CO<sub>2</sub> emissions from land converted to settlements have decreased compared to base year (1989). The major GHG is CO<sub>2</sub>, with non-CO<sub>2</sub> GHG having insignificant contributions (Table 6.2).

**Table 6.2 LULUCF GHG emissions and removals for the period 1989-2016 ('-'CO<sub>2</sub> removals, '+' GHG emissions, in kt)**

Reported year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub> , CO, NMVOC	SO <sub>2</sub>
<b>BY (1989)</b>	-19876	0.00	4.16	NA, NE	NA
<b>1990</b>	-21923	0.02	4.47	NA, NE	NA
<b>1995</b>	-23206	0.01	5.24	NA, NE	NA
<b>2000</b>	-24585	0.13	5.78	NA, NE	NA
<b>2005</b>	-24638	0.01	6.09	NA, NE	NA
<b>2007</b>	-23290	0.11	6.16	NA, NE	NA
<b>2008</b>	-23740	0.03	6.18	NA, NE	NA
<b>2009</b>	-23658	0.04	6.18	NA, NE	NA
<b>2010</b>	-24855	0.01	6.18	NA, NE	NA
<b>2011</b>	-25342	0.04	6.18	NA, NE	NA
<b>2012</b>	-27076	0.05	6.18	NA, NE	NA
<b>2013</b>	-27668	0.05	6.18	NA, NE	NA
<b>2014</b>	-27329	0.04	6.18	NA, NE	NA
<b>2015</b>	-25370	0.04	6.77	NA, NE	NA
<b>2016</b>	-26311	0.04	6.77	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 <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
<b>4.A. Forest Land</b>			
<b>4.A.1. Forest Land remaining Forest Land</b>	<b>R</b>	<b>R</b>	<b>R</b>
Living biomass	R		
Dead Wood	NO		
Litter	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.A.2. Land converted to Forest Land</b>	<b>R</b>	<b>NO</b>	<b>IE, NO</b>
<b>4.A.2.1. Cropland converted to Forest Land</b>			
Living biomass	R		
Dead Wood	NO		
Litter	R		
SOMmin	R		
SOMorg	NO		
<b>4.A.2.2. Grassland converted to Forest Land</b>			
Living biomass	R		
Dead Wood	NO		
Litter	R		
SOMmin	R		
SOMorg	NO		
<b>4.A.2.3. Wetlands converted to Forest Land</b>			
Living biomass	R		
Dead Wood	NO		
Litter	NO		
SOMmin	NO		

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
SOMorg	NO		
<b>4.A.2.4. Settlements converted to Forest Land</b>			
Living biomass	NO		
Dead Wood	NO		
Litter	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.A.2.5. Other Land converted to Forest Land</b>			
Living biomass	R		
Dead Wood	NO		
Litter	R		
SOMmin	R		
SOMorg	NO		
<b>4.B. Cropland</b>			
<b>4.B.1. Cropland remaining Cropland</b>	<b>R</b>	<b>NO</b>	<b>NO</b>
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	R		
<b>4.B.2. Land converted to Cropland</b>	<b>R</b>	<b>NO</b>	<b>R</b>
<b>4.B.2.1. Forest Land converted to Cropland</b>			
Living biomass	NO		
Dead Wood	NO		
Litter	R		
SOMmin	NO		
SOMorg	NO		
<b>4.B.2.2. Grassland converted to Cropland</b>			
Living biomass	R		
DOM	R		

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
SOMmin	R		
SOMorg	NO		
<b>4.B.2.3. Wetlands converted to Cropland</b>			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	IE		
<b>4.B.2.4. Settlements converted to Cropland</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.B.2.5. Other Land converted to Cropland</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.C. Grassland</b>			
<b>4.C.1. Grassland remaining Grassland</b>	<b>NO</b>	<b>NO</b>	<b>NO</b>
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	R		
<b>4.C.2. Land converted to Grassland</b>	<b>R</b>	<b>NO</b>	<b>NO</b>
<b>4.C.2.1. Forest Land converted to Grassland</b>			
Living biomass	NO		
DOM	R		
SOMmin	R		
SOMorg	NO		

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
<b>4.C.2.2. Cropland converted to Grassland</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.C.2.3. Wetlands converted to Grassland</b>			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.C.2.4. Settlements converted to Grassland</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.C.2.5. Other Land converted to Grassland</b>			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.D. Wetlands</b>			
<b>4.D.1. Wetlands remaining Wetlands</b>	<b>NO</b>	<b>NO</b>	<b>NO</b>
<b>4.D.1.1. Peat extraction remaining peat extraction</b>			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.D.1.2. Flooded land remaining flooded land</b>			
Living biomass	NO		

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.D.1.3 Other wetlands remaining other wetlands</b>			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.D.2. Land converted to Wetlands</b>	<b>R</b>	<b>NO</b>	<b>NO</b>
<b>4.D.2.1. Land converted to peat extraction</b>			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.D.2.2. Land converted to flooded land</b>			
<b>4.D.2.2.1. Forest Land converted to flooded land</b>			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
<b>4.D.2.2.2. Cropland converted to flooded land</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.D.2.2.3. Grasslands converted to flooded land</b>			
Living biomass	NO		
DOM	NO		
SOMmin	NO		

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
SOMorg	NO		
<b>4.D.2.2.4. Settlements converted to flooded land</b>			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.D.2.3. Other Land converted to flooded land</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.D.2.4. Land converted to other wetlands</b>			
<b>4.D.2.4.1. Forest Land converted to other wetlands</b>			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
<b>4.D.2.4.2. Cropland converted to other wetlands</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.D.2.4.3. Grasslands converted to other wetlands</b>			
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.D.2.4.4 Settlements converted to other wetlands</b>			
Living biomass	NO		



GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.D.2.4.5 Other Land converted to other wetlands</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.E Settlements</b>			
<b>4.E.1 Settlements remaining Settlements</b>	<b>NO</b>	<b>NE</b>	<b>NE</b>
Living biomass	NO		
DOM	NO		
SOMmin	NO		
SOMorg	NO		
<b>4.E.2 Land converted to Settlements</b>	<b>R</b>	<b>NE</b>	<b>NE</b>
<b>4.E.2.1 Forest Land converted to Settlements</b>			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
<b>4.E.2.2 Cropland converted to Settlements</b>			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.E.2.3 Grassland converted to Settlements</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
SOMorg	NO		
<b>4.E.2.4 Wetlands converted to Settlements</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.E.2.5. Other Land converted to Settlements</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.F. Other Land</b>			
<b>4.F.1. Other Land remaining Other Land</b>			
<b>4.F.2. Land converted to Other Land</b>	<b>R</b>	<b>NO</b>	<b>NO</b>
<b>4.F.2.1. Forest Land converted to Other Land</b>			
Living biomass	R		
DOM	R		
SOMmin	R		
SOMorg	NO		
<b>4.F.2.2. Cropland converted to Other Land</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.F.2.3. Grassland converted to Other Land</b>			
Living biomass	R		
DOM	NO		
SOMmin	R		
SOMorg	NO		

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
<b>4.F.2.4. Wetlands converted to Other Land</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.F.2.5. Settlements converted to Other Land</b>			
Living biomass	NO		
DOM	NO		
SOMmin	R		
SOMorg	NO		
<b>4.G. Other</b>			
Harvested Wood Products	R		
<b>GHG sources</b>			
4 (I) Direct nitrous oxide (N <sub>2</sub> O) 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 <sub>2</sub> O) 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 <sub>2</sub> O) 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

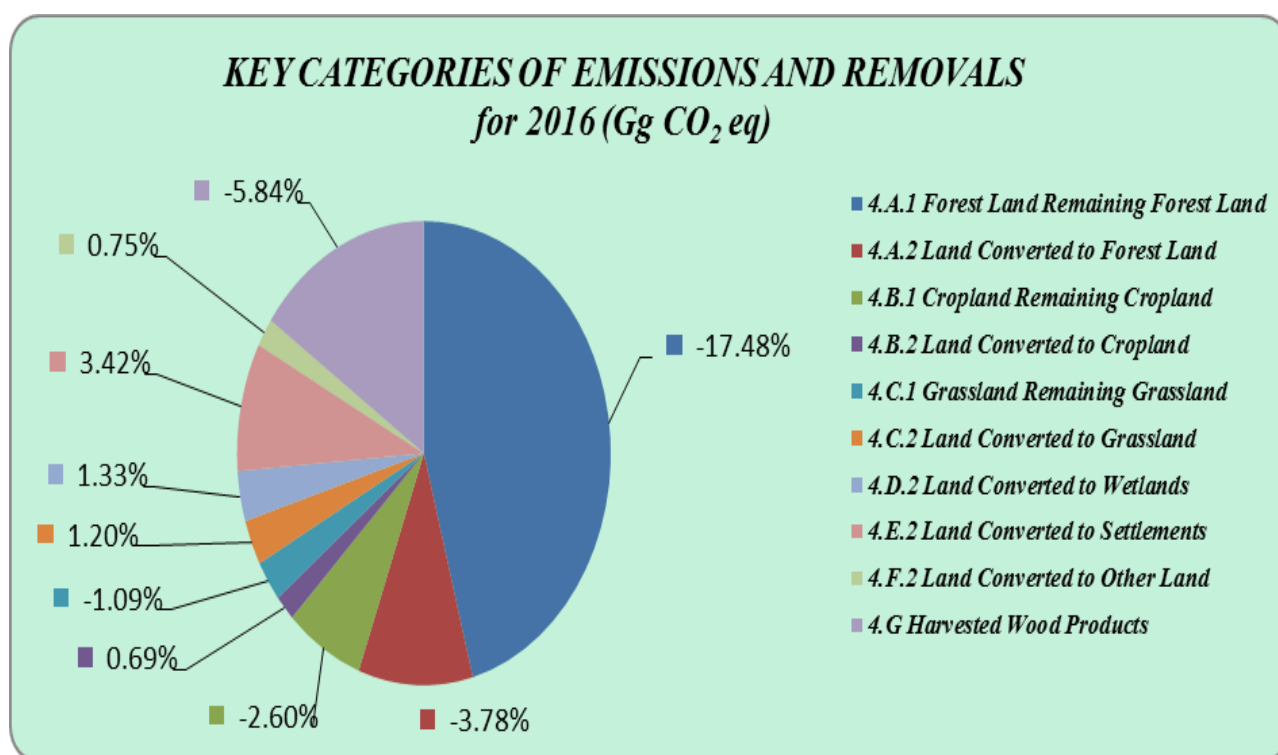
assessment, showing also the change of the annual removals compared to the base year. Both land sub-categories of Forest Land are key categories for CO<sub>2</sub> in the national GHG inventory, thus higher methodological levels is required.

**Table 6.4 Key categories overview – LULUCF, 2016**

Key categories	GHG	Criteria	Contribution of key category in total GHG emissions
4.A.1 Forest Land remaining Forest Land	CO <sub>2</sub>	L, T (excluding and including LULUCF)	-17.48 %
4.A.2 Land converted to Forest Land	CO <sub>2</sub>	L, T (excluding and including LULUCF)	-3.78 %
4.B.1 Cropland remaining Cropland	CO <sub>2</sub>	L, T (excluding and including LULUCF)	-2.60 %
4.B.2 Land Converted to Cropland	CO <sub>2</sub>	L, T (excluding and including LULUCF)	0.69 %
4.C.1 Grassland Remaining Grassland	CO <sub>2</sub>	L, T (excluding and including LULUCF)	-1.09 %
4.C.2 Land Converted to Grassland	CO <sub>2</sub>	L, T (excluding and including LULUCF)	1.20 %
4.D.2 Land Converted to Wetlands	CO <sub>2</sub>	L, T (excluding and including LULUCF)	1.33 %
4.E.2 Land converted to	CO <sub>2</sub>	L, T (excluding and including LULUCF)	3.42 %

Key categories	GHG	Criteria	Contribution of key category in total GHG emissions
Settlements			
4.F.2 Land converted to Other Land	CO <sub>2</sub>	L, T (excluding and including LULUCF)	0.75 %
4.G Harvested Wood Products	CO <sub>2</sub>	L, T (excluding and including LULUCF)	-5.84 %

*Figure 6.1 Key categories from LULUCF sector*



In accordance with the ERT recommendation, Romania have been changed the notation keys from CRF Reporter Application that were associated for several pools, including dead organic matter in wetlands converted to cropland, living biomass and dead organic matter in settlements converted to cropland, dead organic matter for cropland converted to grassland and all pools in

wetlands converted to grassland. Due to this issue, Romania report these pools as “NE” instead of “NO” because the IPCC good practice guidance for LULUCF does not provide methods and/or EFs for these pools and land-use conversions.

## **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*”. All land included in the national forest fund is forest land. There are considered Forests and are included in the national forest fund, land with a surface area of at least 0.25 ha, covered with trees; the trees must reach a minimum height of 5m in maturity under normal vegetation conditions. It does not include land used predominantly for agricultural purposes.
- Agricultural land associate to „*Cropland*”. This class includes lands that serve to crop needs: nurseries, solaria, plantations and mother plant 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).
- 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). Current assumption is that all grasslands are assumed managed.
- 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. Wetlands are assumed to be unmanaged.

- 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, urban/rural lawns, playgrounds in green areas, beach lawn and other areas with lawn, dwellings, industrial and administration buildings, warehouses, huts, ruins, greenhouses, graveyards, dirt roads, trails, rail roads and roads, 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.

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 see 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 (1<sup>st</sup> cycle 2008-2012, 2<sup>nd</sup> 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 – 2016 (kHa)**

Year	1989	2000	2005	2010	2015	2016
<b>Land sub-category</b>						
<b>4a1</b>	<b>6601.98</b>	<b>6615.03</b>	<b>6628.85</b>	<b>6642.67</b>	<b>6656.49</b>	<b>6659.25</b>
<b>4a2.1</b>	<b>55.984</b>	<b>58.92</b>	<b>58.92</b>	<b>58.92</b>	<b>58.92</b>	<b>58.92</b>
<b>4a2.2</b>	218.461	229.96	229.96	229.96	229.96	229.96
<b>4a2.3</b>	23.4077	24.64	24.64	24.64	24.64	24.64
<b>4a2.4</b>	19.2835	20.3	20.3	20.3	20.3	20.3
<b>4a2.5</b>	12.8449	13.52	13.52	13.52	13.52	13.52
<b>4b1</b>	<b>8530.34</b>	<b>8083.47</b>	<b>7905.44</b>	<b>7727.41</b>	<b>7549.38</b>	<b>7513.78</b>
<b>4b2.1</b>	66.04	69.52	69.52	69.52	69.52	69.52
<b>4b2.2</b>	747.15	786.46	786.46	786.46	786.46	786.46



Year	1989	2000	2005	2010	2015	2016
<b>Land sub-category</b>						
<b>4b2.3</b>	73.43	77.30	77.30	77.30	77.30	77.30
<b>4b2.4</b>	150.08	157.98	157.98	157.98	157.98	157.98
<b>4b2.5</b>	12.40	13.04	13.04	13.04	13.04	13.04
<b>4c1</b>	<b>3452.59</b>	<b>3421.94</b>	<b>3442.20</b>	<b>3462.45</b>	<b>3482.71</b>	<b>3486.76</b>
<b>4c2.1</b>	63.63	66.98	66.98	66.98	66.98	66.98
<b>4c2.2</b>	1205.19	1268.62	1268.62	1268.62	1268.62	1268.62
<b>4c2.3</b>	59.20	62.30	62.30	62.30	62.30	62.30
<b>4c2.4</b>	87.68	92.30	92.30	92.30	92.30	92.30
<b>4c2.5</b>	13.30	14.00	14.00	14.00	14.00	14.00
<b>4d1</b>	<b>398.19</b>	<b>502.55</b>	<b>559.68</b>	<b>616.81</b>	<b>673.94</b>	<b>685.36</b>
<b>4d2.1</b>	NO	NO	NO	NO	NO	NO
<b>4d2.2</b>	NO	NO	NO	NO	NO	NO
<b>4d2.3.1</b>	67.01	70.54	70.54	70.54	70.54	70.54
<b>4d2.3.2</b>	167.97	176.80	176.80	176.80	176.80	176.80
<b>4d2.3.3</b>	144.57	152.18	152.18	152.18	152.18	152.18
<b>4d2.3.4</b>	14.69	15.46	15.46	15.46	15.46	15.46
<b>4d2.3.5</b>	11.02	11.60	11.60	11.60	11.60	11.60
<b>4e1</b>	<b>791.95</b>	<b>916.37</b>	<b>985.80</b>	<b>1055.23</b>	<b>1124.66</b>	<b>1138.54</b>
<b>4e2.1</b>	62.87	66.18	66.18	66.18	66.18	66.18
<b>4e2.2</b>	281.79	296.62	296.62	296.62	296.62	296.62
<b>4e2.3</b>	179.89	189.36	189.36	189.36	189.36	189.36
<b>4e2.4</b>	11.48	12.08	12.08	12.08	12.08	12.08
<b>4e2.5</b>	2.30	2.42	2.42	2.42	2.42	2.42
<b>4f1</b>	<b>200.32</b>	<b>232.70</b>	<b>250.09</b>	<b>267.49</b>	<b>284.88</b>	<b>288.36</b>
<b>4f2.1</b>	22.48	23.66	23.66	23.66	23.66	23.66
<b>4f2.2</b>	14.69	15.46	15.46	15.46	15.46	15.46
<b>4f2.3</b>	57.38	60.4	60.4	60.4	60.4	60.4

Year	1989	2000	2005	2010	2015	2016
<b>Land sub-category</b>						
<b>4f2.4</b>	14.69	15.46	15.46	15.46	15.46	15.46
<b>4f2.5</b>	2.75	2.90	2.90	2.90	2.90	2.90

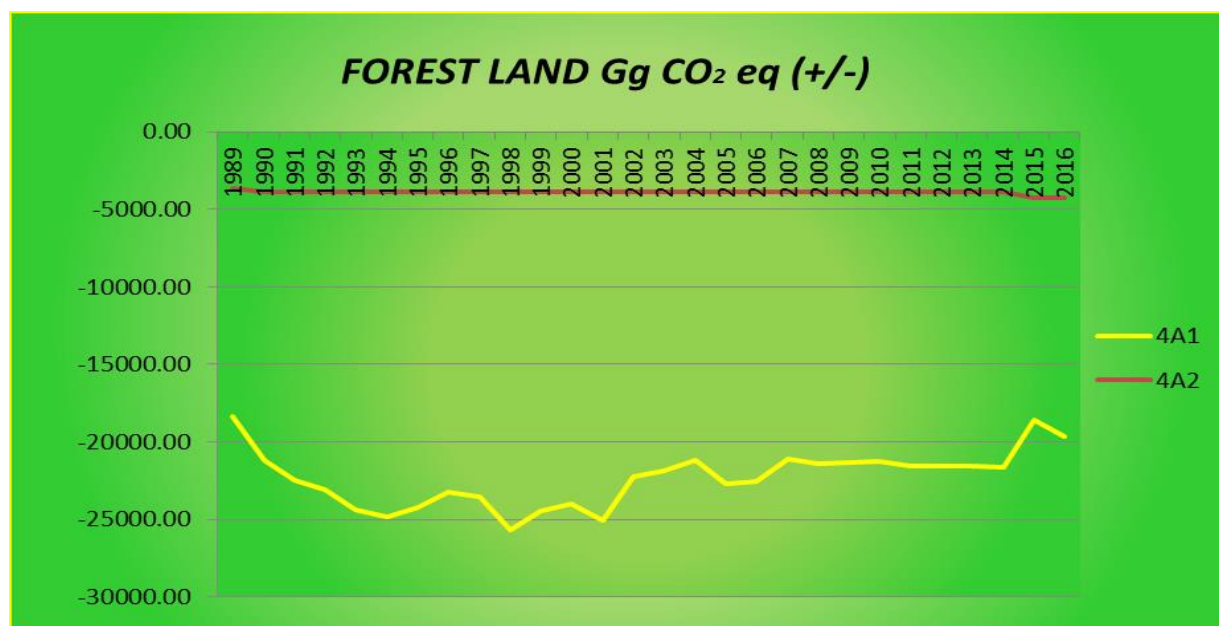
## 6.4 Forest Land (CRF 4.A)

### 6.4.1 Category description

At the end of 2016, forest land area in Romania was about **7006.6 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 (16%), hardwood species (hornbeam, locust, maple, ash, etc. - 20%) and softwood species (poplar, willow, lime, etc. - 7%). 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 NFII data, the stand age class structure reflects an unbalanced distribution of age classes, with a surplus in in 2<sup>nd</sup> age class (23% of total forest land) above 3<sup>rd</sup> and 4<sup>th</sup> 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 6.2 Emissions for 4.A.1 - Forest Land remaining Forest Land and 4.A.2 - Land converted to Forest Land (kt CO<sub>2</sub>)**



#### 6.4.2 Methodological issues

Methods currently implemented allow fully consistent reporting of activity data and C stock 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<sub>2</sub> 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:

- $\Delta CFF_{LB}$  = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land, tonnes C yr<sup>-1</sup>
- $\Delta CFF_G$  = annual increase in carbon stocks due to biomass growth, tonnes C yr<sup>-1</sup>. These estimates result from the multiplication of the activity data and country specific C stock change factors.
- $\Delta CFF_L$  = annual decrease in carbon stocks due to biomass loss, tonnes C yr<sup>-1</sup>. 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
<b>1989</b>	6672.2	2027.1	1992.3	1206.1	1018.2	333.2
<b>1990</b>	6658.4	2025.0	1990.3	1202.0	1013.9	331.8
<b>1995</b>	6706.1	2014.5	2037.8	1199.4	1024.1	335.1
<b>2000</b>	6753.9	1990.3	2078.0	1200.0	1047.5	342.8
<b>2005</b>	6801.6	1996.2	2151.4	1184.5	1040.1	334.1
<b>2010</b>	6849.4	2063.3	2172.1	1148.4	1024.7	345.5
<b>2014</b>	6035.7	2016.3	4073.2	1843.4	1504.2	545.6
<b>2015</b>	6656.5	2004.4	2110.1	1115.6	995.5	335.6
<b>2016</b>	6659.3	2005.2	2110.9	1116.1	995.9	335.8

#### *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 ( $G_{TOTAL}$ )*

$$G_{TOTAL, i} = I_v * D * (I + R)$$

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. Growth 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 <sup>3</sup> /ha/yr]	$D$ [tone d.m./m <sup>3</sup> ]	$R$ [dimensionless]
Coniferous	4.5	0.4	1.215
Beech	5.5	0.655	1.165
Oaks	4.7	0.645	1.185
Various hardwood	4.7	0.6	1.165
Various softwood	7.4	0.41	1.165

- ❖ 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 ( $BCEF_1$ ) 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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O 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 ( $\Delta L_{FF}$ )******Equation 6.3 Annual decrease of carbon stock due to biomass loss***

$$\Delta L_{FF} = L_{fellings} + L_{other losses}$$

where:

- $L_{fellings}$  = 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<sup>3</sup>/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 1989-2016 (Thousands cubic meters / year)**

Year	Distribution on species/groups of species				
	Coniferous	Beech	Oaks	Various Hardwood	Various Softwood
<b>1989</b>	6516	6636	1842	2268	2004
<b>1990</b>	5813	4958	2045	2071	1762
<b>1995</b>	4973	4215	1551	1774	1300
<b>2000</b>	5346	4508	1333	1731	1366
<b>2005</b>	6061	4794	1586	1852	1378
<b>2007</b>	7491	5182	1485	1668	1412
<b>2008</b>	6766	5208	1653	1760	1318
<b>2009</b>	6635	5489	1403	1845	1148
<b>2010</b>	6832	5654	1566	1784	1155
<b>2011</b>	7521	6175	1747	1946	1315
<b>2012</b>	7615	6332	1687	2014	1433
<b>2013</b>	7922	6227	1742	1969	1423
<b>2014</b>	7225	5837	1664	1876	1288
<b>2015</b>	6782	6216	1769	1951	1416
<b>2016</b>	6268	5798	1688	2008	1435

**Other annual carbon losses (unauthorized logging)**

**Equation 6.5 Other annual carbon losses**

$$L_{other\ losses} = H_i \times D \times (1+R) \times CF$$

where:

- $H_i$  = volume extracted annually by illegal logging [ $\text{m}^3/\text{year}$ ].

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 Chapter 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 Chapter 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  $\text{CO}_2$  emission factor for cool temperate forests of  $0.68\text{tC/year/ha}$  (Table 4.6) and  $\text{N}_2\text{O}$  emission factor for mineral soils of  $0.1\text{ kg N}_2\text{O-N ha}^{-1}$  (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***

<b>Plantation age (years)</b>	<b>Poplar &amp; Willow</b>	<b>Robinia</b>	<b>Oak</b>
<b>1</b>	0,1	1,2	0,3
<b>2</b>	1,7	1,6	0,7
<b>3</b>	2,2	1,9	1,1
<b>4</b>	2,4	2,3	1,4

Plantation age (years)	Poplar & Willow	Robinia	Oak
5	2,4	2,6	2,0
6	2,4	3,0	2,4
7	2,4	3,3	2,9
8	2,3	3,7	3,4
9	2,3	4,0	4,0
10	2,2	4,3	4,4
11	2,1	4,4	4,9
12	2,0	4,6	4,3
13	1,9	4,6	4,7
14	1,8	4,6	4,9
15	1,7	4,4	6,0
16	1,6	4,3	6,1
17	1,4	4,0	6,0
18	1,4	3,8	4,9
19	1,3	3,4	4,8
20	1,3	3,1	4,6
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<sub>2</sub>/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  $\sim 0.1 \text{ tC ha}^{-1}\text{yr}^{-1}$  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***

<b>Age (years)</b>	<b>Annual change in Litter pool (tC/ha/an)</b>
<b>1</b>	0,04
<b>2</b>	0,04
<b>3</b>	0,08
<b>4</b>	0,13
<b>5</b>	0,18
<b>6</b>	0,21
<b>7</b>	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<sup>-1</sup>yr<sup>-1</sup>) 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
	<b>CL</b>	-1.84	<b>48</b>	-0.1	-0.1	+0.8	+0.34
	<b>GL</b>	-1.74	+0.1	<b>40</b>	0	+0.9	+0.44
	<b>WL</b>	-1.74	+0.1	0	<b>40</b>	+0.9	+0.44
	<b>SL</b>	-2.64	-0.8	-0.9	-0.9	<b>32</b>	-0.44
	<b>OTL</b>	-2.2	-0.34	-0.44	-0.44	+0.44	<b>41</b>

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  $\pm 10\%$  (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*

CO<sub>2</sub> emissions from this category were recalculated for 2015 year, do to updating of activity data.

#### *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).

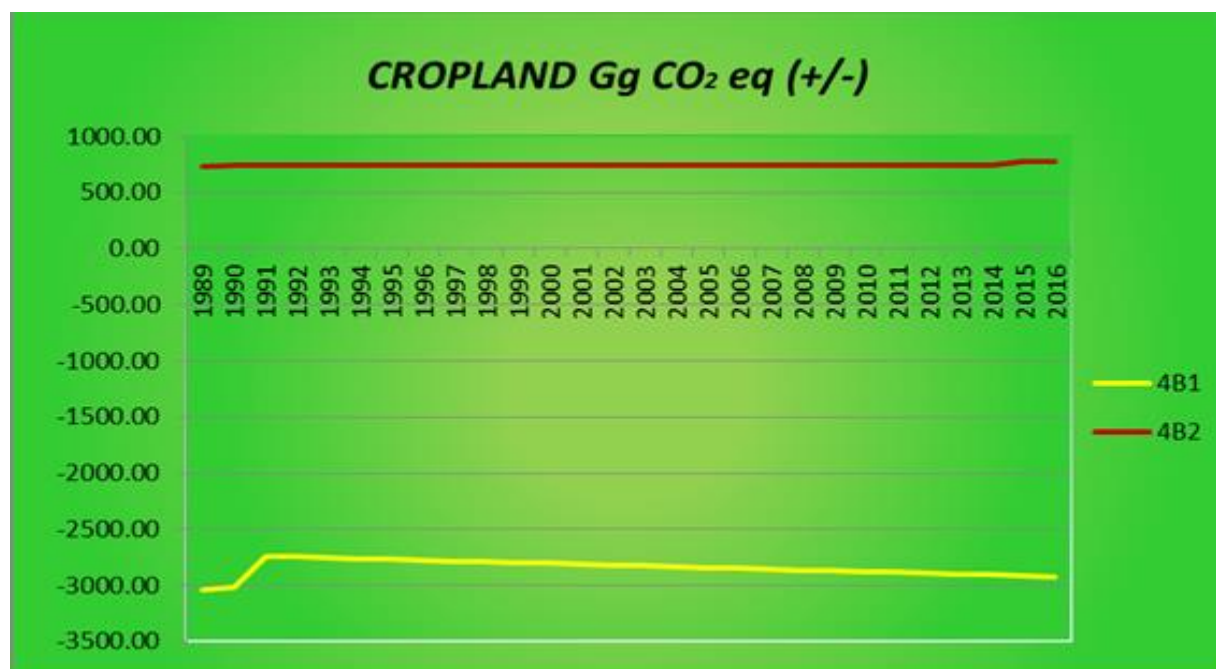
## **6.5 Cropland (CRF 4.B)**

### *6.5.1 Category description*

Cropland covers about 41.1% of the total country territory. Conversions to Cropland represent approximately 1105 kha/year for 25 years, with largest contribution of conversions from Grasslands. In 2016 about 95.9% is arable land, 2.0% is occupied by orchards and 2.1% is covered with vineyards *((until the completion of the cadastre action by the National Agency for Cadastre and Real Estate Advertising, the official data series remain with the values for the year 2014 (according to the specifications of the Romanian Statistical Yearbook - 2016))*.

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<sub>2</sub> removals generally also decrease (Figure 6.3).

**Figure 6.3 Removals and emissions for 4B1 - Cropland remaining Cropland (kt CO<sub>2</sub>) and 4B2 - Land converted to Cropland (kt CO<sub>2</sub>)**



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<sup>-1</sup> year<sup>-1</sup>], 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<sup>-1</sup>], (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 ( $\Delta C_{\text{conversions}}$ ), 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 105 kha in 2016 (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  $1.74 \text{ tC yr}^{-1}\text{ha}^{-1}$ . In conversions from grassland and wetlands, there is a decrease of  $0.1 \text{ tC yr}^{-1}\text{ha}^{-1}$ , while increase is expected in conversions from settlements ( $+0.8 \text{ tC}$ ) and other lands ( $+0.34\text{tC}$ ).  $\text{N}_2\text{O}$  emissions from organic soils under cropland remaining cropland (area of 6.39 kha) are reported under Cultivation of Histosols. For organic soils area,  $\text{CO}_2$  emissions under LULUCF are estimated for the entire time series using 2006 Guideline default emission factor for Cropland under ‘warm temperate dry’ zone of  $10 \text{ tC/ha/yr}$ . This adds annually an amount of  $16 \text{ GgCO}_2$  emissions.

*Definition of organic soils.* Analysis includes histic soil types, like „gleiosols” and „distric and eutric histosols”. 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 Național de Cercetare-Dezvoltare pentru Pedologie, Agrochimie și Protecția Mediului (National Institute for Research and Development for Soil Science, Agrochemistry and Environment, ICPA București) (<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 și 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*

Emissions from this category were recalculated for 2015 year, do to updating of activity data. 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

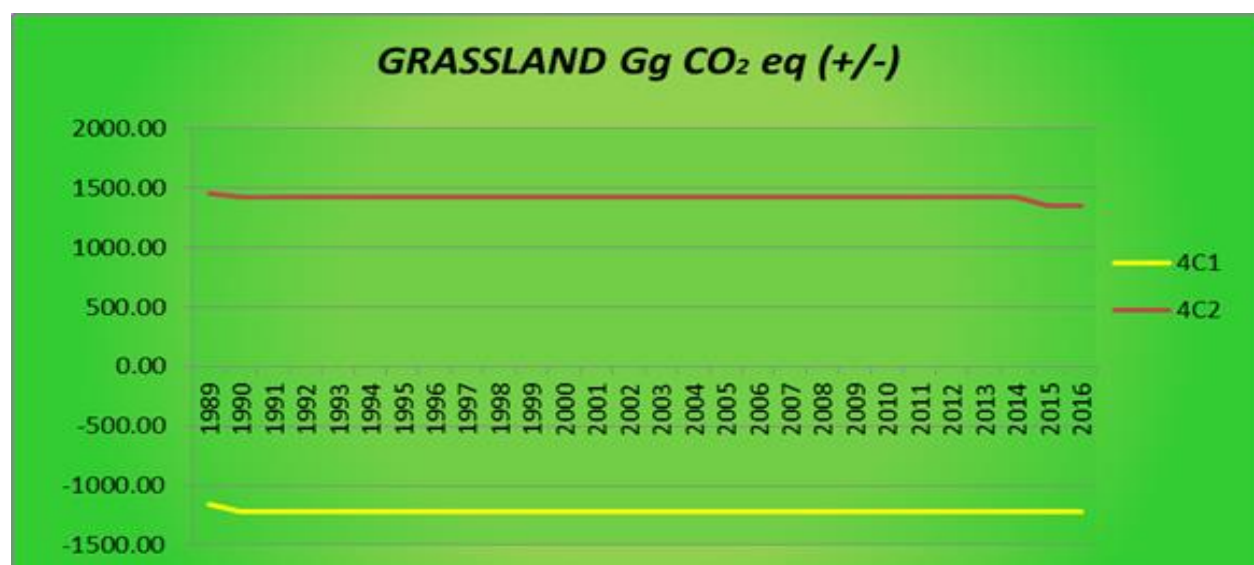
For the estimation of C stock changes in soils of land “remaining croplands” there is an improvement plan available, related to the development of national system to respond accounting requirements set in decision 529/2013UE. According to this decision a reporting to European Commission on the national 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 20.25% 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 6.4 Emissions/removals for 4.C.1 – Grassland remaining grassland and 4.C.2 - Land converted to Grassland (kt CO<sub>2</sub>)**



#### *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 ( $\Delta C_{\text{conversions}}$ ), 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*

Emissions from this category were recalculated for 2015 year, do to updating of activity data.

#### *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

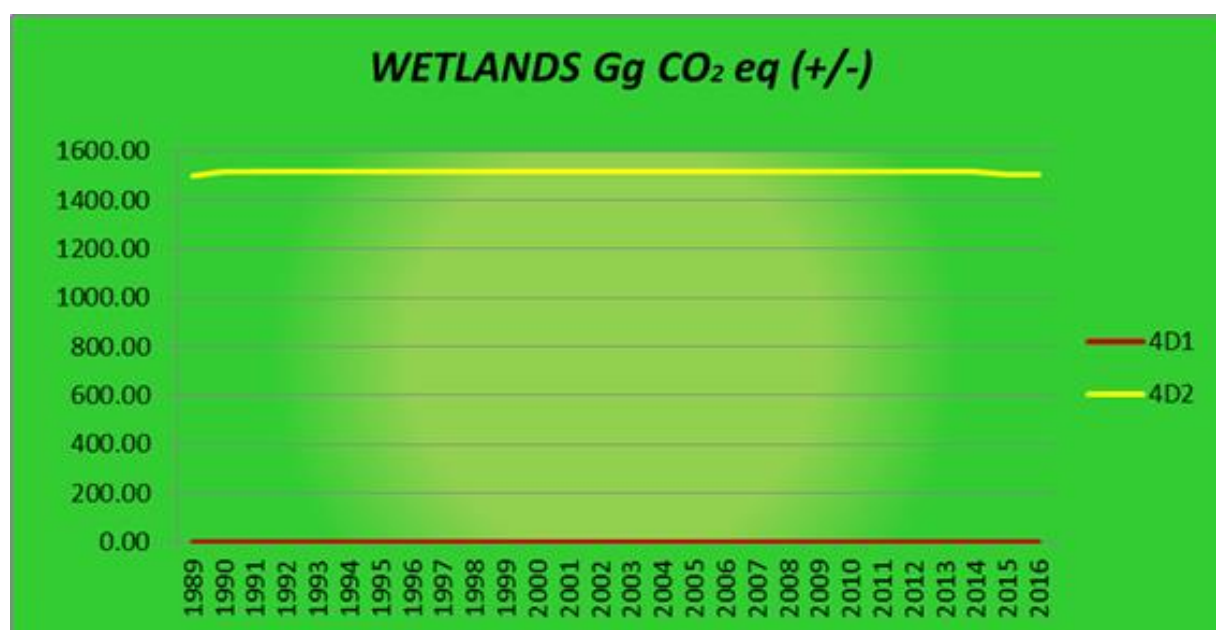
management is due annually for 2016-2018 while provide preliminary estimates before 2022 and final estimates in the final deadline in 2022.

## 6.7 Wetlands (CRF 4.D)

### 6.7.1 Category description

Wetlands area is about 3.49% of total land area. Absolute area is about 831.5 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 6.5 Emissions for 4D2 - Land converted to Wetlands (kt CO<sub>2</sub>)*



#### *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*

CO<sub>2</sub> emissions from this category were recalculated for 2015 year, do to updating of activity data.

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

There are no improvements planned.

### **6.8 Settlements (CRF 4.E)**

#### *6.8.1 Category description*

Area of settlements is about 4.82% of the total land area, respectively 1148 kha.

Conversions to "Settlements" during the last 20 years are about 30% of the total area of this category.

From 1990 to 2016 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 6.6 Emissions for 4.E.2 - Land converted to Settlements (kt CO<sub>2</sub>)**

#### 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<sup>st</sup> year, the area from 1989 is moved under 4.A.1 – Forest Land remaining Forest Land. Below 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  $218 \text{ m}^3\text{ha}^{-1}$  (applied for 1990-2007) and  $314 \text{ m}^3\text{ha}^{-1}$  according to latest NFI (applied for 2008-on). Estimation also considered a weighted average of the wood density of  $420 \text{ kg/m}^3$ , 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  $66.88 \text{ tCha}^{-1}$  for 1990-2007 and  $96.34 \text{ tCha}^{-1}$  for 2008-2016 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  $0.74 \text{ tC/ha}$  and ii) national average litter pool C stock of  $7.42 \text{ tC/ha}$  from ICP Forest database (author Surdu A., 2006).

Dead wood density was considered  $400\text{kg/m}^3$ . 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  $\text{CO}_2$  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  $1.6 \text{ t dm/ha}$ , respectively  $0.8\text{t C/ha}$ , 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.  $\text{CO}_2$  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*

Emissions from this category were recalculated for 2015 year, do to updating of activity data.

### *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 submissions.

## **6.9 Other land (CRF 4.F)**

### *6.9.1 Category description*

Area occupied by "Other Lands" is about 2.08% of the total land area, 495.42 kha respectively. Out of this, 73% are areas under conversion to Other Land.

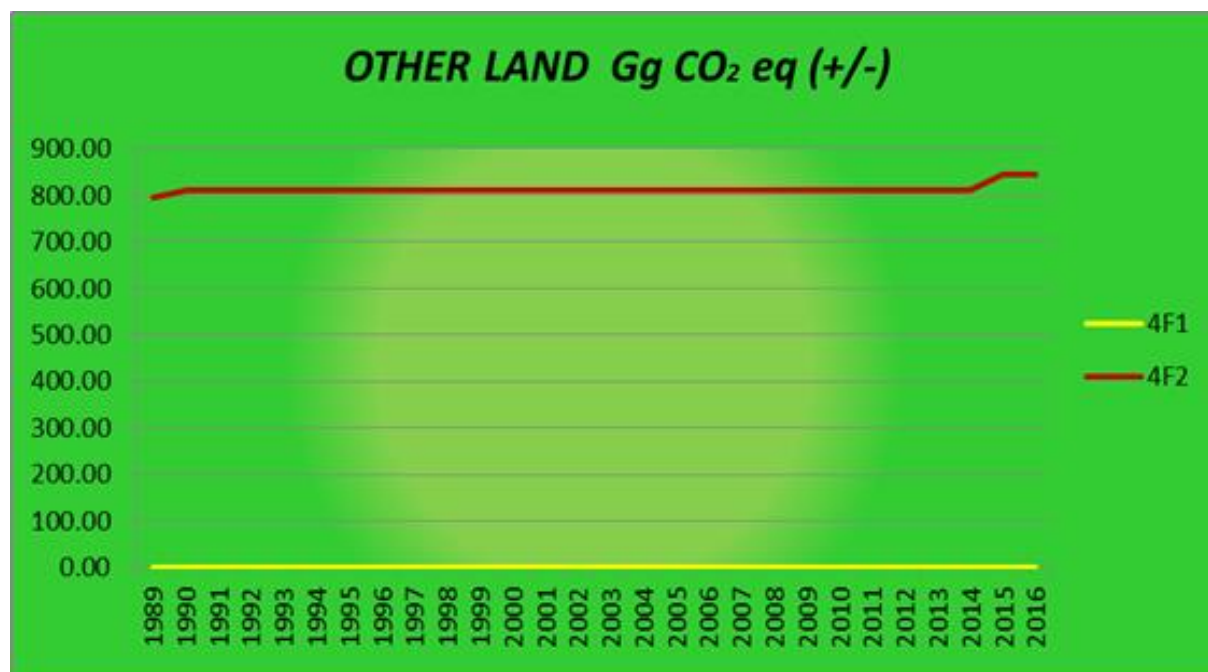
This category was used as a "buffer" in the matrix of land use change (for relocation of areas among categories, so total area of land remaining in the same category and under conversion always equals to the net values reported by the national statistics at the end of each calendar

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  $\pm 0.01\%$ .

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 6.7 Emissions for 5.F.2 - Land converted to Other land (kt CO<sub>2</sub>)**



#### *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<sub>2</sub> 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*

Emissions from this category were recalculated for 2015 year, do to updating of activity data.

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

No specific improvements are envisaged.

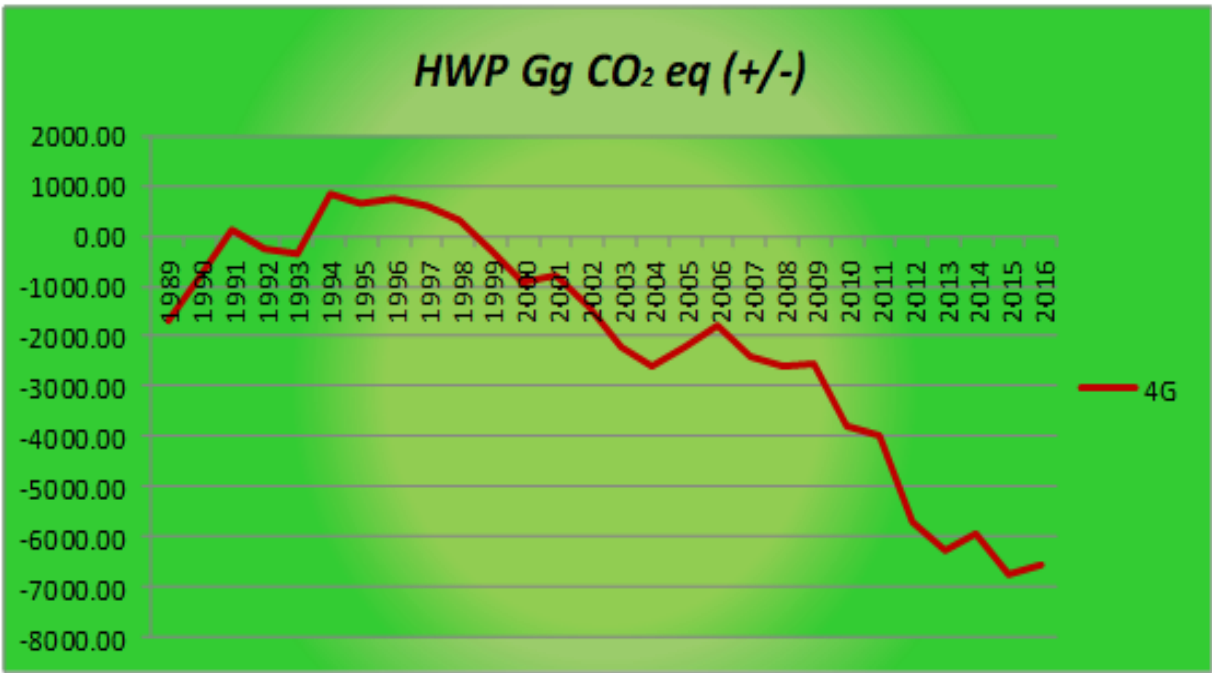
### **6.10 Harvested wood products (CRF 4G)**

#### *6.10.1 Category description*

Changes in the carbon stocks in the harvested wood products (HWP) pool were recalculated based on the methodological guidance of the IPCC 2006 GL and the IPCC 2013 KP Supplement. The following data sources were used for the estimation: international databases from Food and Agriculture Organization of the United Nations (FAO).

Activity data are available since 1961 for the production categories as well as by domestic, import and export.

Figure 6.8 Emissions for 5.G - Harvested wood products (kt CO<sub>2</sub>)



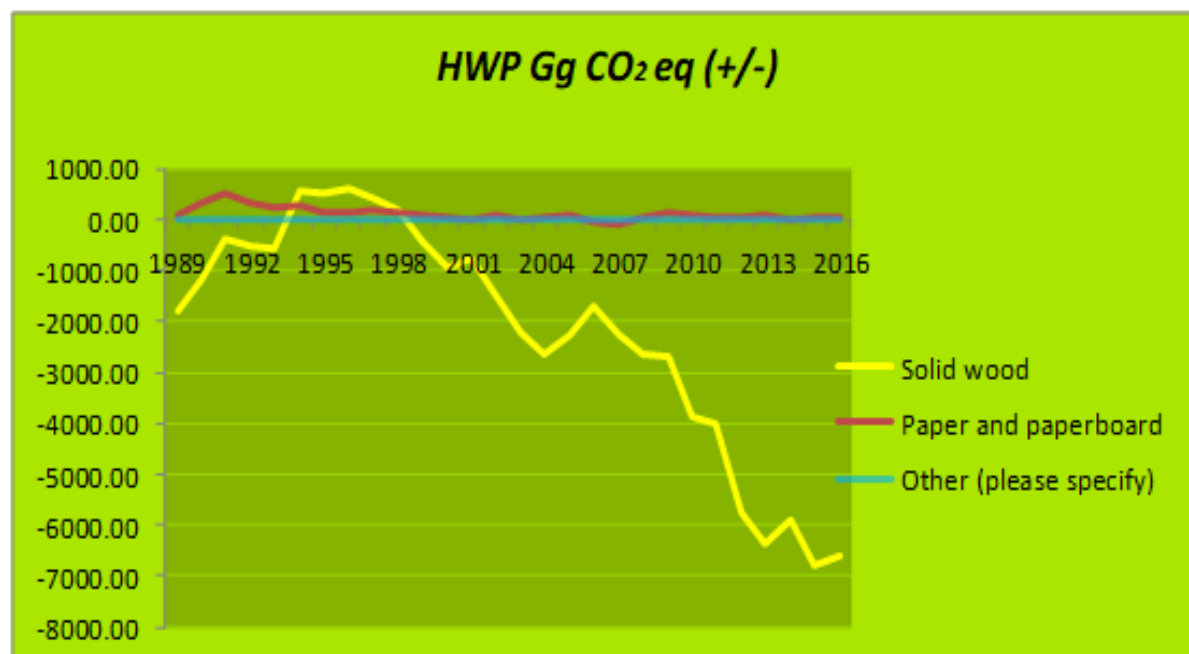
Data used to estimate the carbon stock changes of the HWP pool associated for production, import and export, are presented in Table 6.12.

**Table 6.12 Wood volume by wood product and production categories used in the calculation of the carbon stock changes of the HWP pool.**

Year	PRODUCTION					IMPORT					EXPORT				
	Industrial Roundwood (total)	Sawnwood (total)	Wood-based panel	Paper and paperboard (t)	Wood-PULP	Industrial Roundwood (total)	Sawnwood (total)	Wood-based panel	Paper and paperboard (t)	Wood-PULP	Industrial Roundwood (total)	Sawnwood (total)	Wood-based panel	Paper and paperboard (t)	Wood-PULP
1989	13475000	2850000	1542000	739000	619000	22230	53	2069	40000	71000	0	466207	245487	103631	3000
1990	10725000	2911000	1094000	547000	481000	419928	344	1581	40000	71000	1810	268538	50519	126976	3000
1995	10015000	1777000	437000	364000	298000	79800	2600	46400	62300	17618	0	746000	133100	122700	4000
2000	10116000	3395700	306300	339600	292700	20400	7500	225600	147100	3800	530800	2322400	153200	115100	31200
2005	11542000	4321000	1011000	371000	161000	336000	29000	698833	351000	14022	91000	2310000	704000	130245	15000
2007	11572000	4143000	1263000	558000	169000	400050	47000	1047350	351000	27646	155000	2384000	866000	182200	9000
2008	9517300	3793900	1917476	421563	42438	211698	48950	932808	355869	24914	209863	1910350	908164	101709	4312
2009	8587300	3597780	2322200	342000	15000	383444	48029	937273	401678	67438	167299	2259290	1082182	69857	8700
2010	10548052	4323000	3030000	364000	0	563483	42904	619931	429594	73873	321057	2895944	1604578	93802	1280
2011	10344452	4441808	3192000	385500	0	604999	53193	524179	444107	71555	697542	3058912	1683426	80683	3926
2012	10935713	5500000	4022000	402000	0	647419	47318	494510	527760	80944	393748	3225382	2151011	105031	779
2013	10091483	5532300	4942000	355000	0	735564	46038	460800	582585	99069	481479	3334218	2749251	133312	124
2014	10470620	5404000	4890976	423759	0	1007650	80189	440261	564067	115777	326810	3253080	2715546	132760	1640
2015	10235399	6299709	6038898	389954	0	1792440	142157	515169	644928	121552	169657	2741432	2715496	159636	109
2016	11045711	5600000	6224801	400708	0	1769227	329963	724374	667877	152737	84480	2032230	2628500	177563	6

The estimates include exports.

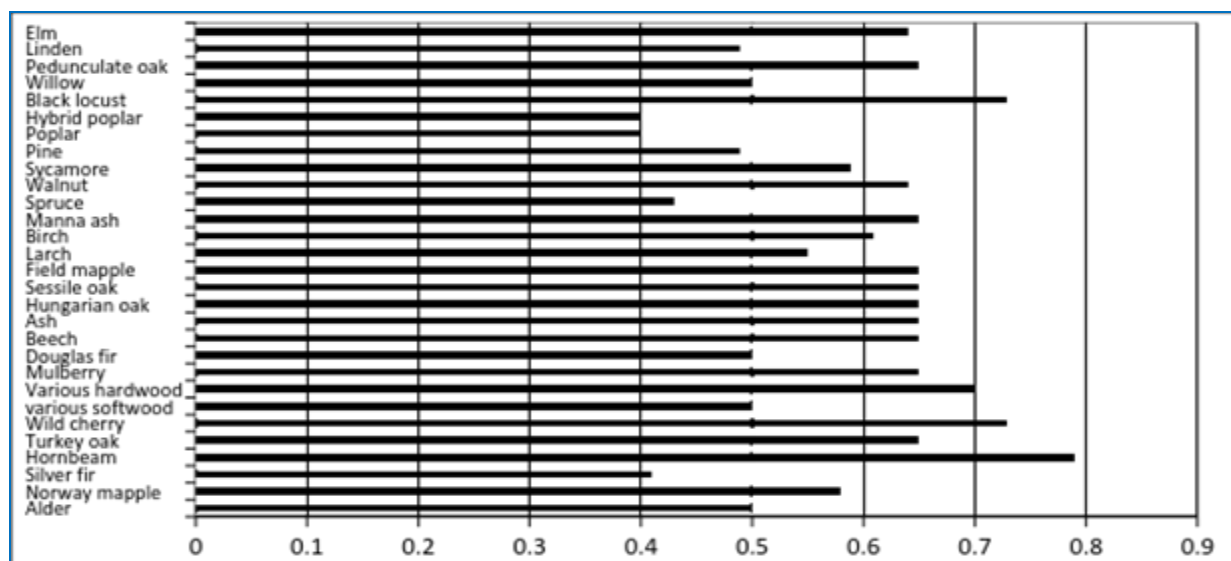
**Figure 6.9 Emissions for 5.G - Harvested wood products (kt CO<sub>2</sub>)- Solid Wood, Paper and paperboard, Other (please specify)**



#### 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 6.10).



**Figure 6.10 Oven dry density of wood (g·cm<sup>-3</sup>) species harvested in Romania**

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 6.13 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	0,450
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<sub>2</sub> 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 *Inventory Software ver 2.12*, available at <http://www.ipcc-nggip.iges.or.jp/software/index.html>

1.4 *Exports and imports* were treated according to Equations 2.8.1 (for industrial roundwood) and 2.8.2 (for wood pulp) of the IPCC KP Supplement. The amounts of volume that are accounted for as input to the HWP pool exclude firewood.

Annual volumes of wood products were converted to carbon using the default conversion factors from Table 2.8.1 of the IPCC KP Supplement. To estimate net carbon stock changes of the HWP pool, the Tier 2 first order decay calculation method was used, i.e., Equation 12.1 from the 2006 IPCC Guidelines, together with default half life time values as required by Equation 2.8.5 of the KP Supplement, as follows: 2 years for paper and paperboard, 25 years for wood panels and 35 years for sawn wood.

### 6.10.3 *Uncertainties and time series consistency*

Estimation of C stock change in HWP is under further refining.

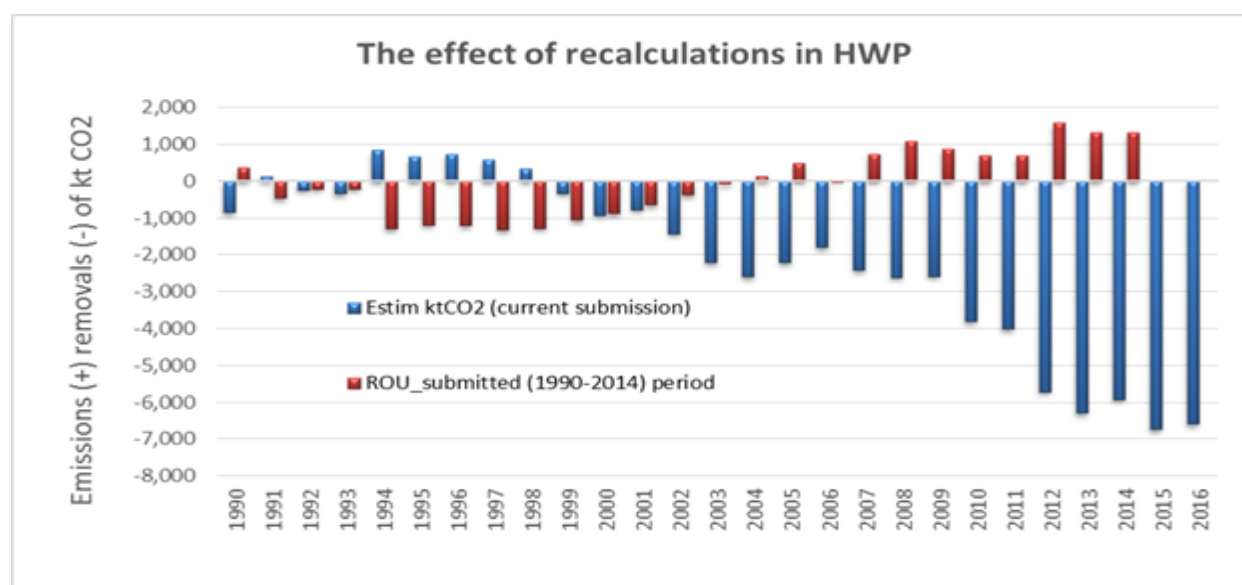
#### 6.10.4 Category-specific QA/QC and verification, if applicable

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 current submission, were made recalculations associated to this category based on information described at methodological issues level.

**Figure 6.11 Changes made on emissions estimates**



#### 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub> emissions reported under 4A1/FM and N<sub>2</sub>O 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<sub>2</sub>O 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 933 kha. To this adds the drainage of non-forestlands, a total of 95.3 kha in 1990 with some 64 % of total area as drainage of organic soils. In 2016 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<sub>2</sub>O emissions by humus decomposition. According the land use matrix, from total cumulated area under conversion to arable land, in 2016, 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<sub>2</sub>O emissions are estimated assuming 20 years transition period. 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O-N/kg N). Thus IEF is constant around 0.01 kg N<sub>2</sub>O-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<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> are all reported in CRF Table 4(V). Annually affected area on land categories is reported by the General Inspectorate of Emergency Situations. In 2016 submission 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 0.75 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<sub>2</sub> 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). DOM is not a net source.

**Table 6.14 Forest fires area**

<b>Year</b>	<b>Total affected area (ha)</b>
<b>1989</b>	<b>93</b>
<b>1990</b>	<b>444</b>
<b>1991</b>	<b>277</b>
<b>1992</b>	<b>729</b>
<b>1993</b>	<b>418</b>
<b>1994</b>	<b>312</b>
<b>1994</b>	<b>208</b>
<b>1996</b>	<b>227</b>
<b>1997</b>	<b>68</b>
<b>1998</b>	<b>137</b>
<b>1999</b>	<b>379</b>
<b>2000</b>	<b>3607</b>
<b>2001</b>	<b>1020</b>
<b>2002</b>	<b>3490</b>
<b>2003</b>	<b>762</b>
<b>2004</b>	<b>124</b>
<b>2004</b>	<b>212</b>
<b>2006</b>	<b>946</b>
<b>2007</b>	<b>2924</b>

Year	Total affected area (ha)
2008	844
2009	974
2010	206
2011	3047
2012	1228
2013	1295
2014	1130
2015	1143
2016	968
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<sup>-1</sup>);
- $S_{forest\ fires}$  = annually affected area (ha yr<sup>-1</sup>);
- $M_f$  = amount of C in „dead wood lying on the soil surface” [MgC ha<sup>-1</sup>].

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<sup>3</sup> (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<sub>2</sub> and non-CO<sub>2</sub> 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<sub>2</sub> and non-CO<sub>2</sub> emissions from forest fires***

$$\text{Emission of CO}_2 [\text{Gg yr}^{-1}] = (C \text{ emitted}) [\text{tC yr}^{-1}] \times (44/12)/1000,$$

$$\text{Emission of CH}_4 [\text{Gg yr}^{-1}] = (C \text{ emitted}) [\text{tC yr}^{-1}] \times (\text{emission ratio}) \times (16/12)/1000,$$

$$\text{Emission of CO} [\text{Gg yr}^{-1}] = (C \text{ emitted}) [\text{tC yr}^{-1}] \times (\text{emission ratio}) \times (28/12)/1000,$$

$$\text{Emission of N}_2\text{O} [\text{Gg yr}^{-1}] = (C \text{ emitted}) [\text{tC yr}^{-1}] \times (\text{N/C ratio}) \times (\text{emission ratio}) \times (44/28)/1000,$$

$$\text{Emission of NO}_x [\text{Gg yr}^{-1}] = (C \text{ emitted}) \times [\text{N/C ratio}] \times (\text{emission ratio}) \times (46/14)/1000,$$

where:

- $(C \text{ emitted}) = L_{\text{forest fires}}$ , respectively total amount of C annually emitted (tC/year),
- $\text{N/C ratio}$  = ratio of nitrogen/carbon in the burnt dead mass, N/C ratio was 1/24,
- $(\text{emission ratio})$  = 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<sub>4</sub> – 0.012; CO – 0.06; N<sub>2</sub>O – 0.007 and NO<sub>x</sub> – 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<sub>2</sub> 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<sub>4</sub> and N<sub>2</sub>O was corrected in 2014 submission. Error consisted in wrong entering of CO<sub>2</sub> 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<sub>4</sub> and CO<sub>2</sub> emissions from Solid Waste Disposal;
- CH<sub>4</sub> and N<sub>2</sub>O emissions from Biological Treatment – Composting;
- CH<sub>4</sub> and N<sub>2</sub>O emissions from Wastewater Treatment and Discharge;
- CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions from Waste Incineration.

Starting with 2013 submission NMVOC emissions from Solid Waste Disposal on Land were estimated.

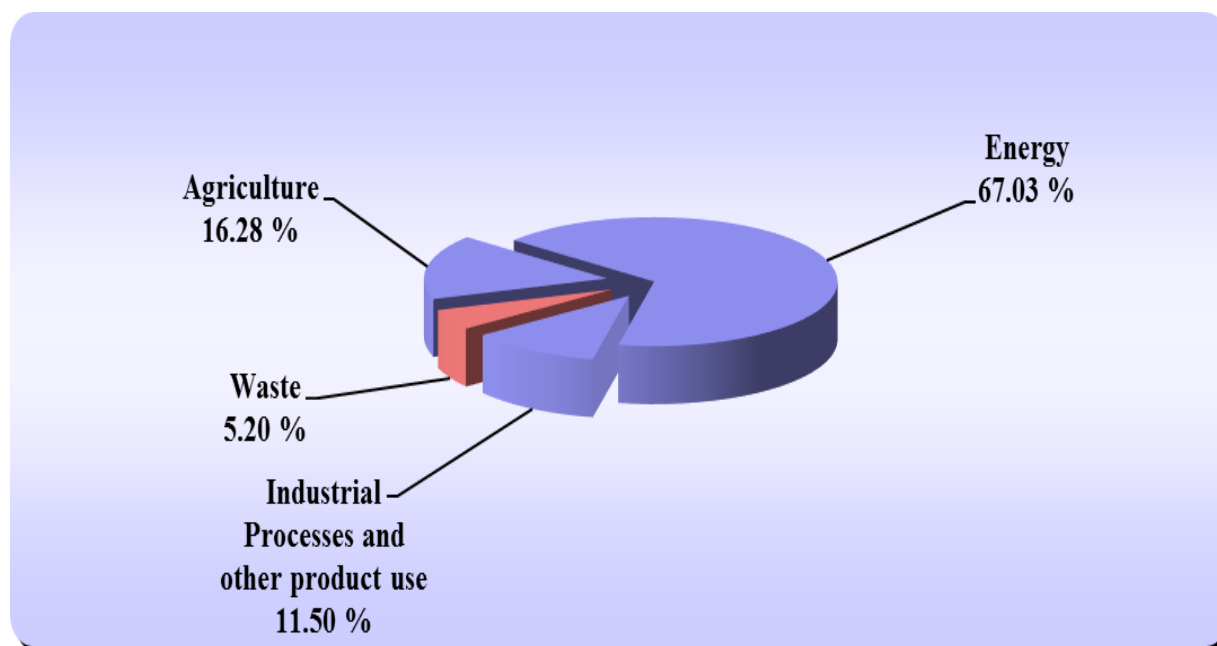
*Table 7.1 Status of the direct GHG emissions estimation in the Waste Sector*

IPCC category	Emissions estimation status		
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
<b>5.A Solid Waste Disposal</b>			
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
<b>5.B Biological Treatment of Solid Waste</b>			
5.B.1 Composting	NA	✓	✓
5.B.1 Anaerobic Digestion at Biogas Facilities	NA	NA	NA
<b>5.C Incineration and open burning of waste</b>			

IPCC category	Emissions estimation status		
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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
<b>5D Wastewater Treatment and Discharge 5D</b>			
5.D.1 Domestic Wastewater	NA	✓	✓
5.D.2 Industrial Wastewater	NA	✓	✓
5.D.3 Other (please specify)	NA	NA	NA
<b>6.E Other</b>	NA	NA	NA

\* CH<sub>4</sub> emissions from industrial sludge are reported under 6.B.1.a – Industrial wastewater.

In 2016 GHG emissions from the Waste Sector accounted for 5848.21 kt CO<sub>2</sub> 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, 2016**

In the base year (1989), the total GHG emissions from the waste sector amounted to 5135.66 kt CO<sub>2</sub> 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 13.87 %, due to increasing of incineration activities and waste generation rate in parallel with increasing of living standards (Table 7.2, Figure 7.2).

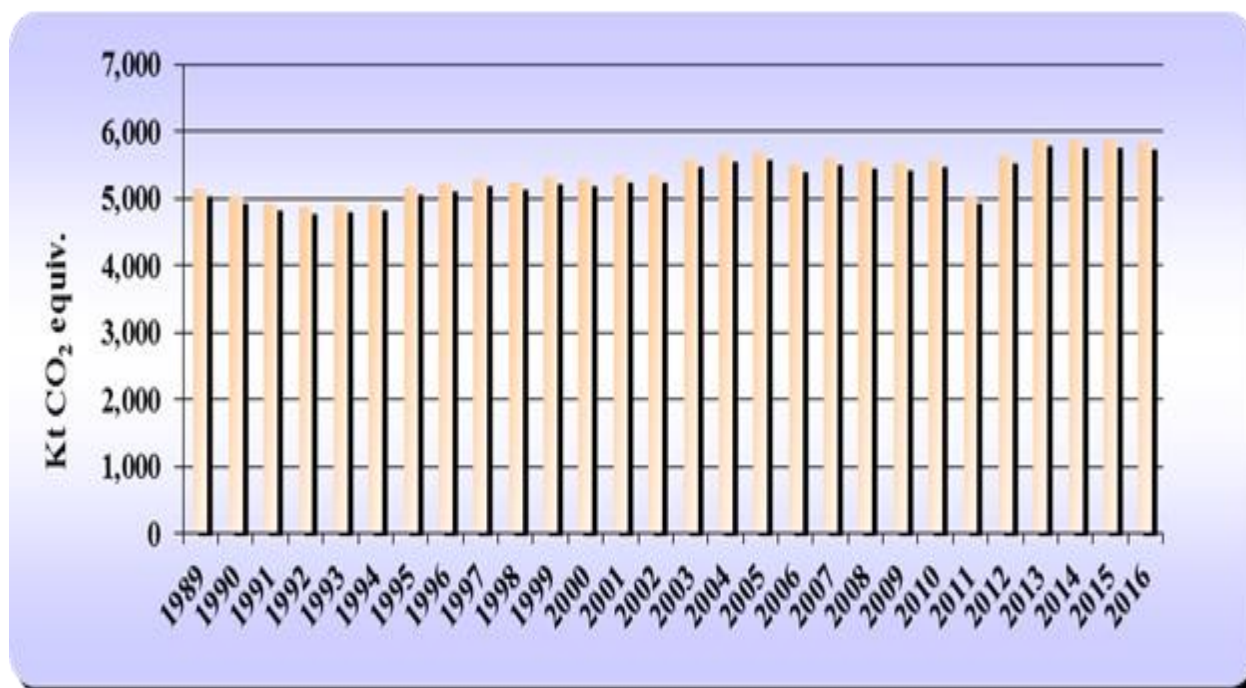
**Table 7.2 The contribution of Waste Sector to the total GHG emissions in Romania, for 1989–2016 period**

Year	Total GHG emissions (excl. LULUCF) [kt CO <sub>2</sub> equiv.]	GHG emissions from Waste [kt CO <sub>2</sub> equiv.]	Contribution of Waste in total GHG emissions [%]
1989	302,630.63	5,135.66	1.70
1990	246,747.86	5,023.36	2.04
1995	180,478.41	5,157.27	2.86
2000	140,733.62	5,303.93	3.77
2005	147,827.94	5,688.26	3.85

Year	Total GHG emissions (excl. LULUCF) [kt CO <sub>2</sub> equiv.]	GHG emissions from Waste [kt CO <sub>2</sub> equiv.]	Contribution of Waste in total GHG emissions [%]
2007	152,984.04	5,603.99	3.66
2008	148,078.36	5,546.58	3.75
2009	127,661.72	5,515.95	4.32
2010	122,182.25	5,584.18	4.57
2011	127,875.46	5,032.30	3.94
2012	124,847.08	5,620.38	4.50
2013	115,262.27	5,884.95	5.11
2014	115,371.21	5,863.88	5.08
2015	116,211.32	5,861.71	5.04
	112,542.36	5,848.21	5.20

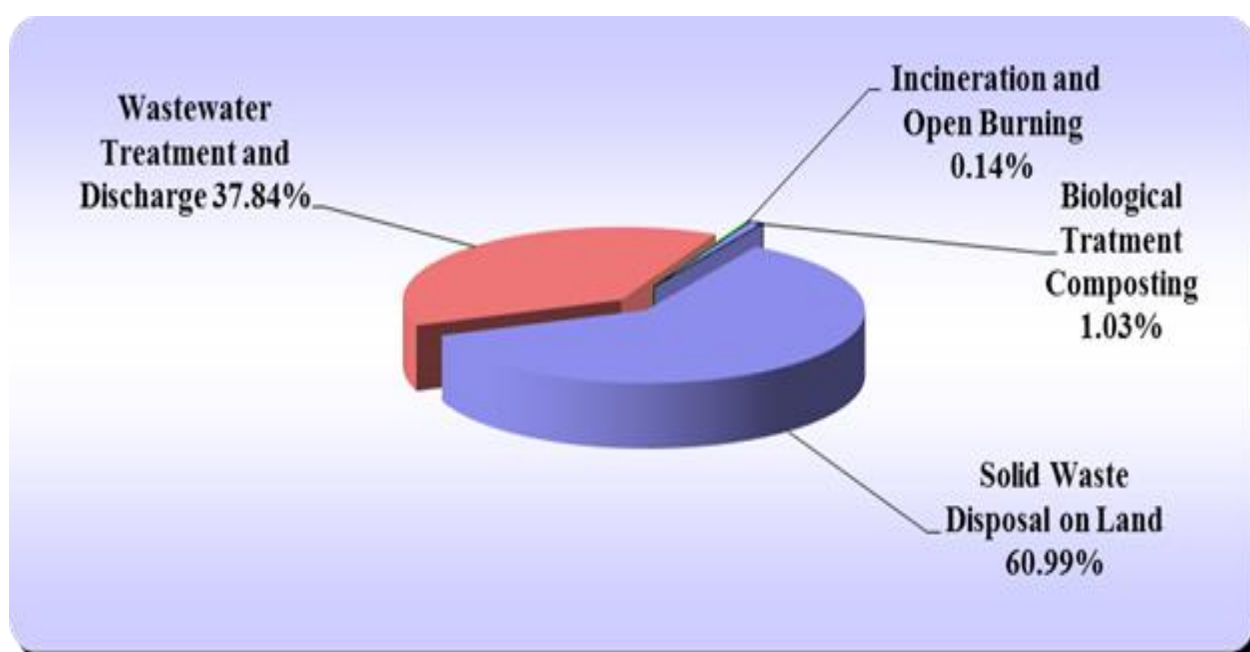
\* Preliminary data

*Figure 7.2 Total GHG emissions trend from Waste Sector for 1989–2016 period*



The most important contribution to GHG emissions from Waste Sector, in 2016 year, has Solid Waste Disposal Subsector, contributing with 60.99% in the total (Figure 7.3), Biological treatment - Composting accounts for 1.03%; Incineration and Open Burning of Waste Subsector accounts for only 0.14 % 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 2016**

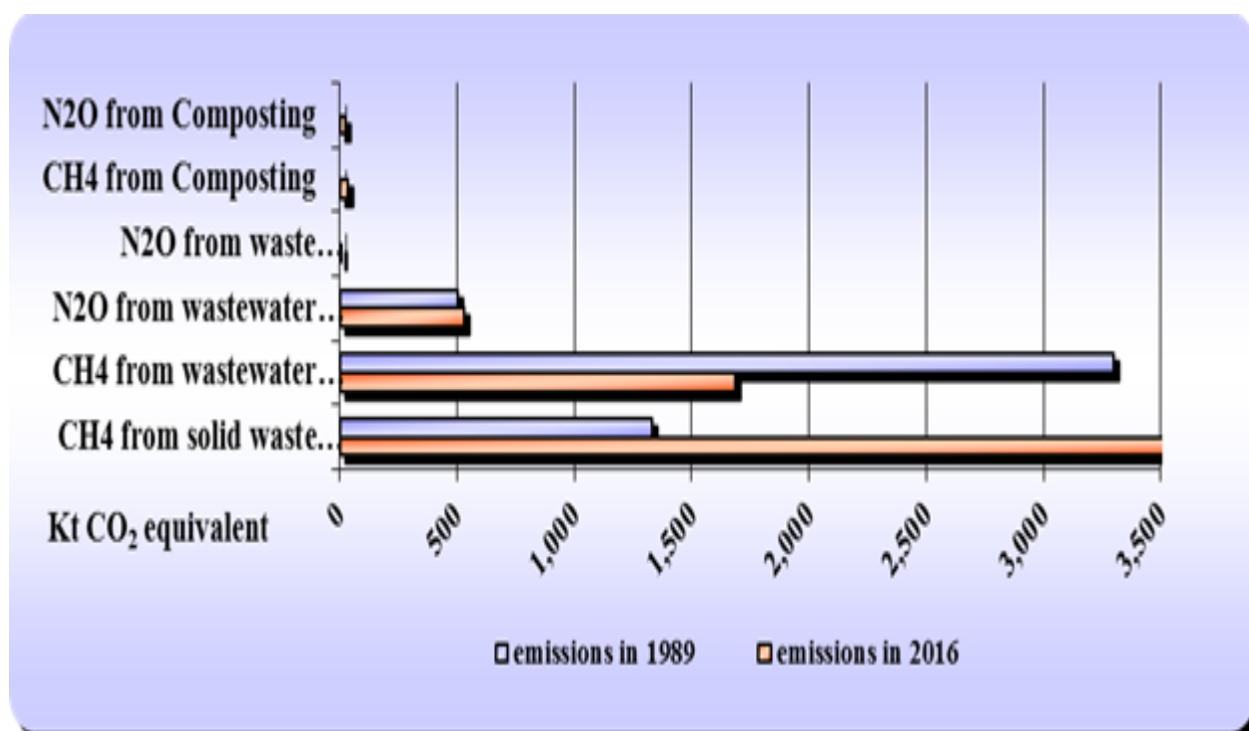


**Table 7.3 Key categories in Waste Sector based on the level and trend assessment in 2016**

Key category	Direct GHG	Criteria for identification	Contribution of key category in total GHG emissions [%] - (excluding LULUCF)
5.A Solid waste disposal	CH <sub>4</sub>	L,T	3.06
5.D Wastewater	CH <sub>4</sub>	L,T	1.45

Key category	Direct GHG	Criteria for identification	Contribution of key category in total GHG emissions [%] - (excluding LULUCF)
Treatment and Discharge	N <sub>2</sub> O	T	0.45

*Figure 7.4 Key categories in Waste Sector both by level and trend criteria, in 2016*



Methane represents the major greenhouse gas from Waste sector with a contribution of 18.51 % to the total methane emissions in Romania, in 2016. In the same year, nitrous protoxide has a contribution of 7.96 % to the total N<sub>2</sub>O emissions in our country. Only CO<sub>2</sub> emissions from Waste Incineration category are reported, these representing 0.01 % of total net CO<sub>2</sub> 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



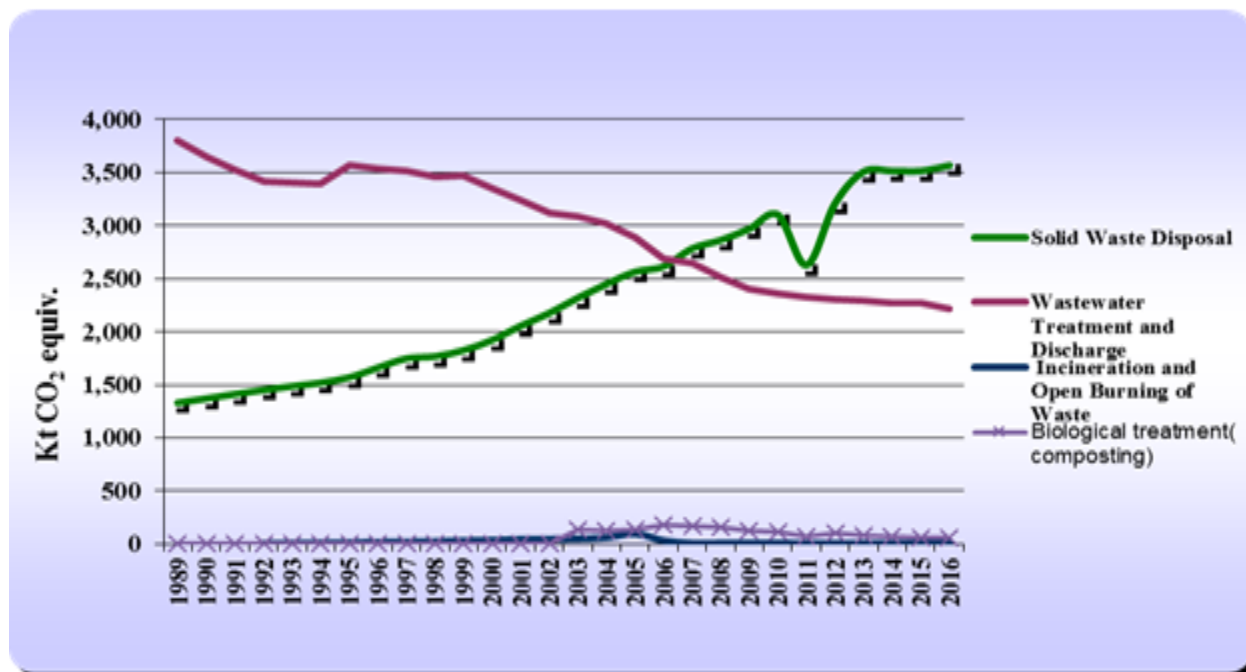
Solid Waste Disposal category (SWD) increased significantly in 2016 year comparing with the level in the base year, with a percentage of 168% (Figure 7.5).

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 41.84% in 2016 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 2016 year comparing with the level in the base year, with a percentage of 55.19 %.

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. Assessing the N<sub>2</sub>O emissions resulting from waste incineration", finished in 2013, in Waste Incineration category were described also the N<sub>2</sub>O emissions, the various type of incinerated waste and in this context the GHG emissions trend increase in 2016 year comparing with the level in 1992 year, with a percentage of 46.09% (Figure 7.5).

In Waste Incineration Subsector the emissions trend has remained almost constant in 2016 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 1989–2016 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<sub>4</sub> and CO<sub>2</sub> generation. To estimate CH<sub>4</sub> 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 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.

In 2015, the amount of waste collected through specialized services to the municipalities or through sanitation companies was 5093 million tone.

For 2016, the data regarding recovered/deposited MSW categories will be finalized later this year after statistical survey.

Concerning the amounts 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 deposited 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.

**Table 7.4 Total amount of collected waste MSW, in 2016 (Source [www.anpm.ro](http://www.anpm.ro))**

<b>Municipal Solid Waste categories</b>	<b>Recovered from total collected MSW (%)</b>	<b>Deposited from total collected MSW (%)</b>
Household and similar waste	4026	79

Municipal Solid Waste categories	Recovered from total collected MSW (%)	Deposited from total collected MSW (%)
Waste from municipal services	672	13
Waste from construction and demolition activities	395	8
Total	5093	100

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 37 sites in 2016 year (Table 7.5). In accordance with European regulations, the unmanaged SWDS are subject to a transition period, storage activity being stopped gradually.

**Table 7.5 Number of Solid waste Disposal Sites (Source Waste Directorate of NEPA)**

Type of SWDS/Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Managed	20	20	20	26	27	31	33	34	34	35	37
Unmanaged deep	90	92	87	87	40	70	49	48	33	25	19
Unmanaged shallow	130	109	96	14	35						

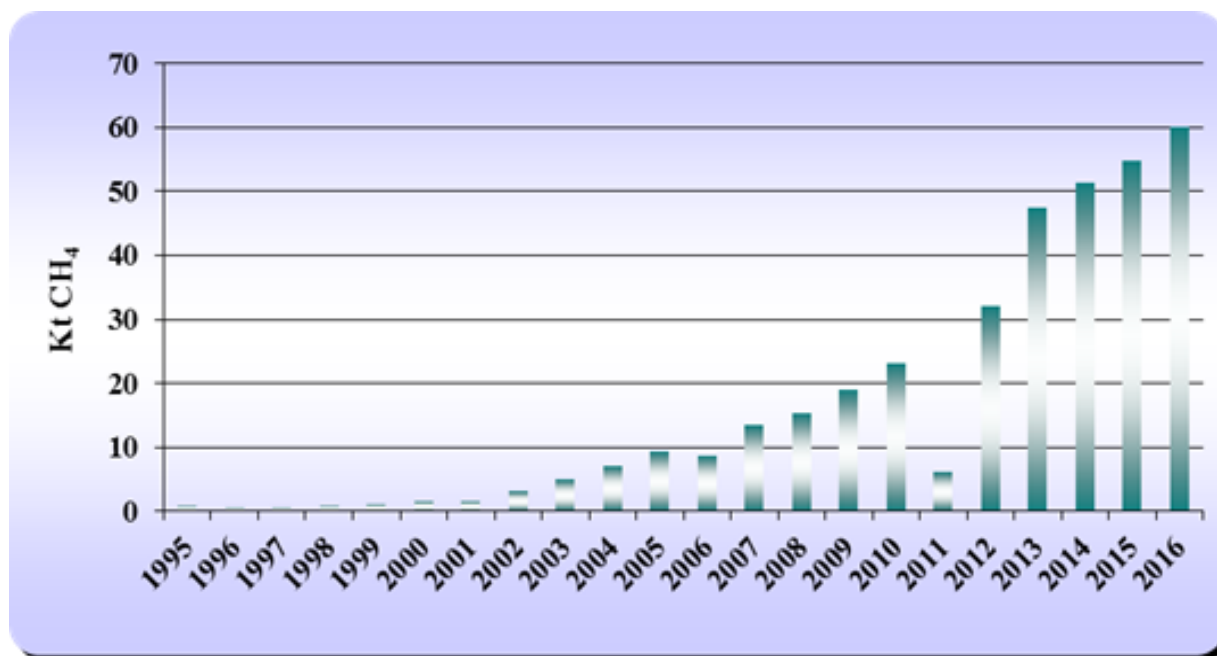
### ***CH<sub>4</sub> emissions from SWDS***

The methane emissions from Solid Waste Disposal Sites to managed landfills were estimated for the period 1995-2016, because in 1995 year was opened the first managed SWDS.

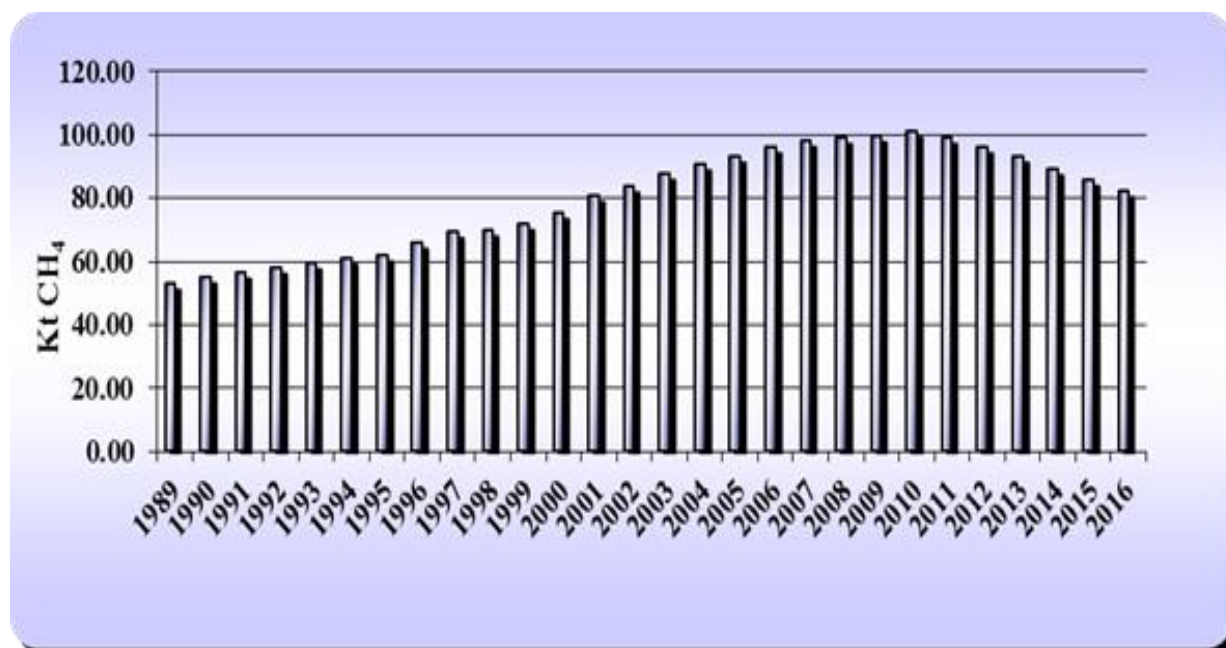
The methane emissions from managed SWDS have an increasing trend between 1995 – 2010 period. The significant difference between the level in 2010 and 2011 years is associated to the amount of CH<sub>4</sub> recovered in 2011 which register a value of 40.80 kt and determine in 2011 a lower level of CH<sub>4</sub> emissions from managed solid waste disposal sites of about 1.78 kt. In 2016 year, the amount of CH<sub>4</sub> recovery register a decrease comparing with 2015 year (9.92 kt in 2015 to

8.85 kt in 2016 year). The decrease associated to the amount of CH<sub>4</sub> 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<sub>4</sub> emissions trend from waste disposed to managed sites for 1995–2016 period**



During 1950-2009, CH<sub>4</sub> 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<sub>4</sub> emissions had a decreasing trend due to the decrease of the amounts of waste stored in unmanaged landfills.

**Figure 7.7 CH<sub>4</sub> emissions trend from waste disposed to unmanaged sites for 1989–2016 period**

### 7.2.2 Methodological issues

#### Methodology

Given the key category status both by level and trend, CH<sub>4</sub> 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 1950-2016 period, according to the IPCC 2006 provisions, to achieve an acceptably accurate result. In order to estimate CH<sub>4</sub> 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<sub>4</sub> 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 2003-2016 (see the Table 7.6).

Given the statistical survey on waste for 2016 has not yet finalised, for this year it was considered the same value as in 2015.

**Table 7.6 The percentage composition of municipal solid waste**

Year	Paper and textiles [%]	Garden & park waste/ other non-food organic	Food waste [%]	Wood/straw [%]	DOC	Source
1989	8.64	10.33	26.51	0.66	0.09	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”
1990	8.74	10.45	26.80	0.67	0.09	
1995	11.92	14.25	36.55	0.91	0.13	
2000	13.68	16.36	41.96	1.04	0.15	
2005	12.76	14.50	38.60	1.00	0.14	NEPA
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	

Year	Paper and textiles [%]	Garden & park waste/ other non-food organic	Food waste [%]	Wood/straw [%]	DOC	Source
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	10.17	6.09	46.62	1.71	0.13	
2016	10.34	5.25	43.46	1.72	0.12	

\* Preliminary data

In order to calculate the CH<sub>4</sub> emissions from municipal solid waste, default values associated with the other parameters, provided through IPCC 2006, taking into account the national circumstances, were used (Table 7.7 and 7.8). 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. Therefore 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 <sub>F</sub>	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 <sub>F</sub>	F	k	OX
Sewage sludge disposed to managed SWDS	1.00	0.05	0.50	0.5	0.06	0.1
Sewage sludge disposed to unmanaged-deep	0.80	0.05	0.50	0.05	0.06	0.00
Sewage sludge disposed to unmanaged-shallow	0.40	0.05	0.50	0.05	0.06	0.00
Source	IPCC 2006					

### *Activity data*

#### *Municipal solid waste*

For 2003-2016 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 2016 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	
<b>1989</b>	NO	2,545.70	1,630.70	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”
<b>1990</b>	NO	2,573.86	1,648.74	
<b>1995</b>	150.00	3,418.33	2,189.67	
<b>2000</b>	565.66	3,684.89	2,360.43	
<b>2005</b>	2,079.84	3,020.00	1,780.00	NEPA
<b>2007</b>	2,841.68	2,874.98	1,132.44	
<b>2008</b>	3,187.59	3,344.19	754.62	
<b>2009</b>	3,158.06	3,022.59	574.24	
<b>2010</b>	3,522.27	1,556.33	372.64	
<b>2011</b>	3,697.73	1,156.85	213.96	
<b>2012</b>	3,802.51	667.38	164.69	
<b>2013</b>	3,788.67	449.03	108.98	
<b>2014</b>	3,899.88	554.69	89.97	
<b>2015</b>	4,202.90	432.32	146.21	
<b>2016*</b>	4,643.89	309.17	22.02	

\*Preliminary data (final data for 2016 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. Assessing the N<sub>2</sub>O 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 2006-2015 were considered in the emission estimation.

Taking into account that the statistical survey on waste has not yet finalized for 2016 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 1950-2016.

***Table 7.10 Total annual sewage sludge disposed to Solid Waste Disposal Sites (1950–2016 period)***

Year	Total amount of sewage sludge in Kt disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
<b>1989</b>	NO	21.78	50.82	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-
<b>1990</b>	NO	21.73	50.70	
<b>1995</b>	72.23	33.97	49.07	
<b>2000</b>	123.39	38.65	55.82	
<b>2005</b>	443.50	31.13	44.96	

Year	Total amount of sewage sludge in Kt disposed to			Source
	managed sites	unmanaged deep sites	unmanaged shallow sites	
2007	572.07	4.99	5.91	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. Assessing the N <sub>2</sub> O emissions resulting from waste incineration"
2008	1186.75	6.17	6.81	
2009	308.48	4.20	0.68	
2010	271.61	2.05	1.80	
2011	692.50	2.06	1.54	NIS
2012	93.11	1.08	0.81	
2013	130.49	37.97	9.22	
2014	403.22	57.35	9.30	
2015	258.85	26.63	9.00	
2016*	274.88	18.30	1.30	

\* Preliminary data (final data for 2016 will be provided after statistical survey of the end of this year).

### ***CH<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub> recovered in 2011 and 2012. The differences between 2010 and 2011 year are due to the CH<sub>4</sub> 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 amount of methane flared is recovered from 17 managed SWDS and the amount of methane for energy purposes is recovered from 4 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<sub>4</sub> recovered from managed SWDS (Source: operators of landfills)***

<b>Year</b>	<b>Amount of CH<sub>4</sub> flared kt/year</b>	<b>Amount of CH<sub>4</sub> for energy recovery kt/year</b>
<b>1989-1995</b>	-	-
<b>1996</b>	0.43	NO
<b>2000</b>	1.97	NO
<b>2005</b>	8.91	NO
<b>2007</b>	13.09	NO
<b>2008</b>	15.91	NO
<b>2009</b>	15.99	NO
<b>2010</b>	16.37	NO
<b>2011</b>	38.32	2.48
<b>2012</b>	14.79	2.77
<b>2013</b>	3.79	2.99
<b>2014</b>	4.92	2.99
<b>2015</b>	4.94	4.28
<b>2016</b>	5.56	3.29

***CO<sub>2</sub> emissions from solid waste disposal on land***

CO<sub>2</sub> 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<sub>4</sub>, solid waste disposal sites can also produce substantial amounts of CO<sub>2</sub>. Decomposition of organic material derived from biomass sources (e.g., crops, forests) which are regrown on an annual basis is the primary source of CO<sub>2</sub> released from waste. Hence, these CO<sub>2</sub> 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<sub>4</sub> and CO<sub>2</sub> (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<sub>2</sub> and a range of carboxylic acids. These acids are then converted to acetic acid which, together with hydrogen and CO<sub>2</sub>, forms the major substrate for growth of methanogenic bacteria.

Landfill gas consists of approximately 50 per cent CO<sub>2</sub> and 50 per cent CH<sub>4</sub> by volume. However, the percentage of CO<sub>2</sub> 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<sub>2</sub> dissolves in water within the site.”

Taking into account these issues and considering the expert judgement, according to which CO<sub>2</sub> represent about 40% from landfill gas, there were estimated CO<sub>2</sub> emissions from SWDS, using CH<sub>4</sub> 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<sub>2</sub> 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, 2<sup>nd</sup> Edition”)*

Year	Greenhouse Gas	
	CH <sub>4</sub>	CO <sub>2</sub>
	kt	%
<b>1989</b>	53.24	40
<b>1990</b>	54.86	40
<b>1995</b>	62.83	40
<b>2000</b>	76.87	40
<b>2005</b>	102.60	40
<b>2007</b>	111.38	40
<b>2008</b>	114.53	40
<b>2009</b>	118.82	40
<b>2010</b>	124.09	40
<b>2011</b>	105.12	40
<b>2012</b>	128.41	40
<b>2013</b>	140.32	40
<b>2014</b>	140.63	40
<b>2015</b>	140.61	40
<b>2016*</b>	142.67	40

\* Preliminary data

### 7.2.3 Uncertainties and time-series consistency

Accuracy in CH<sub>4</sub> and CO<sub>2</sub> 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<sub>4</sub> emissions estimates on managed and unmanaged SWDS are presented in Table 7.13.

**Table 7.13 Uncertainties associated with CH<sub>4</sub> emissions estimates from managed and unmanaged SWDS**

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CH <sub>4</sub> from managed and unmanaged solid waste disposal	CH <sub>4</sub>	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 1989-2016 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 amounts of CH<sub>4</sub> recovery were updated for 2015 year due to an error of reporting data.

***Table 7.14 Changes made parameters and their effects on emission estimates***

The effects of recalculations in Solid waste disposal sub- sector			
Years	NGHGI 2015 v. 1.1	NGHGI 2016 v. 1	Differences [%]
	CH4 emissions [kt]		
1989	53.24	53.24	0.00
1990	54.86	54.86	0.00
1995	62.83	62.83	0.00
2000	76.87	76.87	0.00

The effects of recalculations in Solid waste disposal sub- sector			
Years	NGHGI 2015 v. 1.1	NGHGI 2016 v. 1	Differences [%]
	CH4 emissions [kt]		
2005	102.60	102.60	0.00
2007	111.38	111.38	0.00
2008	114.53	114.53	0.00
2009	118.82	118.82	0.00
2010	124.09	124.09	0.00
2011	105.12	105.12	0.00
2012	128.41	128.41	0.00
2013	140.32	140.32	0.00
2014	140.63	140.63	0.00
2015	140.79	140.61	-0.13

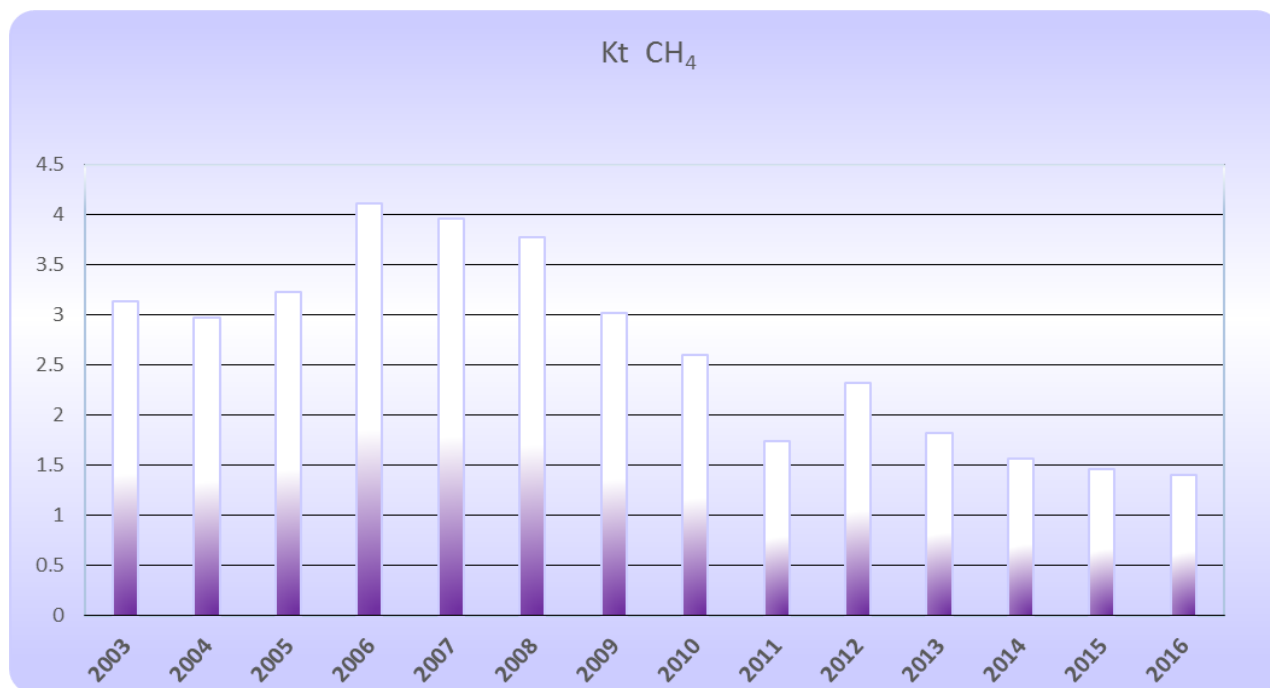
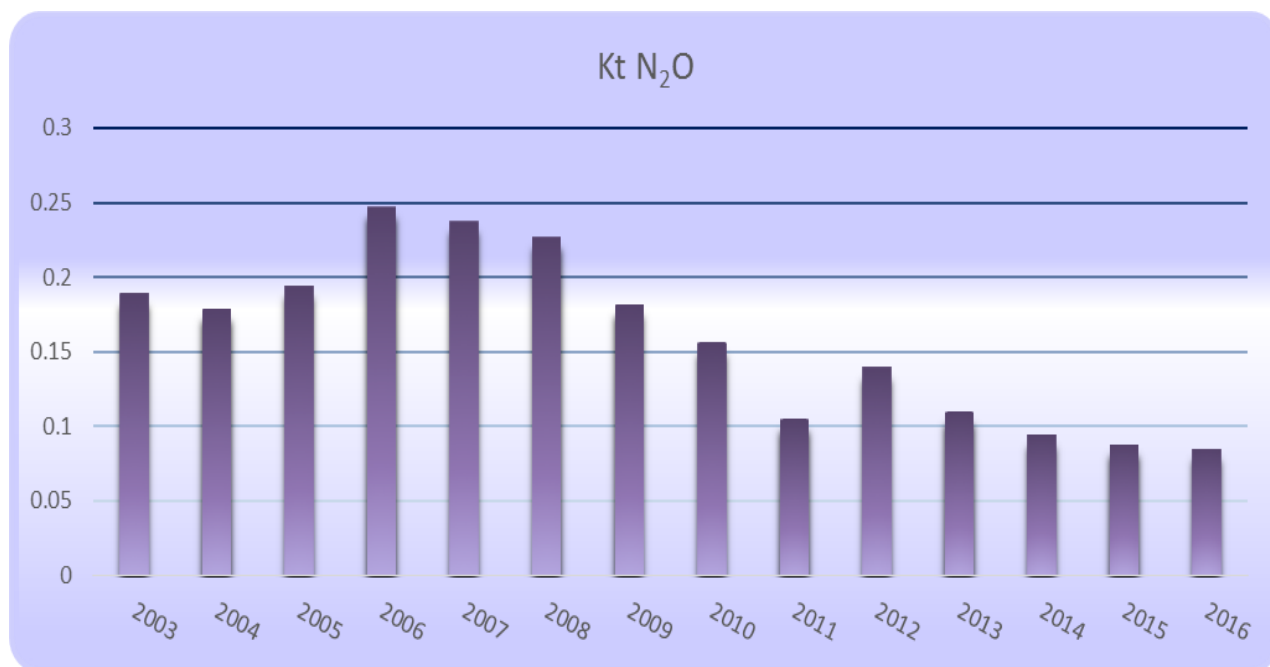
*7.2.6 Category-specific planned improvements, if applicable, including tracking of those identified in the review process*

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<sub>4</sub> and N<sub>2</sub>O emissions in the atmosphere from biological treatment of solid waste (composting). At the end of 2015, according to the Annual report on the state of the environment, at the national level, about 85 plants and platforms were authorized for composting biodegradable municipal waste.

**Figure 7.8 CH<sub>4</sub> emissions trend from composting, for 2003–2016 period****Figure 7.9 N<sub>2</sub>O emissions trend from composting, for 2003–2016 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<sub>4</sub>/kg of waste treated;
- Emission factor 0.24 g N<sub>2</sub>O/kg of waste treated.

The CH<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O emissions estimates is determined by the available data on composted waste. In the table below are presented the uncertainties associated to CH<sub>4</sub> and N<sub>2</sub>O emissions from Composting.

**Table 7.15 Uncertainties for estimation of CH<sub>4</sub> and N<sub>2</sub>O emissions from composting**

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty
Amount of composted municipal waste	CH <sub>4</sub>	20.00	4 (0.03-8)

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty
Amount of composted municipal waste	N <sub>2</sub> O	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*

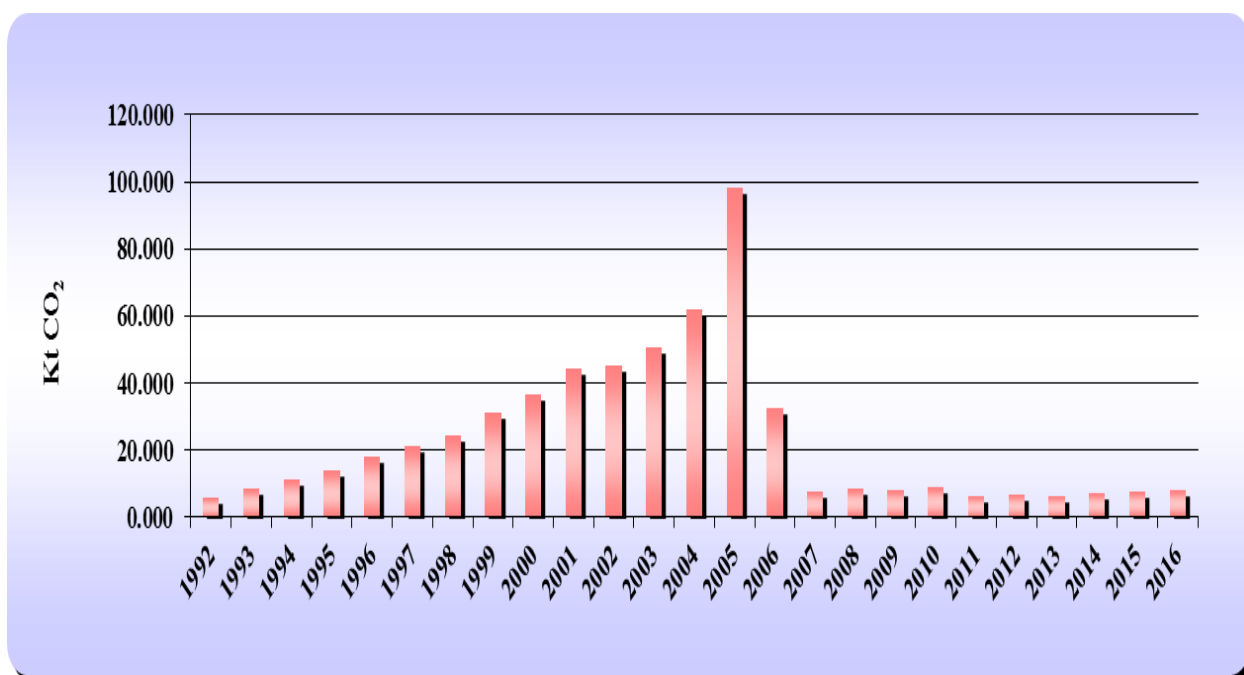
Waste incineration includes emissions resulted from the incineration of clinical waste, hazardous waste, biogenic waste and, like other types of combustion, is a source of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions. Based on the study "Determining the quantities of industrial waste with 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. Assessing the N<sub>2</sub>O emissions resulting from waste incineration" finalized in 2013, were estimated the N<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub> emissions trend from waste incineration, for 1992–2016 period**



The CO<sub>2</sub> emissions from waste incineration were calculated for hazardous and clinical waste.

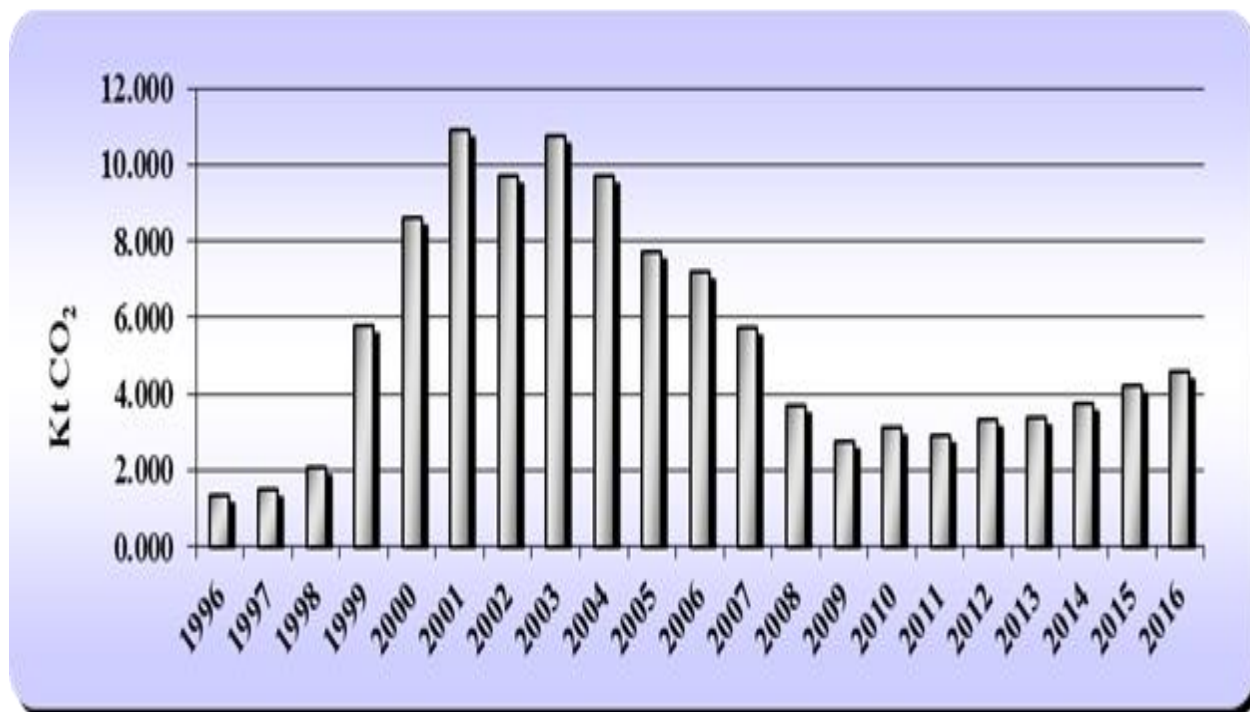
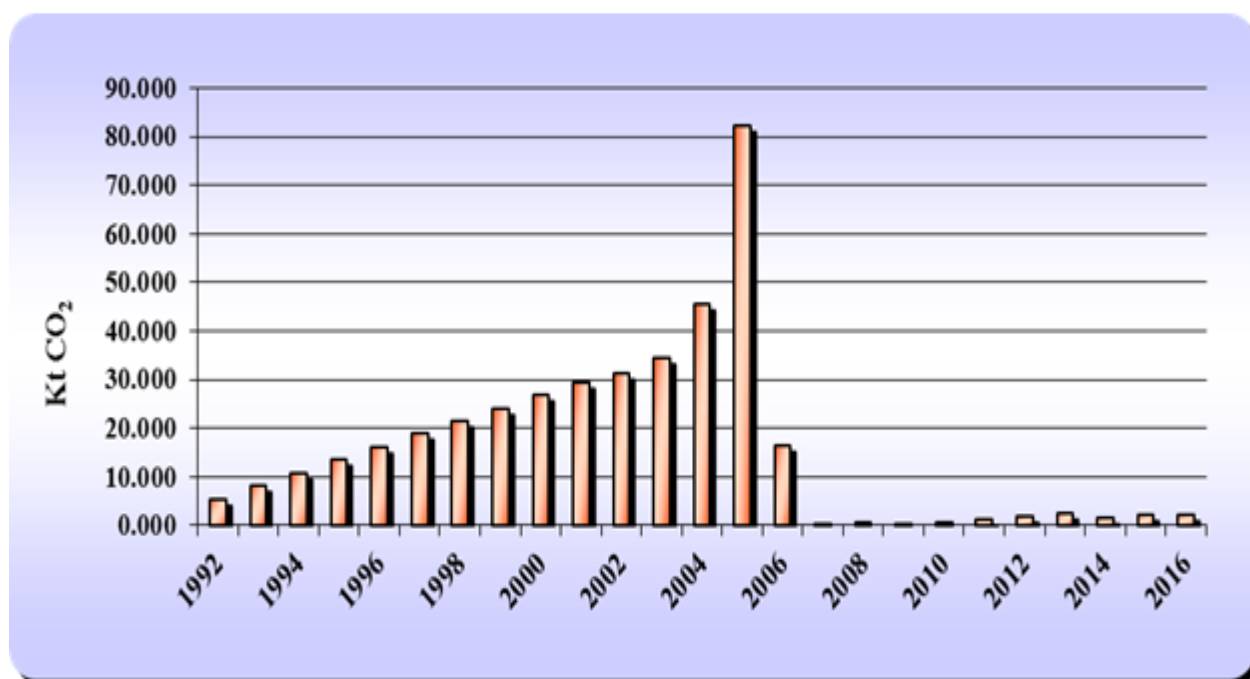
In the estimation of CO<sub>2</sub> emissions from clinical waste incineration were used the amounts of waste incinerated provided by National Institute for Public Health.

Clinical waste are incinerated since 1996, but more accurate data became available after 2000.

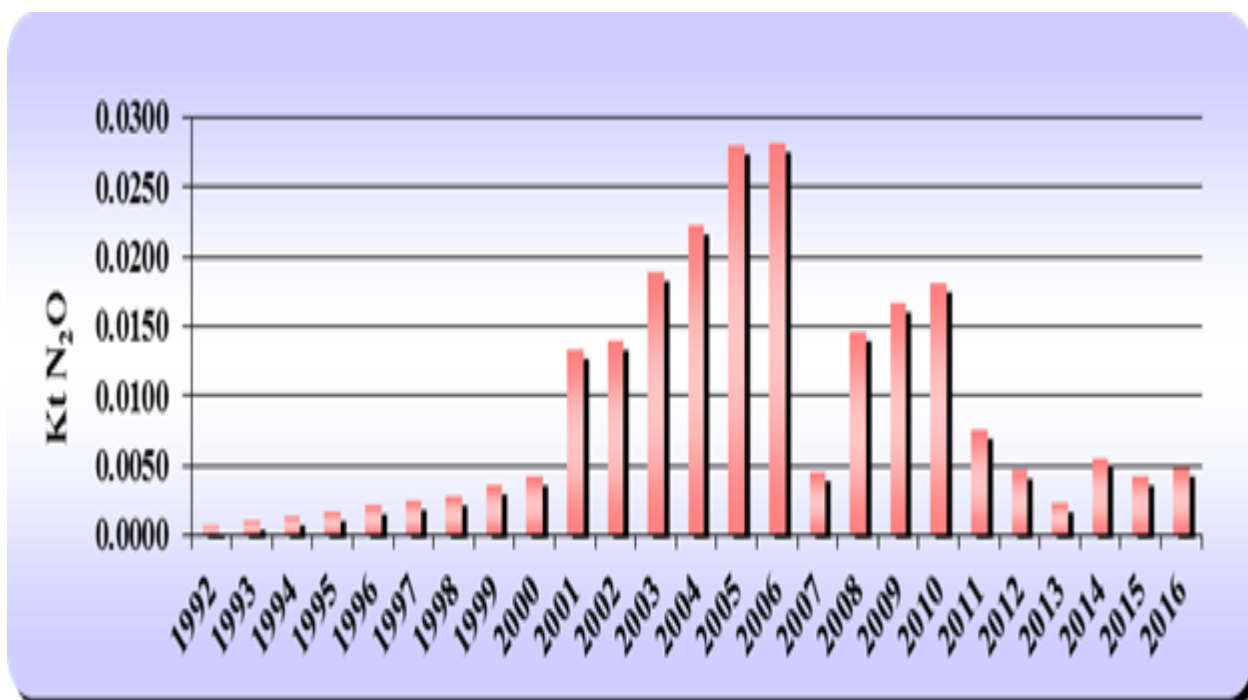
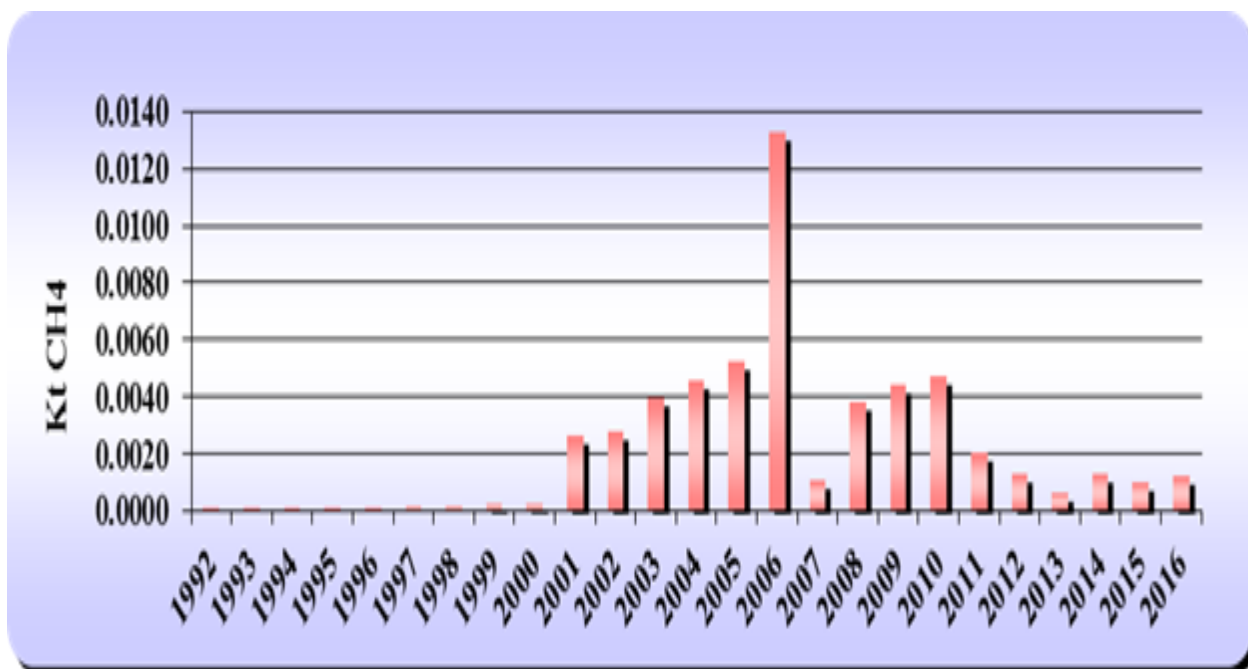
It can observe a period of increasing activity between 1999 and 2007. Since 2008 in Romania were closed all health units crematoria used to burn hazardous medical waste, in according with European regulations.

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.

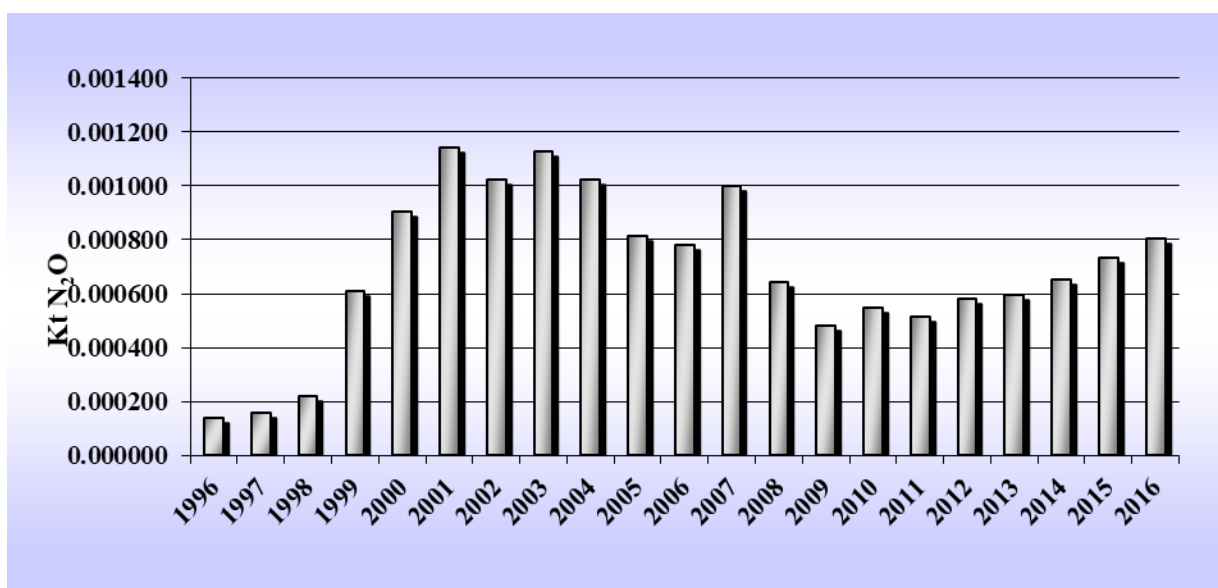
*Figure 7.11 CO<sub>2</sub> emissions trend from clinical waste incineration, for 1996–2016 period**Figure 7.12 CO<sub>2</sub> emissions trend from hazardous waste incineration, for 1992–2016 period*

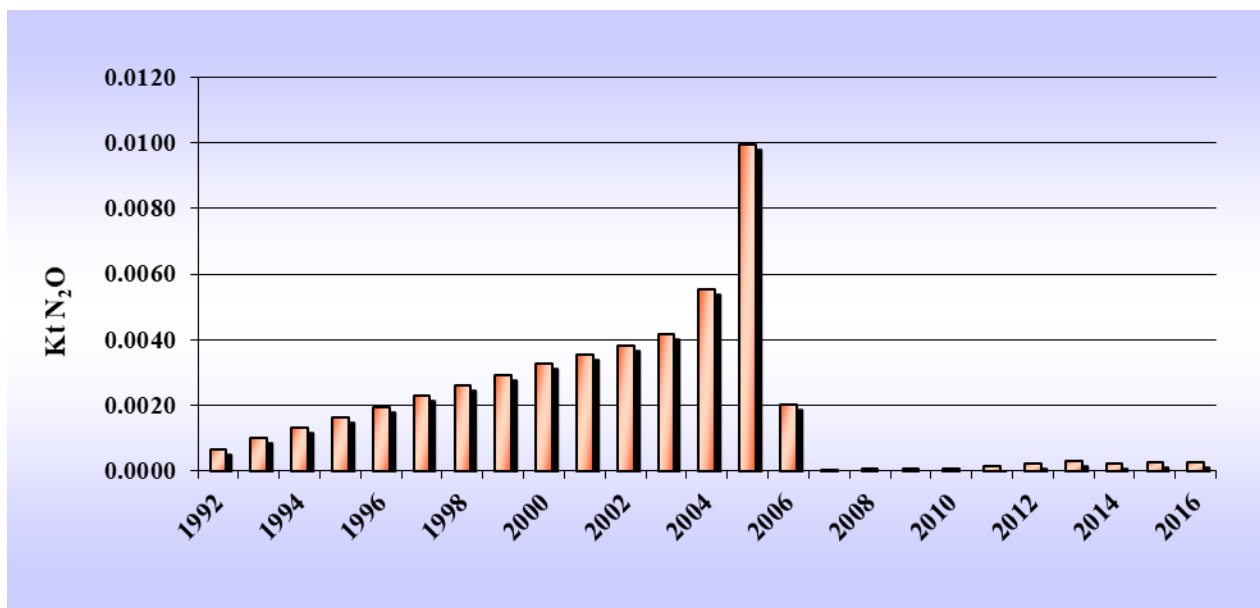
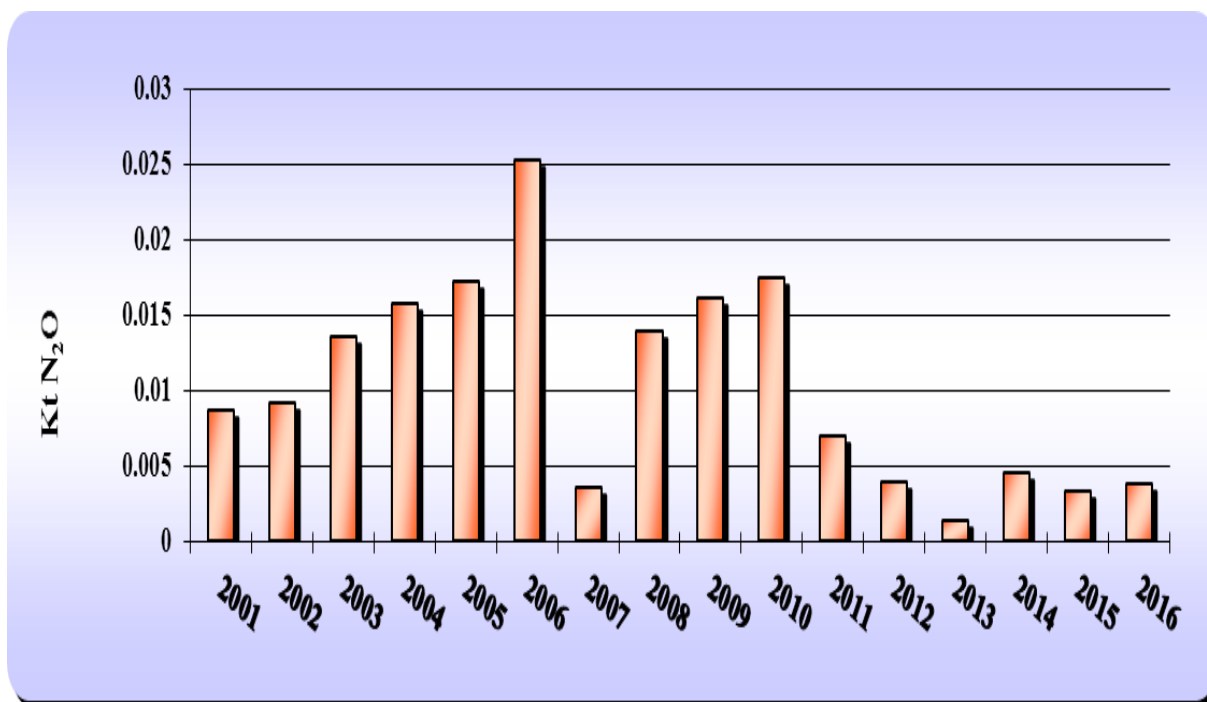


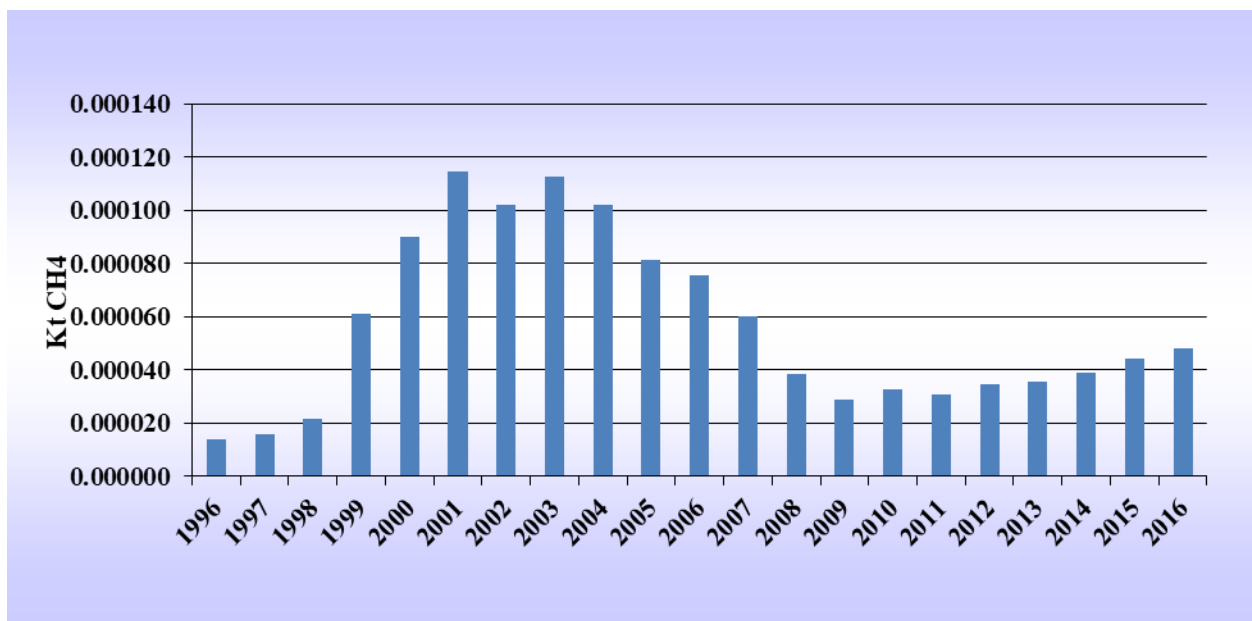
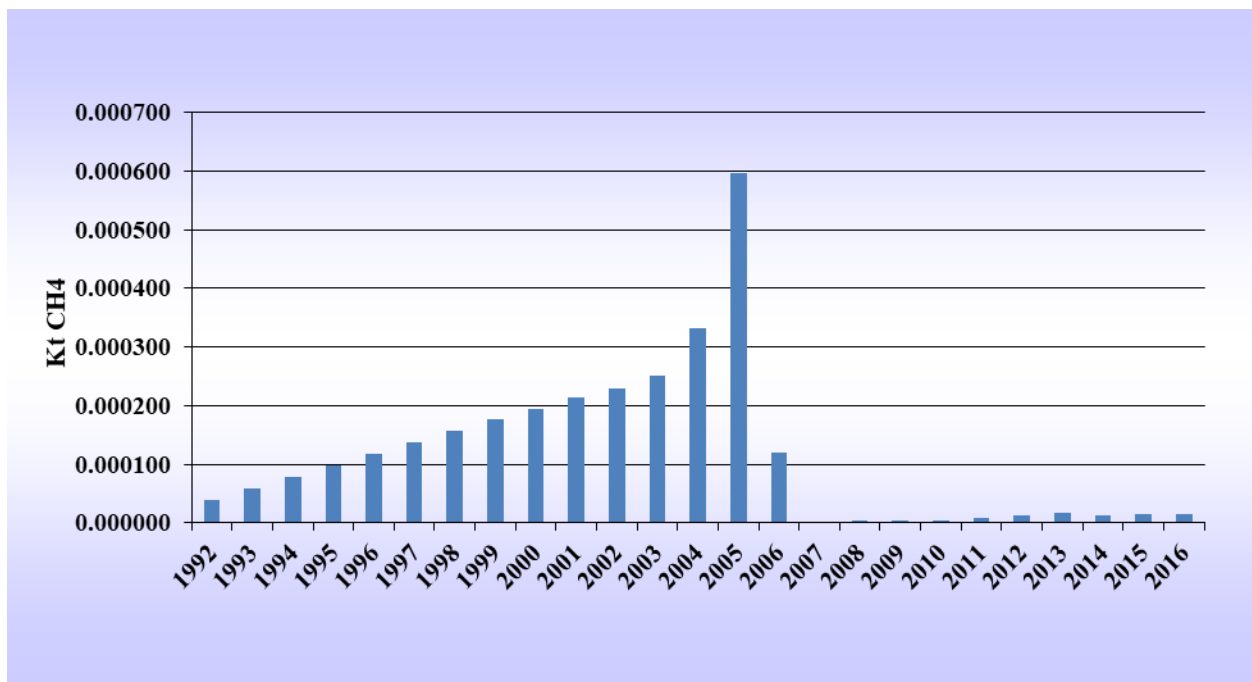
*Figure 7.13 N<sub>2</sub>O emissions trend from waste incineration, for 1992–2016 period**Figure 7.14 CH<sub>4</sub> emissions trend from waste incineration, for 1992–2016 period*

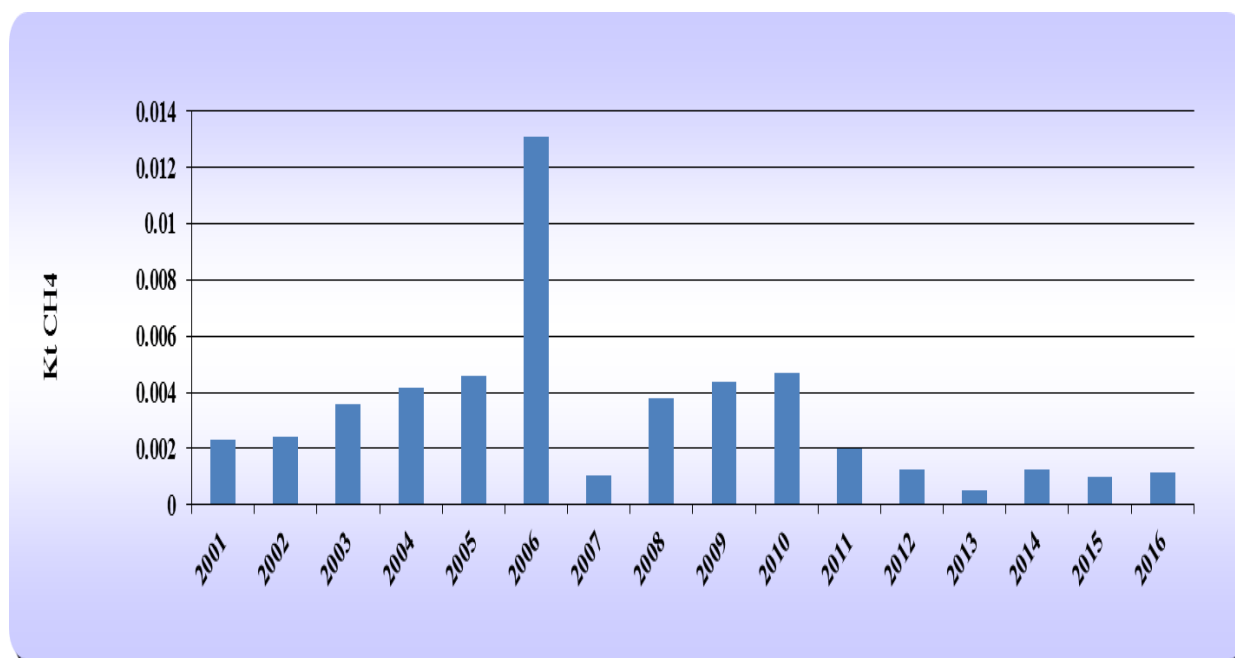
The  $\text{N}_2\text{O}$  and  $\text{CH}_4$  emissions from waste incineration were calculated for hazardous, clinical and biogenic waste. For estimation of  $\text{N}_2\text{O}$  and  $\text{CH}_4$  emissions from clinical waste incineration were used the amounts of waste incinerated provided by National Institute for Public Health. For  $\text{N}_2\text{O}$  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  $\text{N}_2\text{O}$  and  $\text{CH}_4$  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 2013-2016 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  $\text{N}_2\text{O}$  emissions trend from clinical waste incineration, for 1996–2016 period**



*Figure 7.16 N<sub>2</sub>O emissions trend from hazardous waste incineration, for 1992–2016 period**Figure 7.17 N<sub>2</sub>O emissions trend from biogenic waste incineration, for 2001–2016 period*

*Figure 7.18 CH<sub>4</sub> emissions trend from clinical waste incineration, for 1996–2016 period**Figure 7.19 CH<sub>4</sub> emissions trend from hazardous waste incineration, for 1992–2016 period*

**Figure 7.20 CH<sub>4</sub> emissions trend from biogenic waste incineration, for 2001–2016 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 methane 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<sub>2</sub> and N<sub>2</sub>O 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<sub>2</sub> emissions from waste incineration (Source: IPCC 2006. table 5.2)**

<b>Emission Factors</b>	<b>Clinical Waste</b>	<b>Hazardous Waste</b>
C content of Waste	60%	50%
Fossil Carbon as % of Total Carbon	40%	90%
Efficiency of Combustion	95%	100%

**Table 7.17 Default data for estimation of N<sub>2</sub>O emissions from waste incineration (Source: IPCC 2006)**

<b>Type of incinerated waste</b>	<b>N<sub>2</sub>O emission factors, in gN<sub>2</sub>O/t<sub>waste</sub></b>	<b>Source</b>
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<sub>4</sub> emissions from waste incineration (Source: IPCC 2006, Vol.5: Waste, p.5.20, Table 5.3).**

Type of incinerated waste	CH <sub>4</sub> 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 [Gg/yr]	
1996	4.05	2.35
2000	15.03	15.03
2005	15.49	13.55
2007	14.08	10.00

Year	Clinical waste generated	Clinical waste incinerated
	Unit [Gg/yr]	
2008	11.11	6.44
2009	9.78	4.79
2010	10.50	5.46
2011	8.85	5.13
2012	8.93	5.81
2013	7.94	5.94
2014	7.72	6.53
2015	7.72	7.35
2016	7.72	8.02

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 2003-2016 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
1995	16.35	Study 2013	-	-	-	-
2000	32.53		15.03	ISPB	-	-
2005	99.54		13.55		76.33	Study 2013
2007	0.45		10.00		17.04	
2008	0.75		6.44		63.18	



Year	Hazardous waste		Clinical waste		Biogenic	
	Incinerated waste[kt/yr]	Source	Incinerated waste[kt/yr]	Source	Incinerated waste[kt/yr]	Source
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	2.94		5.94		9.01	
2014	2.06	NEPA	6.53		21.30	Operators
2015	2.67		7.35		16.26	
2016	2.67		8.02		19.17	

\* Preliminary data (final data for 2016 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<sub>2</sub> emissions from waste incineration.

**Table 7.21 Uncertainties for estimation of CO<sub>2</sub> emissions from waste incineration**

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CO <sub>2</sub> from waste incineration	CO <sub>2</sub>	5.00	20.00	20.62
N <sub>2</sub> O from waste incineration	N <sub>2</sub> O	5.00	50.00	50.2

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CH <sub>4</sub> from waste incineration	CH <sub>4</sub>	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 Biogenic waste other than Municipal Solid Waste subsector, the CH<sub>4</sub> emissions were recalculated for 2001-2015 years due to an transcription error.

*Table 7.22 Changes made on emission estimates*

The effects of recalculations in Biogenic waste other than Municipal Solid Waste			
Years	NGHGI 2017	NGHGI 2018	Differences [%]
	CH <sub>4</sub> emissions [kt]		
1989-1991	NE,NO		
1992	0.0000	0.0000	0.0000
1995	0.0001	0.0001	0.0000
2000	0.0003	0.0003	0.0000
2005	0.0027	0.0053	-0.0026
2007	0.0045	0.0011	0.0034
2008	0.0038	0.0038	0.0000
2009	0.0011	0.0044	-0.0034
2010	0.0131	0.0048	0.0084
2011	0.0046	0.0020	0.0026
2012	0.0042	0.0013	0.0029
2013	0.0037	0.0006	0.0031
2014	0.0025	0.0013	0.0011
2015	0.0024	0.0010	0.0013

*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 2016, from a total volume of 2,383.56 million m<sup>3</sup>/year wastewater evacuated, 99.70% was wastewater which requiring treatment. From this, 56.92% was represented wastewater sufficient (appropriate) treated, 13.20% untreated wastewater and 29.58% insufficient treated wastewater (Table 7.23).

**Table 7.23 Wastewater evacuated into Romania, in 2016 (Source: National Administration “Romanian Waters”)**

Wastewater category	Volume (mil. mc)	Percentage (%)
Total wastewater evacuated	2,383.56	-
Total domestic wastewater evacuated	1,276.45	53.55
Total industrial wastewater evacuated	1,089.42	45.71
Domestic wastewater treated	1,151.74	48.32
Industrial wastewater treated	895.50	37.57
Total wastewater requiring treatment	2,376.42	99.70
Sufficient treated wastewater	1,356.81	56.92
Insufficient treated wastewater	705.09	29.58
Untreated wastewater	314.53	13.20

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 1123.89 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: 39 treatment plants;

- secondary stage: 600 treatment plants;
- tertiary stage: 140 treatment plants.

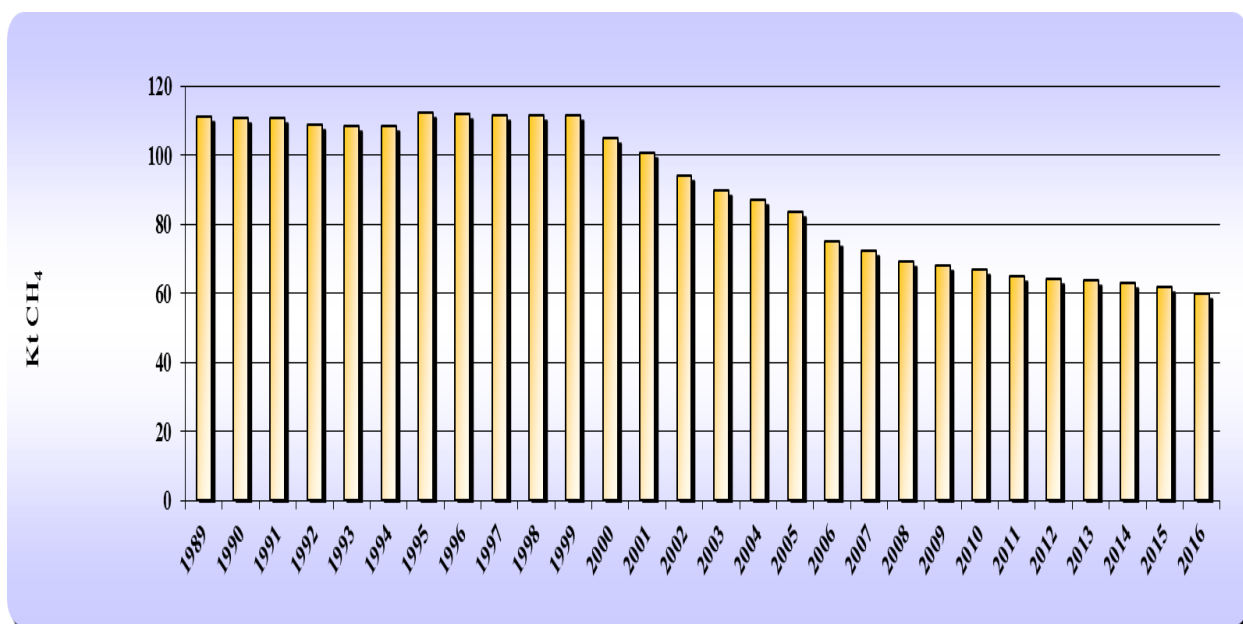
This situation is changing every year because the sewage system extends under projects financed by government programs, enhancing the connection to the sewerage and wastewater treatment.

### *CH<sub>4</sub> emissions from wastewater*

#### *CH<sub>4</sub> emissions from domestic and commercial wastewater and sludge (CRF 5.D. 1)*

In estimation of CH<sub>4</sub> 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 2016 compared to base year (1989) is in decreasing with 46.07 %.

**Figure 7.21  $CH_4$  emissions trend from domestic/commercial wastewater and sludge treatment for 1989–2016 period**



#### ***CH<sub>4</sub> emissions from industrial wastewater (CRF 5.D2)***

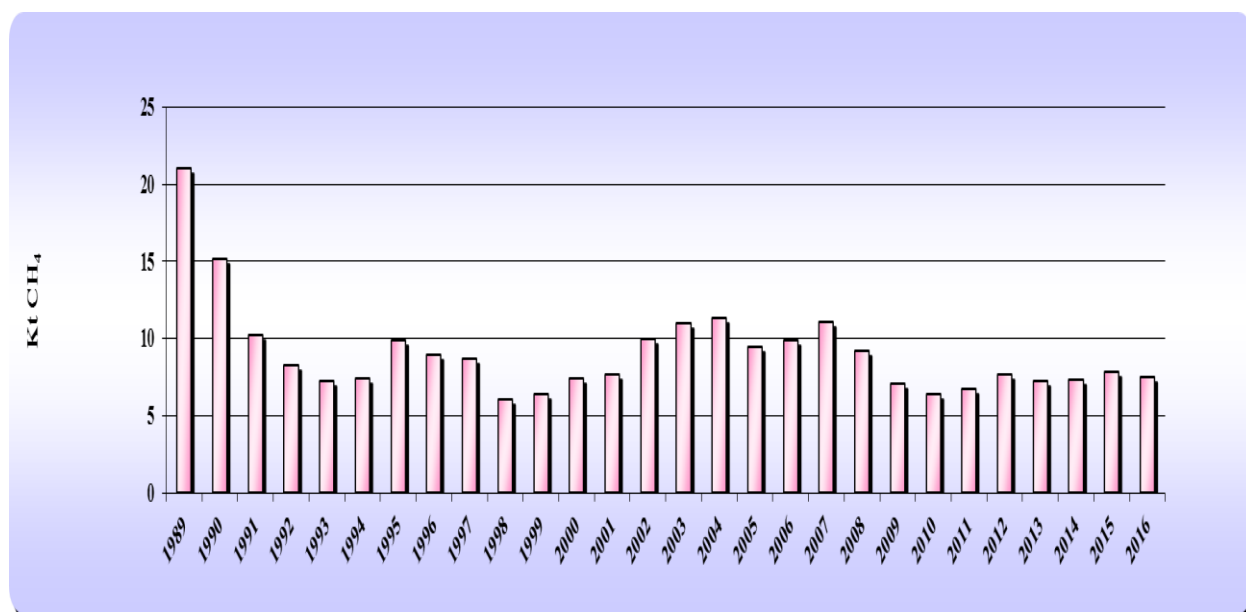
Depending on the industry of origin, industrial wastewaters have a different composition.

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<sub>4</sub> emissions trend from industrial wastewater handling for 1989–2016 period**

Compared with the base year (1989), CH<sub>4</sub> emissions from industrial wastewater treatment decreased with 64.50 %.

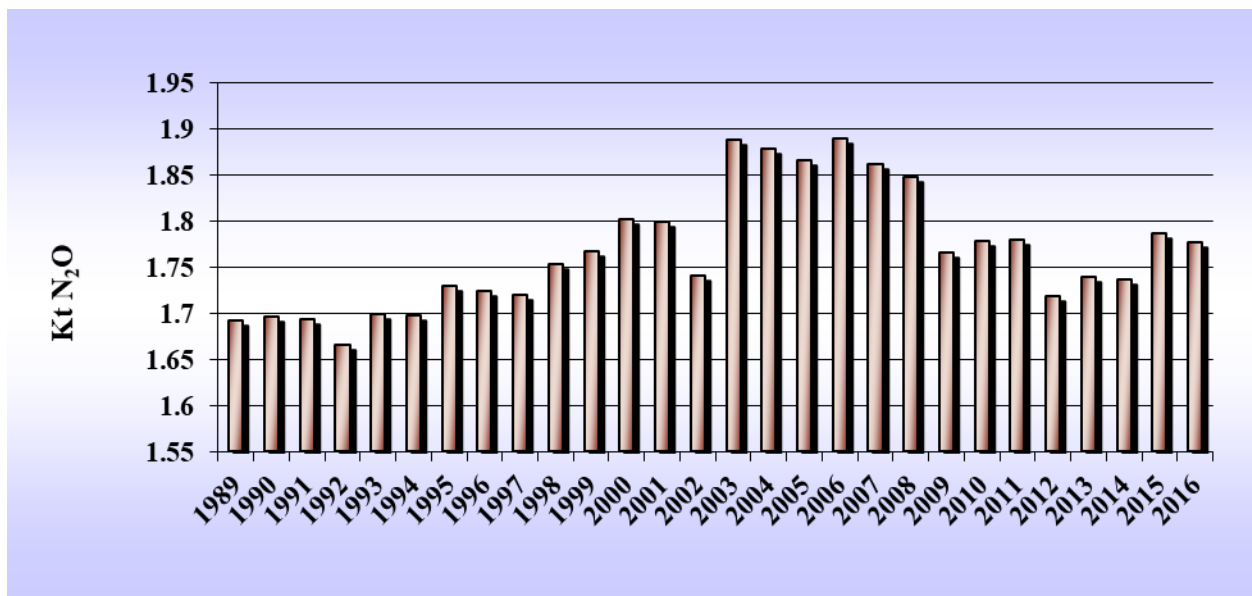
**Table 7.24 Explanations on methane emissions estimates**

Period	Methane emissions from industrial wastewater treatment -Explanations
<b>1989-1996</b>	Values between 21.01–8.96 kt; These values are decreasing following decreasing industrial production.
<b>1997-2004</b>	Values between 8.65–11.34 kt; These values are relatively higher than previous period due to: <ul style="list-style-type: none"> <li>• progress in Romanian economy, increase of the production;</li> <li>• increasing of fraction of wastewater treated anaerobically.</li> </ul>
<b>2005-2016</b>	Values between 9.44 –7.46; Relatively lower values compared with 1997-2004 period, but since 2009 following a sharp decline due to economic crisis, then slightly increase 2010-2016



The same decreasing tendency is noted for CH<sub>4</sub> emissions from domestic/commercial wastewater (Figure 7.21). For estimate N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions recorded in 2002, compared with 2001 year, is due to the severe loss of population number. Additional, the increasing trend of N<sub>2</sub>O emissions recorded in 2003, compared with 2002 year is due to the increasing values of protein consumption. After 2009 year, the emissions register a sharply decrease, being influenced by the several decrease of protein consumption values, reflecting so the impact of economic crisis. (Figure 7.19 and Table 7.22).

**Figure 7.23 N<sub>2</sub>O emissions trend from domestic wastewater for 1989–2016 period**



### 7.5.2 Methodological issues

#### **CH<sub>4</sub> emissions from domestic and commercial wastewater (CRF 5.D.1)**

Domestic wastewater is treated in municipal treatment plants wastewater by the following processes: mechanical treatment, chemical-mechanical treatment or biological-mechanical treatment.

In biological treatment are two types of processes:

- aerobic processes, when result energy by oxidation of organic substances. Aerobic processes depend on the existence of aerobic bacteria, and these on the presence of dissolved oxygen. By aerobic treatment process organic material is removed from the wastewater.
- anaerobic processes, characterized by reducing oxygen and energy consumption. Anaerobic treatment of wastewater leads to nitrogen removal by nitrification and denitrification processes. During anaerobic processes occur methane emissions.

Aerobic treatment process required oxygen is transferred from the mass flow by air into water O<sub>2</sub> 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<sub>2</sub> and age requirements sludge. The O<sub>2</sub> concentration must be higher than the critical concentration calculated for a sludge age. In addition to this required O<sub>2</sub>, it should be provided that in each point of the aeration tank to be an excess of O<sub>2</sub> dissolved.

In aerobic biological treatment tank air is introduced. At each point in the aeration tank maintain a dissolved O<sub>2</sub> in excess of 1-3 mg O<sub>2</sub> / l. The concentration of O<sub>2</sub> 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.

Number of wastewater treatment plants for each category in 2016 year:

- municipal treatment plants: 779
- industrial treatment plants: 4292
- individual treatment plants: 5342

### ***Methodology***

To estimate CH<sub>4</sub> 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<sub>4</sub> 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 7.25 Calculation of Emission Factors domestic/commercial wastewater, for 1989-2016 period**

<b>Parameter</b>	<b>B<sub>oi</sub></b> (kg CH <sub>4</sub> /kg BOD)	<b>MCF<sub>j</sub></b>	<b>EFs</b>
Population connected to sewerage without treatment	0.60	0.0	<b>0.00</b>
Centraled, aerobic treatment plant	0.6	0.2	<b>0.12</b>
Population unconnected to sewerage	0.60	0.5	0.30
<b>Source:</b>	<b>IPCC 2006</b>	<b>Expert opinion</b>	<b>-</b>

#### *Activity data*

To estimate methane emissions from domestic/commercial wastewater, data provided by 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”.

The number of population connected to sewerage with treatment was calculated using total population and fraction of population connected to sewerage with treatment. The data on total population, the urban population and the population in rural areas were obtained from the 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 by making the difference between total population and population connected to sewerage.

**Table 7.26 The sources of activity data used in methane emissions estimates from domestic/commercial wastewater treatment**

Activity Data	Source
Total population [1000 persons]	<i>National Institute for Statistics</i>
Total population connected to sewerage with treatment [1000 persons] - $P_{tot\ tr}$	<i>1989 -2005 period: <math>P_{tot\ tr} = P_{urb\ tr} + P_{rur\ tr}</math> ; 2006 – 2016 : National Institute for Statistics</i>
Urban population	<i>National Institute for Statistics</i>
Population in rural areas	<i>National Institute for Statistics</i>

To calculate Total Organic Wastewater we used the parameters provided by the study (Table 7.27).

**Table 7.27 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 2008-2016 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<sub>4</sub> 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<sub>2</sub>O emissions from domestic wastewater***

Direct emissions of N<sub>2</sub>O 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<sub>2</sub>O emissions.

### ***Methodology***

To estimate N<sub>2</sub>O 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<sub>2</sub>O- N/kg N), emission factor (0.005 kg N<sub>2</sub>O – N/kg N).

### ***Activity data***

In estimation of N<sub>2</sub>O 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 1989-2016 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 7.28.

**Table 7.28 Values of Protein Consumption for Romania in period 1989-2016**

<b>Year</b>	<b>Protein consumption [kg protein/person/yr]</b>	<b>Source</b>
<b>1989</b>	33.22	Statistical Yearbook 2004-2006
<b>1990</b>	33.22	FAO - Romania Country Profile
<b>1993</b>	33.95	Interpolation between 1992 and 1994 by expert judgement
<b>1994</b>	33.95	Statistical Yearbook 2009
<b>1995</b>	34.68	FAO - Romania Country Profile
<b>2000</b>	36.5	FAO - Romania Country Profile
<b>2005</b>	39.79	Statistical Yearbook 2010
<b>2007</b>	40.52	FAO - Romania Country Profile
<b>2008</b>	40.88	National Institute for Statistics
<b>2009</b>	39.42	
<b>2010</b>	39.93	
<b>2011</b>	40.15	
<b>2012</b>	38.95	
<b>2013</b>	39.57	
<b>2014</b>	39.64	
<b>2015</b>	40.99	
<b>2016*</b>	40.99	<i>Preliminary data</i>

***CH<sub>4</sub> 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 use 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<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub> 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 7.29 The Emissions Factors for aerobic and anaerobic treatment***

<b>Emission Factor</b>			
<b>Beer industry - Period</b>	<b>Methane Conversion Factor – MCF</b>	<b>Maximum methane producing capacity - B<sub>0</sub> (kg CH<sub>4</sub>/kg COD)</b>	<b>Emission factor for industrial wastewater - EF (kg CH<sub>4</sub>/kg COD)</b>
1989 - 1997; treated aerobically	0.05	0.25	0.01
1998 - 2015; anaerobic treatment	0.70	0.25	0.18
<b>Pulp, paper and petroleum refinery - Period</b>	<b>Methane Conversion Factor– MCF</b>	<b>Maximum methane producing capacity - B<sub>0</sub> (kg CH<sub>4</sub>/kg COD)</b>	<b>Emission factor for industrial wastewater - EF (kg CH<sub>4</sub>/kg COD)</b>
1989 - 1997; treated aerobically	0.05	0.25	0.01
1998 - 2015; anaerobic treatment	0.20	0.25	0.01

Emission Factor			
	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<sub>4</sub>/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 7.30).

***Table 7.30 Industrial production of the industrial sectors with the greatest potential for methane emissions (source: NIS - Statistical Yearbook 2016)***

Year	Production (t/year)			
	Beer	Paper	Pulp	Petroleum Refining
<b>1989</b>	1,151,300	552,000	574,000	30,615,000
<b>1990</b>	1,052,700	427,000	380,000	23,664,000
<b>1995</b>	876,800	332,000	194,000	15,259,000
<b>2000</b>	1,266,400	328,000	187,000	10,532,000
<b>2005</b>	1,529,500	385,000	103,000	13,890,000
<b>2007</b>	1,921,300	461,000	86,000	13,006,000
<b>2008</b>	2,024,000	369,000	22,000	13,095,000
<b>2009</b>	1,809,000	310,000	*	11,340,000
<b>2010</b>	1,665,600	325,000	*	9,931,000

Year	Production (t/year)			
	Beer	Paper	Pulp	Petroleum Refining
2011	1,723,900	335,000	*	9,516,000
2012	1,832,500	343,000	*	9,142,000
2013	1,751,900	372,000	*	9,366,000
2014	1,658,100	398,000	*	10,620,000
2015	1,809,100	459,000	*	10,477,000
2016	1,802,900	505,000	*	11,443,000

\* Confidential data

As regards Degradable Organic Component and Wastewater generated, we used the default values from IPCC 2006 (Table 7. 31).

**Table 7.31 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 <sup>3</sup> /Mg]	6.3	162	0.6

In estimation of methane emissions from industrial wastewater Degradable Organic Component removed as sludge was considered zero.

#### ***CH<sub>4</sub> 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 7.32).

**Table 7.32 The amounts of CH<sub>4</sub> recovered from industrial wastewater treatment (Source: economic operators)**

Year	Amount of Methane flared Gg/year	Amount of Methane for energy recovery Gg/year
<b>1989-1997</b>	-	-
<b>2000</b>	0.41	
<b>2005</b>	0.84	
<b>2007</b>	1.14	
<b>2008</b>	1.62	
<b>2009</b>	2.17	
<b>2010</b>	2.54	
<b>2011</b>	2.51	
<b>2012</b>	1.95	
<b>2013</b>	0.94	1.51
<b>2014</b>	1.03	1.33
<b>2015</b>	1.99	1.03
<b>2016</b>	0.78	3.09

### ***CH<sub>4</sub> emissions from industrial sludge***

CH<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub> emissions from industrial wastewater are presented in the next table:

***Table 7.33 Uncertainties for estimation of CH<sub>4</sub> emissions from industrial wastewater***

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CH <sub>4</sub> from industrial wastewater	CH <sub>4</sub>	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<sub>4</sub> 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<sub>4</sub> emissions from domestic/commercial wastewater treatment.

***Table 7.34 Uncertainties for estimation of CH<sub>4</sub> emissions from domestic/commercial Wastewater***

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
CH <sub>4</sub> from domestic and commercial wastewater	CH <sub>4</sub>	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<sub>2</sub>O from domestic 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 to N<sub>2</sub>O emissions from human sewage.

***Table 7.35 Uncertainties for estimation of N<sub>2</sub>O emissions from domestic wastewater***

IPCC source category	GHG	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty (%)
N <sub>2</sub> O from wastewater handling	N <sub>2</sub> O	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 7.36 Comparison between data provided by EUROSTAT and data provided by NIS**

Year	Total number of population (1000 persons)		Difference
	NGHGI 2016 (Source NIS) 1 July	EUROSTAT 1 January	
	1 July		
1989	23,151,564	-	-
1990	23,206,720	23,211,395	4,675
1995	22,680,951	22,712,394	31,443
2000	22,435,205	22,455,485	20,280
2005	21,319,673	21,382,354	62,681
2007	20,882,980	21,130,503	247,523
2008	20,537,848	20,635,460	97,612
2009	20,367,437	20,440,290	72,853
2010	20,246,798	20,294,683	47,885
2011	20,147,657	20,199,059	51,402
2012	20,060,182	20,095,996	35,814
2013	19,988,694	20,020,074	31,380
2014	19,916,451	19,947,311	30,860

Year	Total number of population (1000 persons)		Difference
	NGHGI 2016 ( <i>Source NIS</i> ) 1 July	EUROSTAT 1 January	
	1 July		
2015	19,819,697	19,870,647	50,950
2016	19,706,529	19,760,314	53,785

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

Recalculations were performed due to a transcription error at the CH<sub>4</sub> recovery from industrial Wastewater for 2013 and 2014 years.

**Table 7.37 Changes made on emission estimates**

The effects of recalculations from industrial wastewaster Wastewater			
Years	NGHGI 2016	NGHGI 2017	Differences [%]
	CH <sub>4</sub> emissions [kt]		
1989	21.01	21.01	0.00
1990	15.13	15.13	0.00
1995	9.90	9.90	0.00
2000	7.42	7.42	0.00
2005	9.45	9.45	0.00
2007	11.04	11.04	0.00
2008	9.19	9.19	0.00
2009	7.05	7.05	0.00
2010	6.38	6.38	0.00
2011	6.71	6.71	0.00
2012	7.70	7.70	0.00



The effects of recalculations from industrial wastewater Wastewater			
Years	NGHGI 2016	NGHGI 2017	Differences [%]
	CH4 emissions [kt]		
2013	7.12	7.27	2.01
2014	7.40	7.33	-0.90
2015	7.83	7.83	0.00

*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<sub>2</sub> 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<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>.

###### *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<sub>x</sub>, CO, NMVOC, SO<sub>2</sub> emission factors for stationary sources*

The following tables present the values of the emission factors used for the emissions estimations of the NO<sub>x</sub>, CO and NMVOC indirect gases.

*Table 9.1 NO<sub>x</sub> emission factors for different fuels*

EF NO <sub>x</sub> [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<sub>x</sub>, CO, NMVOC, the emissions factors provided by the National Inventory of Air Pollutants under the CLRTAP, were used.

\*\* The above default NO<sub>x</sub>, CO, NMVOC emission factors are in accordance with the IPCC 1996 Guidelines.

For the 2005–2016 period, the NO<sub>x</sub> 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<sub>x</sub> emissions, the emission factors provided by the National Inventory of Air Pollutants under the CLRTAP, were used.

### ***SO<sub>2</sub> Emission Factors***

For the estimation of the SO<sub>2</sub> 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<sub>2</sub> Emissions***

<b>EF SO<sub>2</sub> [g/GJ]</b>	<b>Hard Coal</b>	<b>Brown Coal</b>	<b>Natural Gas</b>	<b>Derived Gases</b>	<b>Heavy Fuel Oil</b>	<b>Other Liquid Fuels</b>	<b>Biomass</b>
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<sub>2</sub> 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<sub>2</sub> country specific emission factor was determined and used for the 1989–2004 time-series. For the 2005–2016 period, the SO<sub>2</sub> 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<sub>2</sub> emissions, the emission factors provided by the National Inventory of Air Pollutants under the CLRTAP, were used.

**Table 9.5 Country Specific SO<sub>2</sub> emission factors – 1.A.1.a, solid fuel**

EF SO <sub>2</sub> [Kg/GJ]	1989-2003	2004
COAL combusted in 1.A.1.a Electricity and Heat Production	1.782	1.782

#### *9.1.1.1.3 Uncertainties and time-series consistency*

The values for the uncertainty of the activity data were collected/elaborated in the framework of implementing the "Environmental Integrated Informational System" study, by the Austrian Environment Agency-University of Graz consortium. Based on the above background information, the results of the uncertainties associated to the used activity data, are as follows:

#### ***AD uncertainty***

- ❖ Liquid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Solid fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Gaseous fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Peat, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;
- ❖ Other fuels, CRF categories 1A1, 1A2, 1A4 and 1A5a: 7%.
- ❖ Biomass, CRF categories 1A1, 1A2, 1A4 and 1A5a: 3%;

*EFs uncertainty – averages of the ranges provided through the EMEP/EEA emission inventory guidebook 2016, were used.*

- ***NO<sub>x</sub>, CO gases:***
  - ❖ 1A1, 1A2,: 40%;
  - ❖ 1A4 and 1A5a: 125%;
- ***NMVOC gas:***
  - ❖ 1A1, 1A2, 1A4 and 1A5a: 125%;
- ***SO<sub>2</sub> 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<sub>x</sub>, 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<sub>2</sub> 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<sub>x</sub> and SO<sub>2</sub> 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 (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) 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* in 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 (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) from combustion of aviation fuel. The NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> 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*

#### ***NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub> emissions***

- *activity data*: jet fuels: 5 %.
- *emission 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 2016.

#### *9.1.1.2.4 Category-specific QA/QC and verification*

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

No recalculations were performed.

#### *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<sub>x</sub>, CO, NMVOC, and SO<sub>2</sub> 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<sub>x</sub>, CO, NMVOC, and SO<sub>2</sub>) from fuel combustion of vehicles.

### 9.1.1.3.2 Methodological issues

#### *NO<sub>x</sub>, CO, SO<sub>2</sub> 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 cars, 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<sub>x</sub>, CO, SO<sub>2</sub> 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<sub>x</sub>, CO, NMVOC are used emission factors from EMEP/EEA air pollutant emission inventory guidebook 2016.

Model Copert 4, Tier 1 was used in the absence of more detailed fleet data (for the period 1989-2004). Tier 1 emission factors of Copert 4 will give somewhat higher emission values as is the case of Romania than Tier 2 or 3 methodology for countries whose fleet comprises vehicles which comply with more recent (i.e. Euro 2 / Euro II and later) emission standards.

The maximum values for the emission factors used correspond to uncontrolled vehicle technology.

***Table 9.6 Emission Factors for Tier 1 method of Copert 4***

Category	Fuel	CO (g/kg fuel)	NMVOC (g/kg fuel)	NO <sub>x</sub> (g/kg fuel)
Passenger Cars	Gasoline	269.5	34.42	29.89
Passenger Cars	Diesel	8.19	1.88	13.88
Passenger Cars	LPG	117	25.66	34.30
Light-Duty Vehicles	Gasoline	238.3	26.08	25.46

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<sub>2</sub> 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<sub>2</sub>) are directly related to the sulphur content of the fuel:

***Equation 9.1 The Emission Factor for SO<sub>2</sub>***

$$EF_{SO_2} [kg/TJ] = 2 \times (s/100) \times 1/Q \times 10^6 \times (100 - r/100) \times (100 - n/100)$$

where:

- EF = Emission Factor (kg/TJ);
- 2 = SO<sub>2</sub>/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 2005-2016*

Model Copert 4, Tier 3 was used for the period 2005-2016, detailed statistics necessary to use higher level methods have allowed. For period 2005-2016 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 <sub>2</sub>	EF NMVOC	EF NO <sub>x</sub>	EF CO	EF SO <sub>2</sub>	EF NMVOC	EF NO <sub>x</sub>
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*

No recalculations were implemented.

*9.1.1.3.6 Category-specific planned improvements, including tracking of those identified in the review process*

No source-specific planned improvements are envisaged.

*9.1.1.4 RAILWAYS (1.A.3.c.)*

*9.1.1.4.1 Description of sources of indirect emissions in GHG inventory*

The sources of indirect emissions are provided from railway transport for both freight and passenger traffic routes. The activity data and emission values for the precursors (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) 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 2016.

*9.1.1.4.2 Methodological issues*

This section provides the estimation methods for emissions of precursors (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) caused by combustion of railway fuel. The NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> 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 2016.

#### *9.1.1.4.3 Uncertainties and time-series consistency*

#### ***NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub> emissions***

- *activity data*: Liquid: 5%

  - Solid: 3%

- *emission 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 2016.

#### *9.1.1.4.4 Category-specific QA/QC and verification*

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

No recalculations were performed.

#### *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 (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) 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 2016.

##### 9.1.1.5.2 *Methodological issues*

This section provides the estimation methods for emissions of precursors (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) caused by combustion of railway fuel. The NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> 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*

#### ***NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub> emissions***

- *activity data*: Residual Fuel Oil:5.0 %

Diesel oil: 5.0%

Gasoline:3.0%

- *emission 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 2016.

#### *9.1.1.5.4 Category-specific QA/QC and verification*

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

No recalculations were performed.

#### *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 (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) 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 2016.

#### *9.1.1.6.2 Methodological issues*

This section provides the estimation methods for emissions of precursors (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) caused by combustion of railway fuel. The NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> 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*

##### ***NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub> emissions***

- *activity data*: Liquid: 3.0%

  - Solid: 3.0%

  - Gaseous: 3.0%

  - Biomass: 3.0%

- *emission 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 2016.

#### *9.1.1.6.4 Category-specific QA/QC and verification*

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

No recalculations were performed.

*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 (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) from *Oil production* (1.B.2.a) is the “crude oil throughput” of the Domestic RO Energy Balance 2016.

***Emission Factor***

The default emission factors from Revised 1996 IPCC Guidelines and from EMEP/EEA Emission Inventory Guidebook 2016 have been used.

#### 9.1.1.7.2 *Methodological issues*

This section provides the estimation methods for emissions of precursors (NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>) from *Production and upgrading Oil*.

The NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> 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*

##### ***NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub> 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 2016.

#### 9.1.1.7.4 *Category-specific QA/QC and verification*

All quality control activities described in the QA/QC Programme were performed. A cross-checking approach was used in the implementation of QC activities: the activities were implemented by the sectorial expert administrating the 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<sub>2</sub> 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<sub>2</sub> emissions from cement production are estimated using the below equation.

***Equation 9.2 The SO<sub>2</sub> emissions from cement production***

$$SO_2 [Gg] = \text{Quantity of Cement Produced (t)} \times \text{Emission Factor} \times 10^{-6}$$

The default emission factor of 0.3 kg SO<sub>2</sub>/tonne cement is used.

***Table 9.9 Cement Production data and SO<sub>2</sub> emissions from Cement Production in the period 1989–2016***

Year	Activity data and SO <sub>2</sub> emissions from Cement Production Sub-sector		
	Cement production [kt]	Emission factor [kg SO <sub>2</sub> /t cement]	SO <sub>2</sub> Emissions [kt]
<b>1989</b>	12,225.00	0.30	3.67
<b>1990</b>	9,468.00	0.30	2.84
<b>1995</b>	6,842.00	0.30	2.05
<b>2000</b>	6,058.00	0.30	1.82
<b>2005</b>	7,043.00	0.30	2.11
<b>2007</b>	10,060.00	0.30	3.02
<b>2008</b>	10,660.00	0.30	3.20
<b>2009</b>	7,902.00	0.30	2.37
<b>2010</b>	6,992.00	0.30	2.10
<b>2011</b>	8,087.00	0.30	2.43
<b>2012</b>	8,223.00	0.30	2.47
<b>2013</b>	7,451.00	0.30	2.24
<b>2014</b>	7,621.00	0.30	2.29
<b>2015</b>	8,356.00	0.30	2.51
<b>2016</b>	8,038.00	0.30	2.41

#### *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 2016.

#### *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<sub>2</sub> 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<sub>2</sub> emissions from ammonia production are estimated using the below equation.

***Equation 9.4 SO<sub>2</sub> emissions from ammonia production***

$$SO_2 [Gg] = \text{Quantity of Ammonia Produced (t)} \times \text{Emission Factor} \times 10^{-6}$$

The default emission factors of 7.9 kg CO/ tonne of product and 0.03 kg SO<sub>2</sub>/ 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<sub>2</sub> emissions from Ammonia Production in the period 1989–2016***

<b>Year</b>	<b>Total annual production [t/an]</b>	<b>Emission Factor (kg CO/t ammonia produced)</b>	<b>Emission Factor (kg SO<sub>2</sub> /t ammonia produced)</b>	<b>CO emissions kt</b>	<b>SO<sub>2</sub> emissions kt</b>
<b>1989</b>	2,360,290.00	7.9	0.03	18.646	0.071
<b>1990</b>	1,757,965.00	7.9	0.03	13.888	0.053
<b>1995</b>	1,641,398.00	7.9	0.03	12.967	0.049
<b>2000</b>	1,245,068.00	7.9	0.03	9.836	0.037
<b>2005</b>	1,601,724.00	7.9	0.03	12.654	0.048
<b>2007</b>	1,365,890.00	7.9	0.03	10.791	0.041
<b>2008</b>	1,273,413.10	7.9	0.03	10.060	0.038
<b>2009</b>	1,022,020.99	7.9	0.03	8.074	0.031
<b>2010</b>	1,379,884.00	7.9	0.03	10.901	0.041
<b>2011</b>	1,542,980.00	7.9	0.03	12.190	0.046
<b>2012</b>	1,525,120.00	7.9	0.03	12.048	0.046
<b>2013</b>	1,123,463.00	7.9	0.03	8.875	0.034
<b>2014</b>	1,188,019.00	7.9	0.03	9.385	0.036
<b>2015</b>	607,971.00	7.9	0.03	4.803	0.018
<b>2016</b>	536,503.00	7.9	0.03	4.238	0.016

*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<sub>3</sub> 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 in:

- Medium and high pressure operation facilities (six plants);
- Old facilities, erected before 1975, without NSCR (one plant).

In 2016 year there are currently two chemical plants, where four HNO<sub>3</sub> 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 NO<sub>x</sub> emission factor is 5 – 12 kg NO<sub>x</sub> /t HNO<sub>3</sub>, according to the 2013/EMEP/EEA Emissions inventory guidebook, chap. 3.3.2.2. The **7.5 kg NO<sub>x</sub>/t HNO<sub>3</sub>** 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 NO<sub>x</sub> emission factor is **12 kg NO<sub>x</sub> /t HNO<sub>3</sub>**, according to the 2013/EMEP/EEA Emissions inventory guidebook.

The analysis of the NO<sub>x</sub> emission level trend was carried out under the following conditions:

- The HNO<sub>3</sub> production facilities are old, as they were erected between 1963 and 1978;
- The HNO<sub>3</sub> 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 NO<sub>x</sub> reduction system operated between 1997 and 2008;
- There are currently two chemical plants, where four HNO<sub>3</sub> production facilities are in operation.;
- Four operating HNO<sub>3</sub> production facilities are fitted with nitrogen oxide reduction and emission monitoring systems;
- Upgrading efforts are made in all seven operating HNO<sub>3</sub> production facilities, to reduce nitrogen oxide emissions.

#### ***NO<sub>x</sub> 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 NO<sub>x</sub> reduction systems.

*NO<sub>x</sub> emission monitoring systems*

NO<sub>x</sub> 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<sub>x</sub> emissions in the period 1989–2016**

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 <sub>x</sub> emissions [kt]	NO <sub>x</sub> emissions [kt]
<b>1989</b>	1,993.70	0.88	14.40
<b>1990</b>	1,260.98	0.67	9.04
<b>1995</b>	1,025.81	0.09	7.64
<b>2000</b>	874.12	0.22	5.42
<b>2005</b>	1,102.14	0.17	2.75
<b>2007</b>	981.38	0.23	2.26
<b>2008</b>	867.39	0.46	1.71
<b>2009</b>	642.48	0.25	1.90
<b>2010</b>	1,055.38	0.41	3.28
<b>2011</b>	1,076.96	0.56	2.72
<b>2012</b>	983.80	0.46	1.47
<b>2013</b>	949.58	0.19	0.62
<b>2014</b>	1,001.15	0.23	0.60
<b>2015</b>	734.50	NO	0.49
<b>2016</b>	668.011	NO	0.40

#### 9.1.2.2.2.3 Adipic Acid Production (CRF 2.B.3)

##### *Methodology*

The NO<sub>x</sub>, 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**

<b>EMISSION FACTORS FOR ADIPIC ACID PRODUCTION (KG/TONNE PRODUCT)</b>		
<b>NO<sub>x</sub></b>	<b>NMVOC</b>	<b>CO</b>
8.1	43.3	34.4

**Table 9.13 Adipic Acid Production related to the NO<sub>x</sub>, NMVOC and CO emissions in the period 1989–2001**

<b>Year</b>	<b>Amount of Adipic Acid Produced</b>	<b>NO<sub>x</sub> emissions kt</b>	<b>NMVOC emissions kt</b>	<b>CO emissions kt</b>
<b>1989</b>	7,287.00	0.06	0.32	0.25
<b>1990</b>	6,169.00	0.05	0.27	0.21

Year	Amount of Adipic Acid Produced	NO <sub>x</sub> 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 NO<sub>x</sub>, CO, NMVOC, and SO<sub>2</sub> 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, polypropylene, polyvinylchloride, 1, 2 dichloroethane). Carbon black and sulphuric acid are not produced anymore.



***Emission factors***

For confidentiality reasons the presentation of emission factors used to estimate emission from those productions are omitted.

Emissions of NO<sub>x</sub>, CO, NMVOC, and SO<sub>2</sub> were estimated from those productions.

***Table 9.14 The NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> emissions for Petrochemical and carbon black Production Sub-sector***

<b>Year</b>	<b>NO<sub>x</sub> emissions kt</b>	<b>CO emissions kt</b>	<b>NMVOC emissions kt</b>	<b>SO<sub>2</sub> emissions kt</b>
<b>1989</b>	0.03	0.77	6.81	29.76
<b>1990</b>	0.02	0.58	5.32	19.62
<b>1995</b>	0.01	0.22	4.82	8.42
<b>2000</b>	0.01	0.15	5.01	3.21
<b>2005</b>	NO	NO	6.74	0.19
<b>2007</b>	NO	NO	2.90	NO
<b>2008</b>	NO	NO	2.92	NO
<b>2009</b>	NO	NO	1.54	NO
<b>2010</b>	NO	NO	1.31	NO
<b>2011</b>	NO	NO	1.62	0.04
<b>2012</b>	NO	NO	1.23	NO
<b>2013</b>	NO	NO	1.59	NO
<b>2014</b>	NO	NO	1.23	NO
<b>2015</b>	NO	NO	1.11	NO
<b>2016</b>	NO	NO	1.25	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 2016.

#### ***SO<sub>2</sub> 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 2016.

##### *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 2016.

#### 9.1.2.2.3.3 *Adipic Acid Production (CRF 2.B.3)*

##### ***CO, NO<sub>x</sub> 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 2016.

#### 9.1.2.2.3.4 *Petrochemical and carbon black Production (CRF 2.B.8)*

##### ***CO, NO<sub>x</sub> and NMVOC emissions***

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

- AD: 5 %;
- EF: 125 %;
- 125.10 % associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation from Chapter 5, of the EMEP/EEA emission inventory guidebook 2016.

##### ***SO<sub>2</sub> 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 2016.

#### *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), Aluminium Production (CRF 2.C.3) and Magnesium Production (CRF 2.C.4).

### 9.1.2.3.2 Methodological issues

#### 9.1.2.3.2.1 Iron and Steel Production (CRF 2.C.1)

##### **Methodology**

The NMVOC, NO<sub>x</sub>, CO, SO<sub>2</sub> emissions are estimated using the default emission factors applied to the first fusion raw Pig Iron Production.

##### **Activity data**

The data collection was performed based on questionnaires sent to the economic agents identified by the Local Agencies for Environmental Protection.

##### **Emission factors**

The default emission factors of 0.112 kg CO/ tonne of product, 0.02 kg NMVOC/ tonne of product, 0.076 kg NO<sub>x</sub>/ tonne of product and 0.03 kg SO<sub>2</sub>/ 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
1995	4,118,570	0.02	82
2000	3,041,540	0.02	61
2005	4,117,920	0.02	82
2007	3,946,680	0.02	79
2008	3,238,790	0.02	65
2009	1,568,860	0.02	31

Year	Iron production, t	Emission factor, kg/t	NMVOC emissions, t
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
2016	1,972,284	0.02	39

*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
1995	4,118,570	0.076	313
2000	3,041,540	0.076	231
2005	4,117,920	0.076	313
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
2016	1,972,284	0.076	150

**Table 9.17 CO emissions for category CRF 2.C.1 – Iron and Steel Production**

<b>Year</b>	<b>Iron production, t</b>	<b>Emission factor, kg/t</b>	<b>CO emissions, t</b>
<b>1989</b>	8,495,130	0.112	951
<b>1990</b>	5,916,270	0.112	663
<b>1995</b>	4,118,570	0.112	461
<b>2000</b>	3,041,540	0.112	341
<b>2005</b>	4,117,920	0.112	461
<b>2007</b>	3,946,680	0.112	442
<b>2008</b>	3,238,790	0.112	363
<b>2009</b>	1,568,860	0.112	176
<b>2010</b>	1,721,750	0.112	193
<b>2011</b>	1,581,250	0.112	177
<b>2012</b>	1,468,160	0.112	164
<b>2013</b>	1,603,843	0.112	180
<b>2014</b>	1,631,338	0.112	183
<b>2015</b>	1,983,136	0.112	222
<b>2016</b>	1,972,284	0.112	221

**Table 9.18 SO<sub>2</sub> emissions for category CRF 2.C.1 – Iron and Steel Production**

<b>Year</b>	<b>Iron production, t</b>	<b>Emission factor, kg/t</b>	<b>SO<sub>2</sub> emissions, t</b>
<b>1989</b>	8,495,130	0.03	255
<b>1990</b>	5,916,270	0.03	177
<b>1995</b>	4,118,570	0.03	124
<b>2000</b>	3,041,540	0.03	91
<b>2005</b>	4,117,920	0.03	124
<b>2007</b>	3,946,680	0.03	118
<b>2008</b>	3,238,790	0.03	97
<b>2009</b>	1,568,860	0.03	47

<b>Year</b>	<b>Iron production, t</b>	<b>Emission factor, kg/t</b>	<b>SO<sub>2</sub> emissions, t</b>
<b>2010</b>	1,721,750	0.03	52
<b>2011</b>	1,581,250	0.03	47
<b>2012</b>	1,468,160	0.03	44
<b>2013</b>	1,603,843	0.03	48
<b>2014</b>	1,631,338	0.03	49
<b>2015</b>	1,983,136	0.03	59
<b>2016</b>	1,972,284	0.03	59

#### *9.1.2.3.2.2 Aluminium Production (CRF 2.C.3)*

##### ***Methodology***

The **CO<sub>2</sub>**, **SO<sub>2</sub> 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<sub>2</sub>/ tonne of product and 0.9 kg SO<sub>2</sub>/ 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<sub>2</sub> from primary Aluminium Production**

<b>Gas</b>	<b>Process</b>	<b>Emission Factor [kg/tonne primary Al produced]</b>
CO	Anode baking	<b>400</b>
SO <sub>2</sub>	Anode baking	<b>0.9</b>

**Table 9.20 The CO and SO<sub>2</sub> emissions from primary Aluminium Production**

<b>Year</b>	<b>SO<sub>2</sub> emissions kt</b>	<b>CO emissions kt</b>
<b>1989</b>	0.239	106.217
<b>1990</b>	0.151	67.095
<b>1995</b>	0.127	56.240
<b>2000</b>	0.156	69.308
<b>2005</b>	0.215	95.604
<b>2007</b>	0.236	105.002
<b>2008</b>	0.239	106.095
<b>2009</b>	0.181	80.222
<b>2010</b>	0.186	82.688
<b>2011</b>	0.202	89.802
<b>2012</b>	0.182	80.830
<b>2013</b>	0.178	78.898
<b>2014</b>	0.176	78.0996
<b>2015</b>	0.185	82.352
<b>2016</b>	0.187	82.931

#### 9.1.2.3.2.3 Magnesium Production (CRF 2.C.4)

##### **Methodology**

The **SO<sub>2</sub> 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<sub>2</sub> in a proportion of up to 3% SO<sub>2</sub>.

##### **Emission factors**

The default emission factors of 26 kg SO<sub>2</sub> / 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<sub>2</sub> emissions from Magnesium Production**

<b>Year</b>	<b>SO<sub>2</sub> emissions, kt</b>
<b>1989</b>	NO
<b>1990</b>	NO
<b>1995</b>	NO
<b>2000</b>	NO

Year	SO <sub>2</sub> emissions, kt
2005	NO
2007	NO
2008	NO
2009	NO
2010	NO
2011	NO
2012	NO
2013	NO
2014	NO
2015	0.164
2016	0.234

#### 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 NO<sub>x</sub> 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 2016.

#### *SO<sub>2</sub> 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 2016.

#### *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 2016.

##### ***SO<sub>2</sub> 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 2016.

#### *9.1.2.3.3.3 Magnesium Production (CRF 2.C.4)*

##### ***SO<sub>2</sub> 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 2016.

#### *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**

<b>Year</b>	<b>Activity data kt</b>	<b>NMVOC emissions kt</b>
<b>1989</b>	NE	NE
<b>1990</b>	NE	NE
<b>1995</b>	NE	NE
<b>2000</b>	223.196	0.004
<b>2005</b>	676.403	0.011
<b>2007</b>	C	0.038
<b>2008</b>	C	0.009
<b>2009</b>	C	0.022
<b>2010</b>	C	0.026
<b>2011</b>	C	0.025
<b>2012</b>	C	0.029
<b>2013</b>	C	0.032
<b>2014</b>	C	0.033
<b>2015</b>	C	0.034
<b>2016</b>	C	0.025

*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***

<b>EMISSIONS FACTORS FOR ASPHALT ROOFING PRODUCTION–SATURATION PROCES [kg/tonne product]</b>	
<b>NMVOC</b>	0.0475
<b>CO</b>	0.0095
<b>EMISSIONS FACTORS FOR ASPHALT BLOWING PROCESS – no control [kg/tonne product]</b>	
<b>NMVOC</b>	2.4

***Table 9.24 The CO and NMVOC emissions from Asphalt Roofing Production Sector***

<b>Year</b>	<b>Activity data kt</b>	<b>CO emissions kt</b>	<b>NMVOC emissions kt</b>
<b>1989</b>	NE	NE	NE
<b>1990</b>	NE	NE	NE
<b>1995</b>	NE	NE	NE
<b>2000</b>	NE	NE	NE



Year	Activity data kt	CO emissions kt	NMVOC emissions kt
2005	12.144	0.00	0.03
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	0.095
2016	C	0.00	0.042

#### 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 2016.

##### 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 2016.

#### *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 nonconformities 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 NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> 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 NO<sub>x</sub>, CO, NMVOC, and SO<sub>2</sub> 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 fat/Cakes, biscuits and breakfast cereals/Bread production.

### ***Emission factors***

For confidentiality reasons the presentation of NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub> 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 1989–2016.

#### *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 nonconformities 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<sub>2</sub>O emissions from Manure management (3B 2.5)**

*9.1.3.1.1 Description of sources of indirect emissions in GHG inventory*

N<sub>2</sub>O Indirect emissions result from N volatilization in forms of ammonia and NO<sub>x</sub> 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<sub>2</sub>O emissions was used the value default emissions factor from IPCC, respectively EF<sub>4</sub> (Table 11.3 - of IPCC 2006).

##### ***Activity data***

They were used the same livestock population numbers as for calculation of CH<sub>4</sub> 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<sub>2</sub>O emissions.

The values for percent of managed manure nitrogen for livestock that volatilises as NH<sub>3</sub> and NO<sub>x</sub> 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:25 %;
- EF: 40%;
- 47.17% associated with the overall uncertainty, as resulted after the aggregation of AD and EF related uncertainties, according to the equation in Chapter 3, Volume 1 of the IPCC 2006.

Due to the fact that most of activity data are provided by NIS or FAO and the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“ and were obtained using the same method (the use of two methods for obtaining the livestock data is ensuring the consistency of data series considering the national circumstances; detailed information is provided in Section 5.2.2), were used default emission factors using the same method and the fact that the same estimation method was used for the whole period, the data series 1989-2016 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*

It was not made any recalculation compared to the last transmission.

*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  $\text{NH}_3$  and  $\text{NO}_x$  in the manure management system S, % ( $\text{Frac}_{\text{GasMS}}$ )

*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  $\text{N}_2\text{O}$  emissions from Managed soils (3D2)**

*9.1.3.3.1 Description of sources of indirect emissions in GHG inventory*

Emissions of  $\text{N}_2\text{O}$  also take place through two indirect pathways:

- ❖ The first of these pathways is the volatilisation of N as  $\text{NH}_3$  and oxides of N ( $\text{NO}_x$ ), and the deposition of these gases and their products  $\text{NH}_4^+$  and  $\text{NO}_3^-$  onto soils and the surface of lakes and other waters. The sources of N as  $\text{NH}_3$  and  $\text{NO}_x$  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  $\text{N}_2\text{O}$  emissions in an exactly analogous way to those resulting from deposition of agriculturally derived  $\text{NH}_3$  and  $\text{NO}_x$ , 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.

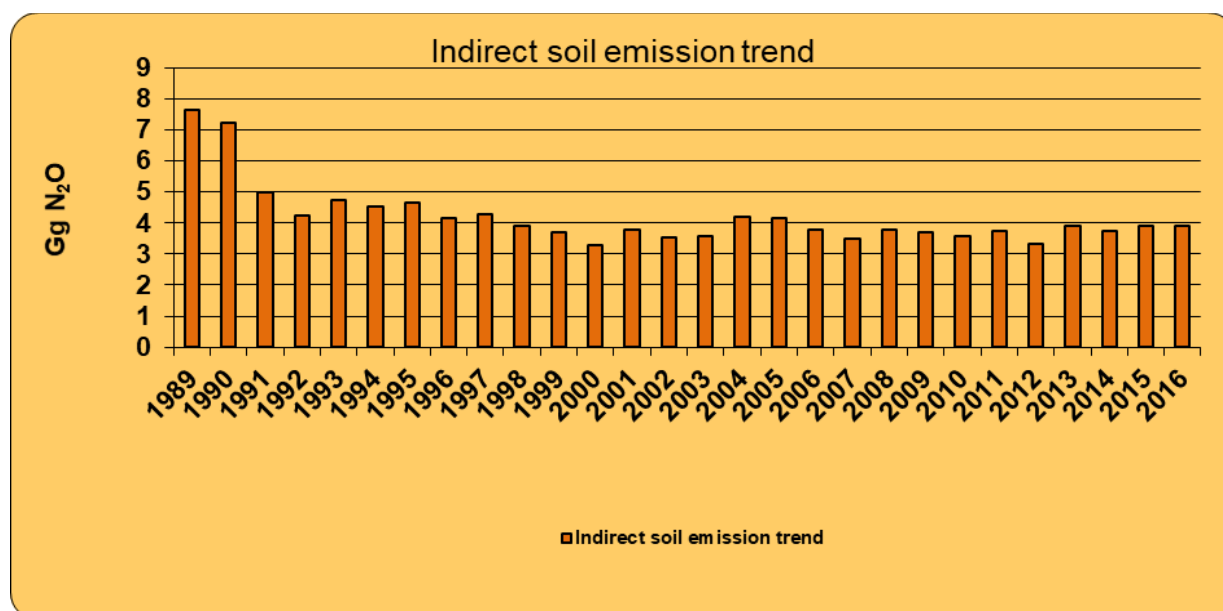


Microbial processes of nitrification and denitrification in agricultural soils produce indirect nitrous oxide emissions.

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 2016,  $N_2O$  Indirect soil emissions represented 20.28 % of total  $N_2O$  emissions in the Agriculture sector);
  - ❖ is third source in the Agriculture sector (in 2016,  $N_2O$  Indirect soil emissions as  $CO_2$  equivalent represented 6.38 % from Total Agriculture emissions);
  - ❖ contributed with 1.03 % 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<sub>2</sub>O-N/kg NH<sub>3</sub>-N and NO<sub>x</sub>-N volatilised];
- ❖  $EF_5 = 0.0075$  (kg N<sub>2</sub>O-N/kg N leaching/runoff)<sup>-1 23</sup>

##### **Activity data**

For the Frac<sub>GASF</sub> fraction was used the 0.1 value, Frac<sub>GASM</sub> was used 0.2 and Frac<sub>LEACH-(H)</sub> 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 1989-2016 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*

It was not made any recalculation compared to the last transmission.

#### *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  $\text{NH}_3$  and  $\text{NO}_x$ , specific to synthetic fertilizers nitrogen adjusted for volatilization ( $\text{Frac}_{\text{GASF}}$ );
- ❖ fraction that volatilizes as  $\text{NH}_3$  and  $\text{NO}_x$ , specific to animal manure nitrogen used as fertilizer, adjusted for volatilization ( $\text{Frac}_{\text{GASM}}$ );
- ❖ national values for activity data in totality;
- ❖ fraction of N input that is lost through leaching and runoff ( $\text{Frac}_{\text{LEACH}}$ ).

#### 9.1.3.4 FIELD BURNING OF AGRICULTURAL RESIDUES (3F)

##### **NO<sub>x</sub> 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, we 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 9.25 Default emission factors for various types of burning***

<b>Gas</b>	<b>Default IPCC 2006 emission ratios</b>
Carbon monoxide (CO)	92
Nitrogen oxides (NO <sub>x</sub> )	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 2016.

***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<sub>4</sub> 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 9.26 Percentage of direct and indirect Greenhouse Gas emissions from waste category 5A**  
(Source: International Solid Waste Association – “Landfill Operational Guideline, 2<sup>nd</sup> Edition”)

Year	Greenhouse Gas			
	CH <sub>4</sub>		NMVOC	
	kt	%	kt	%
<b>1989</b>	53.24	50	0.75	0.7
<b>1990</b>	54.86	50	0.77	0.7
<b>1995</b>	62.83	50	0.88	0.7
<b>2000</b>	76.87	50	1.08	0.7
<b>2005</b>	102.60	50	1.44	0.7
<b>2007</b>	111.38	50	1.56	0.7
<b>2008</b>	114.53	50	1.60	0.7
<b>2009</b>	118.82	50	1.66	0.7
<b>2010</b>	124.09	50	1.74	0.7
<b>2011</b>	105.12	50	1.47	0.7
<b>2012</b>	128.41	50	1.80	0.7
<b>2013</b>	140.32	50	1.96	0.7
<b>2014</b>	140.63	50	1.97	0.7
<b>2015*</b>	140.79	50	1.97	0.7

Year	Greenhouse Gas			
	CH <sub>4</sub>		NMVOC	
	kt	%	kt	%
2016*	142.67	50	2.00	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<sub>2</sub> and nitrous oxide emissions

Under paragraph 29 of the UNFCCC Inventory Reporting Guidelines, Romania did not choose to report indirect CO<sub>2</sub> emissions from the atmospheric oxidation of CH<sub>4</sub>, CO and NMVOCs, or indirect N<sub>2</sub>O 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 2017 Greenhouse Gas Inventory submission and 2018 Greenhouse Gas Inventory submission. Since the 2017 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 2017 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 2017 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 methodological 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
<b>Total (Net Emissions)</b>			
<b>1. Energy</b>			
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		√	Chapter 3 of the National Inventory Report
5. Other		√	Chapter 3 of the National Inventory Report
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 methodological 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 <sub>2</sub> transport and storage			
<b>2. Industrial processes and product use</b>			
A. Mineral industry			
B. Chemical industry	√	√	Recalculation have been made for the entire period 1989-2015 due to an improvement in the activity data used in the CO <sub>2</sub> emissions estimates from category 2.B.1 Ammonia Production. CO <sub>2</sub> emissions are calculated based on natural gas consumption (energy and non-energy use). From CO <sub>2</sub> emissions from

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
			ammonia production are subtracted, in addition to the CO <sub>2</sub> emissions resulting from the use of urea as a fertilizer, wich are included in the Agriculture sector in H and the annual amount of CO <sub>2</sub> used for the production of urea exported. (CRF category 2B.1)
C. Metal industry			
D. Non-energy products from fuels and solvent use	√	√	The recalculations have been made for the 1989-2015 period due to an improvement in the activity data used in the CO <sub>2</sub> emissions estimates from 2D Non-energy products from fuels and solvent use subsector, taking into account emissions from petroleum coke. (CRF 2.D.3.d)
E. Electronic industry			

<b>GREENHOUSE GAS SOURCE AND SINK CATEGORIES</b>	<b>DESCRIPTION OF METHODS</b>	<b>RECALCULATIONS</b>	<b>REFERENCE</b>
	<b>Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR</b>	<b>Please tick where this is also reflected in recalculations compared to the previous year CRF</b>	<b>If ticked please provide some more detailed information for example related to sub- category, gas, reference to pages in the NIR, etc</b>
F. Product uses as substitutes for ODS			
G. Other product manufacture and use			
H. Other			
<b>3. Agriculture</b>			
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			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methodological 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
H. Urea application			
I. Other carbon containing fertilisers			
J. Other			
<b>4. Land use, land-use change and forestry</b>	√	√	Romania have been made recalculations for the specific categories in accordance with IPCC methodology and KP LULUCF Supplement due to updated of activity data.
A. Forest land		√	Recalculations have been made for 2015 year due to updated of activity data for this category
B. Cropland		√	Recalculations have been made for 2015 year due to updated of activity data for this category
C. Grassland		√	Recalculations have been made for 2015 year due to updated of activity data for this category
D. Wetlands		√	Recalculations have been made for 2015 year

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methodological 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
			due to updated of activity data for this category
E. Settlements		√	Recalculations have been made for 2015 year due to updated of activity data for this category
F. Other land		√	Recalculations have been made for 2015 year due to updated of activity data for this category
G. Harvested wood products	√	√	Romania have been made recalculations for the entire time series related to 4G category, using the approach B1 in accordance with IPCC 2006 and KP LULUCF Supplement.
H. Other		√	Recalculations have been made for 2015 year due to updated of activity data for this category
<b>5. Waste</b>			
A. Solid waste disposal			
B. Biological treatment of solid waste			

<b>GREENHOUSE GAS SOURCE AND SINK CATEGORIES</b>	<b>DESCRIPTION OF METHODS</b>	<b>RECALCULATIONS</b>	<b>REFERENCE</b>
	<b>Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR</b>	<b>Please tick where this is also reflected in recalculations compared to the previous year CRF</b>	<b>If ticked please provide some more detailed information for example related to sub- category, gas, reference to pages in the NIR, etc</b>
C. Incineration and open burning of waste			
D. Wastewater treatment and discharge			
E. Other			
<b>6. Other (as specified in Summary 1.A)</b>			
<b>KP LULUCF</b>			
<b>Article 3.3 activities</b>			
Afforestation/reforestation			
Deforestation			
<b>Article 3.4 activities</b>			
Forest management			
Cropland management (if elected)			



<b>GREENHOUSE GAS SOURCE AND SINK CATEGORIES</b>	<b>DESCRIPTION OF METHODS</b>	<b>RECALCULATIONS</b>	<b>REFERENCE</b>
	<b>Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR</b>	<b>Please tick where this is also reflected in recalculations compared to the previous year CRF</b>	<b>If ticked please provide some more detailed information for example related to sub- category, gas, reference to pages in the NIR, etc</b>
Grazing land management (if elected)			
Revegetation (if elected)			
Wetland drainage and rewetting (if elected)			
<b>NIR Chapter</b>	<b>DESCRIPTION</b>		<b>REFERENCE</b>
	<b>Please tick where the latest NIR includes major changes in descriptions compared to the previous year NIR</b>		<b>If ticked please provide some more detailed information for example reference to pages in the NIR</b>
<b>Chapter 1.2 Institutional arrangements</b>			
<b>Chapter 1.6 QA/QC plan</b>			

## **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<sub>2</sub> Emission factors:***

- The CO<sub>2</sub> emission factor values for 2015 year have been updated because the Country Specific Emission Factor values for 2015 have been updated.

##### ***Net calorific values:***

- The fuels which have determined or modified the CO<sub>2</sub> CS EF as above, the net calorific values were updated or determined, too.
- For the 2015 year, for the all fuels, the net calorific values were recalculated in accordance with the reporting on the EU-ETS reports.

##### ***3. Activity data:***

- Because the activity data from Energy Balance provided from National Institute of Statistics were updated for 1995-2015 period from the 1.A.1 Energy Industry sub-sector, the CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions values for the 1995-2015 period were recalculated.
- In 1.A.2 Manufacturing Industries and Construction category – 1.A.2.c Chemicals sub-category, the reported quantities of the natural gas consumption used for energy purposes,

was subtracted from in *Annex 4.1 Energy Balance 1989* (the column Natural Gas, line 63) for the 1989 year.

In 1.A.2 Manufacturing Industries and Construction category – 1.A.2.c Chemicals sub-category, the reported quantities of the natural gas consumption used for energy purposes, was subtracted from in *Annex 4.4 Energy Balance\_1990\_2016\_natural gas* (the sheet Table 2b\_TFC\_Energy use, the line 12) for the 1990-2016 period.

This quantities of the natural gas consumption, used in energy purposes, was subtracted as above, and are reported in the Industrial Processes and Product Use sector (IPPU), in the 2B1, Ammonia Production category, in according to the 2006 IPCC methodology. In this case the CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions values for the 1989-2015 period were updated.

- Because the activity data from Energy Balance provided from National Institute of Statistics were updated for the 1990,1992, 1993, 1994, 1995, 2014 and 2015 years from the 1.A.4 Other sub-sector, the CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions values for this years were recalculated.

## Energy Transport

### ➤ Domestic Navigation (1.A.3.d)

- The CO<sub>2</sub> emission values for 2015 have been updated because the Country Specific Emission Factor values for 2015 have been updated and the activity data value of fuel consumption for 2015 has been updated;
- The CH<sub>4</sub> and N<sub>2</sub>O emission values for 2015 have been updated due to updated of the activity data value of fuel consumption for 2015.

### ➤ Feedstocks and non-energy use of fuels (1.AD)

## *Solid Fuels*

### *Activity data*

- In 1990-2015 period are made the recalculations from 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)*****Activity data:***

- Transmission and storage (1.B.2.b.4) category: the emission values for 1989-2015 period have been updated because additional activity data related to storage of natural gas has been added;
- Other (1.B.2.b.6) category: it was necessary to reallocate the activity data in 1.B.2.b.6 because new data from 1.B.2.d have been coming;
- Other (please specify) (1.B.2.d): the activity data have been reallocated to Other (1.B.2.b.6) category.

***Emission factors:***

- Refining/Storage (1.B.2.a.6) category: the emission value of CO<sub>2</sub> for 1989-2015 period has been updated because the Country Specific Emission Factor value for 1989-2015 period has been updated;
- Refining/Storage (1.B.2.a.6) category: the CH<sub>4</sub> emission values for 1989-2015 period have been updated because the Emission Factor value for 1989-2015 period has been changed (the value of 880 kg/PJ has been replaced by 0.0000218 (Gg per 10<sup>3</sup>m<sup>3</sup> oil refined);
- Transmission and storage (1.B.2.b.4) category: the CO<sub>2</sub> and CH<sub>4</sub> emission values for 1989-2015 period have been updated because additional activity data related to storage of natural gas have been added;
- Other (1.B.2.b.6) category: it was necessary to reallocate the CH<sub>4</sub> emissions in 1.B.2.b.6 because new emissions from 1.B.2.d have been coming;
- Other (please specify) (1.B.2.d): CH<sub>4</sub> emissions have been reallocated to category 1.B.2.b.6.

**Industrial Processes and Product Use**

- Recalculation have been made for the 2007-2015 period. Recalculations were made as a result of due to an improvement in activity data for the 2.A.4.d Other category (a new

operator has sent data on limestone and dolomite consumption for those years). (CRF Category 2.A.4 d);

- Recalculation have been made for the entire period 1989-2015 due to an improvement in the activity data used in the CO<sub>2</sub> emissions estimates from category 2.B.1 Ammonia Production. CO<sub>2</sub> emissions are calculated based on natural gas consumption (energy and non-energy use). From CO<sub>2</sub> emissions from ammonia production are subtracted, in addition to the CO<sub>2</sub> emissions resulting from the use of urea as a fertilizer, which are included in the Agriculture sector in H and the annual amount of CO<sub>2</sub> used for the production of urea exported. (CRF category 2B.1);
- Recalculation have been made for the 2000-2015 period. Recalculations were made as a result of due to an improvement in activity data for the consistency of the data used to estimate emissions in preparation of the greenhouse gas inventories with the data used to prepare inventories of air pollutants under Directive 2001/81/EC and under the UNECE Convention on Long-range Transboundary Air Pollution. (CRF Category 2.D.3.a);
- Recalculation have been made for the 1989-2015 period due to an improvement in the activity data used in the CO<sub>2</sub> emissions estimates from 2D Non-energy products from fuels and solvent use subsector, taking into account emissions from petroleum coke. (CRF Category 2.D.3.d);
- Recalculation of the HFC emissions have been made for the 2013-2014 period. Recalculations were made as a result of due to the changes in activity data for 2013 year. (CRF Category 2.F.4);
- Recalculation have been made for the 2004-2015 period. The recalculations were made as a result of the improvement in activity data (two new operators have sent data on the use of nitrous oxide in medical applications for those years). (CRF Category 2.G.3.a).

## Agriculture

- **Manure management (3.B) - CH<sub>4</sub>**
- Results a difference due to of transcription errors for 2015 year.

## LULUCF

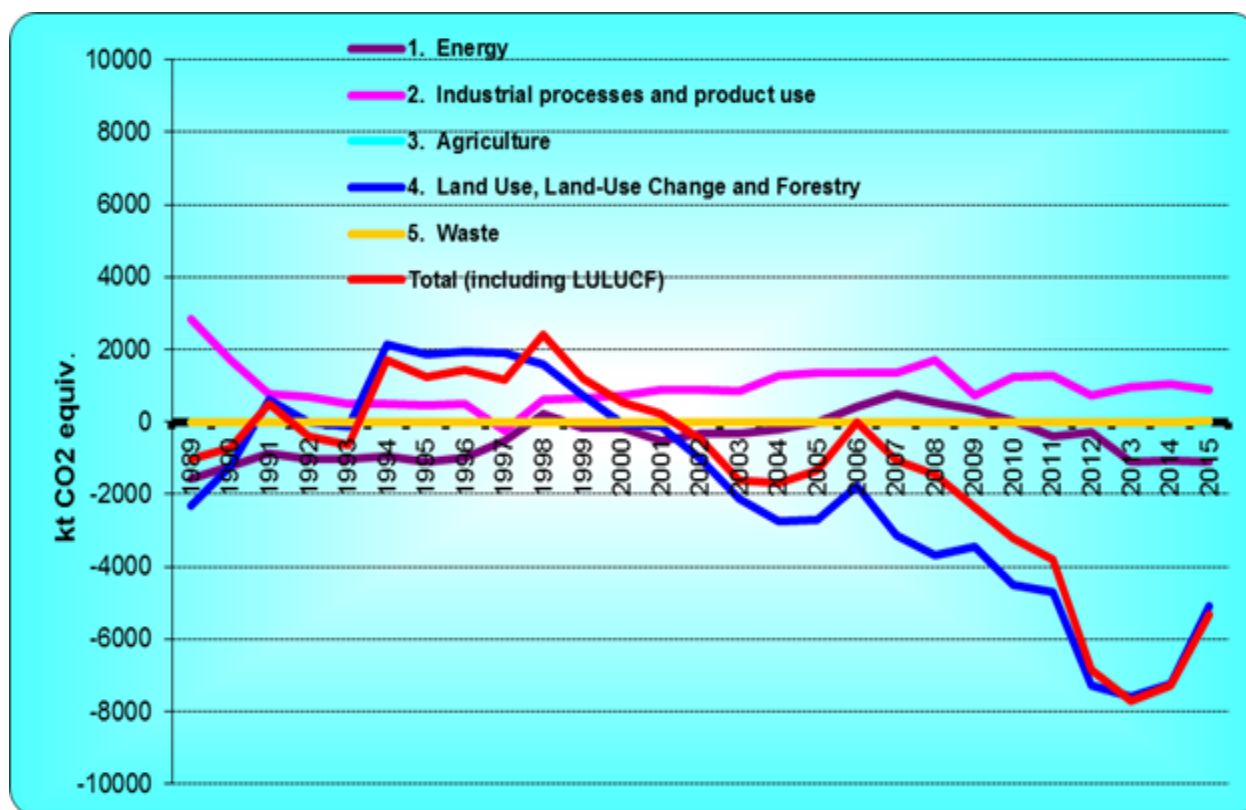
In the current submission Romania have been made the following recalculations:

- Recalculations associated to 2015 year for 4A, 4B, 4C, 4D, 4E, 4F and 4H categories do to updated of activity data, in respect to the LULUCF Sector.
- Recalculations for the entire time series related to 4G category, using the approach B1 in accordance with IPCC 2006 and KP LULUCF Supplement.

## Waste

- **Solid Waste Disposal (5.A)**
  - The amount of MSW deposited in managed and unmanaged SWDS was updated based on the final data provided by Waste directorate of NEPA;
  - The amounts of CH<sub>4</sub> recovery were updated for 2015 year due to an error of reporting data.
- **Waste Incineration and Open Burning of Waste (5.C)**
  - For Biogenic waste other than Municipal Solid Waste subsector, the CH<sub>4</sub> emissions were recalculated for 2001-2015 years due to an transcription error.
- **Wastewater Treatment and Discharge (CRF 5.D)**
  - Recalculations were performed due to a transcription error at the CH<sub>4</sub> recovery from industrial Wastewater for 2013 and 2014 years.

**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 2017 submission**



### Recalculations by gases

CO<sub>2</sub> recalculations were carried out in the following sectors:

- Energy Industry sub-sector (1.A.1);
- Chemicals (1.A.2.c);
- Other sectors (1.A.4);
- Other (1.A.5);
- Domestic Navigation (1.A.3.d);
- Refining/Storage (1.B.2.a.6);
- Transmission and storage (1.B.2.b.4);
- Other (2.A.4.d);
- Ammonia Production (2.B.1);

- Solvent Use (2.D.3.a);
- Other - Petroleum coke use (2.D.3.d);
- Forest Land (4.A);
- Cropland (4.B);
- Grassland (4.C);
- Wetlands (4.D);
- Settlements (4.E);
- Other Lands (4.F);
- Harvested wood products (4.G).

CH<sub>4</sub>/N<sub>2</sub>O recalculations were carried out in the following sectors:

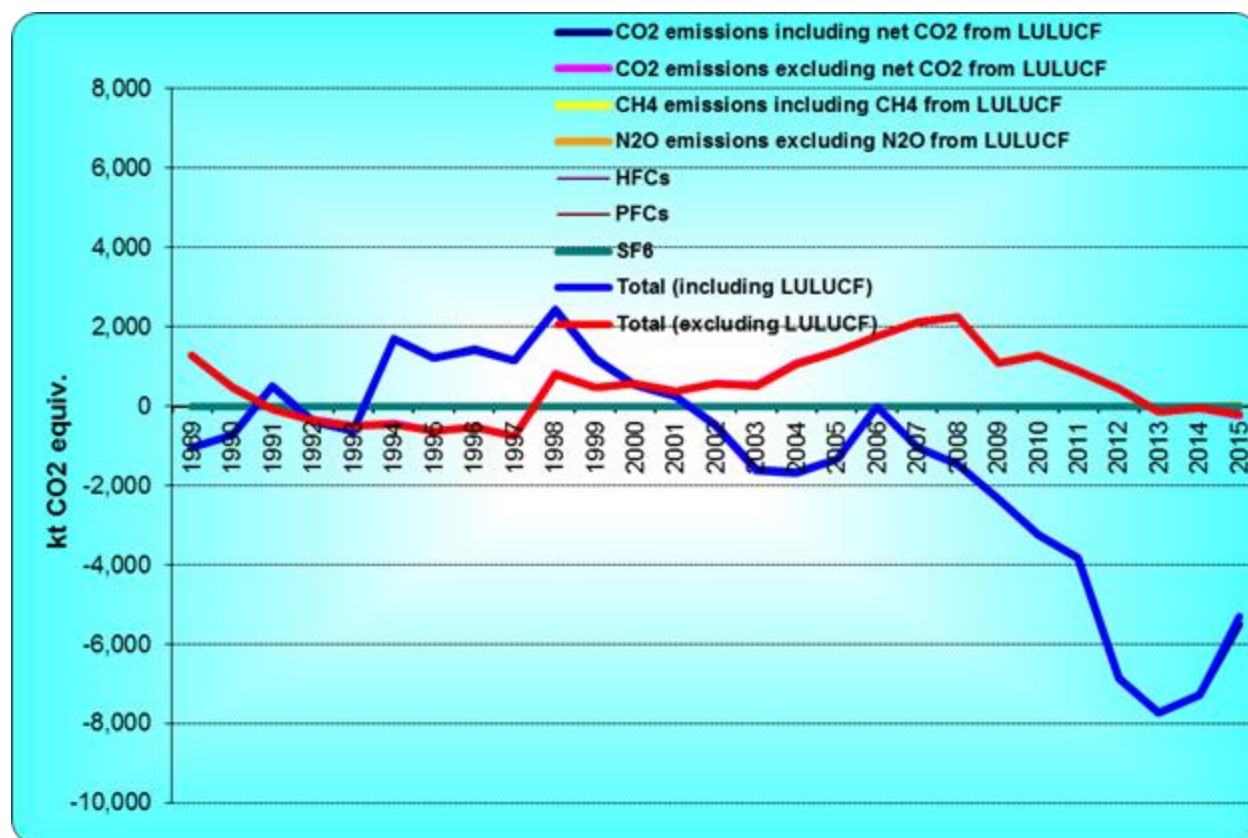
- Energy Industry sub-sector (1.A.1);
- Chemicals (1.A.2.c);
- Other sectors (1.A.4);
- Other (1.A.5);
- Refining/Storage (1.B.2.a.6);
- Transmission and storage (1.B.2.b.4);
- Other (1.B.2.b.6);
- Other (please specify) (1.B.2.d);
- N<sub>2</sub>O from Product Uses - Medical Applications (2.G.3.a);
- Manure management CH<sub>4</sub> (3.B);
- Cropland - N<sub>2</sub>O (4.B);
- Settlements - N<sub>2</sub>O (4.E);
- Other Lands - N<sub>2</sub>O (4.F);
- Solid Waste Disposal (5.A);
- Waste Incineration and Open Burning of Waste (CRF 5.C)
- Wastewater Treatment and Discharge (CRF 5.D);

HFC/PFC/SF<sub>6</sub> recalculations were carried out in the following sectors:

- Aerosols (2.F.4)



**Figure 10.2 Category total emissions/removals change, for all gases, and for the entire time series, in comparison to the figures in the 2017 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

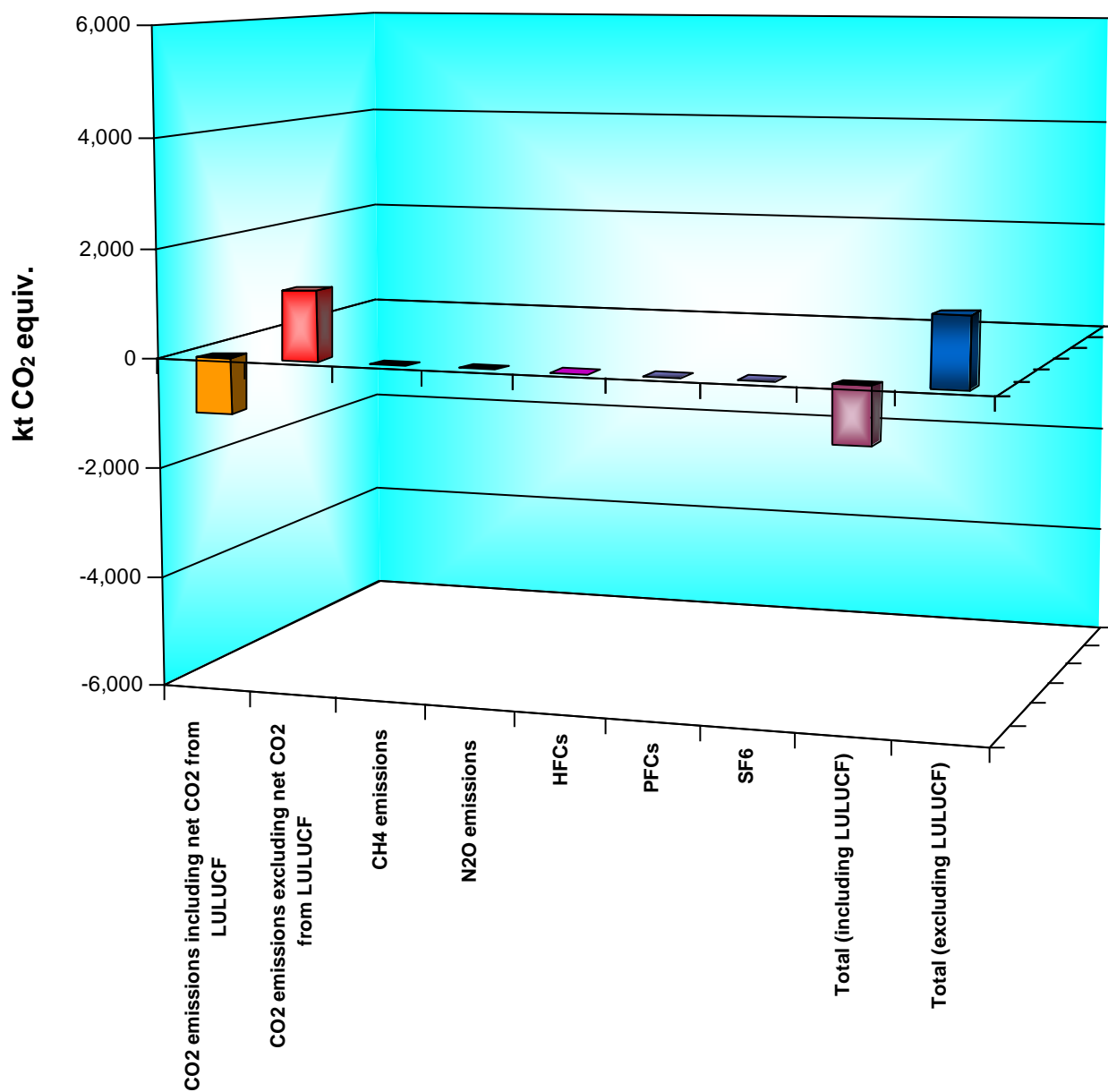
Not applicable.

## 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:

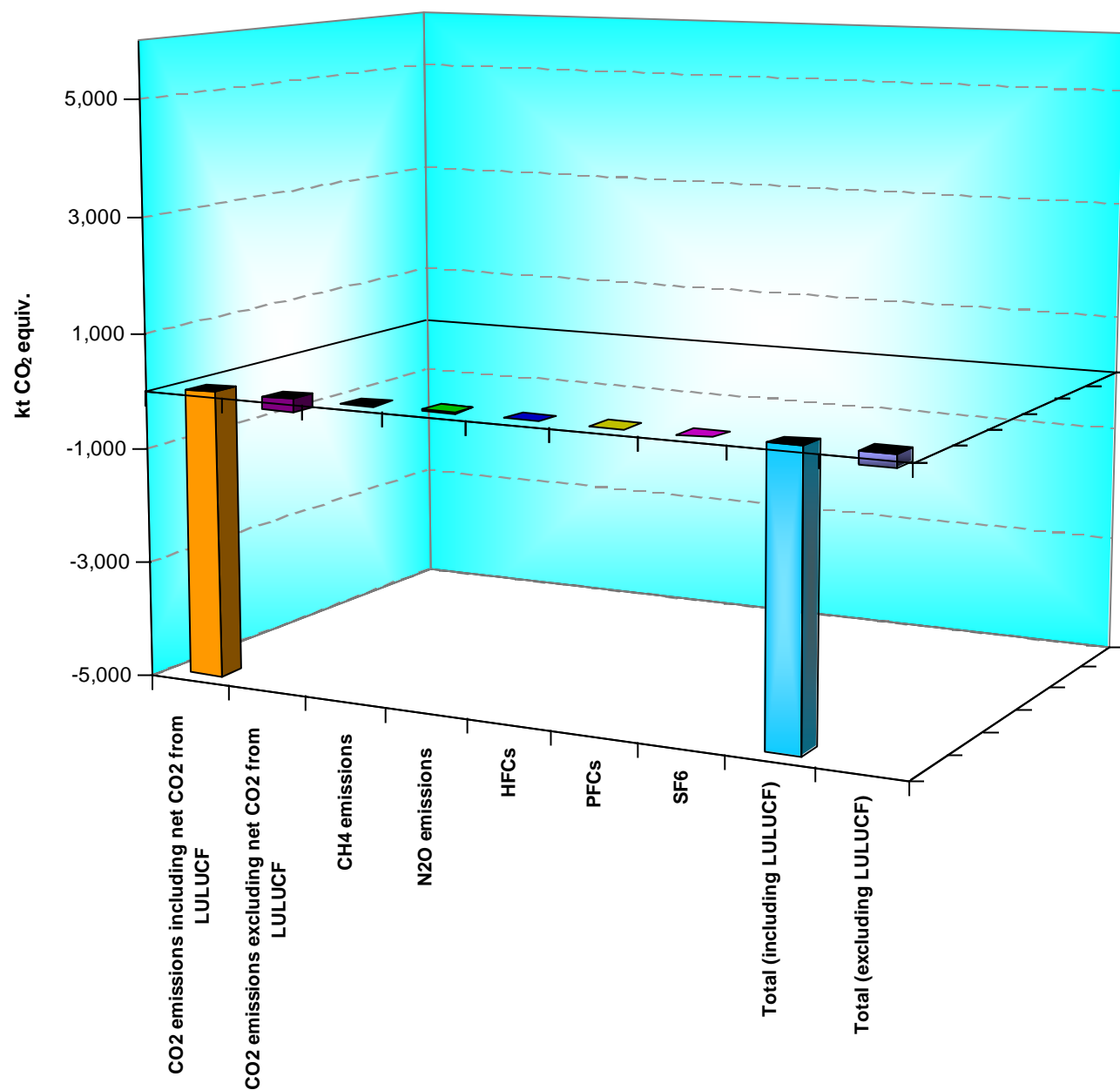
- CO<sub>2</sub> including LULUCF (-0.54%), CO<sub>2</sub> excluding LULUCF (0.62%);
- CH<sub>4</sub> including and excluding LULUCF (-0.01%);
- N<sub>2</sub>O including and excluding LULUCF (0.00%);
- HFC (0.00%);
- PFC (0.00%)
- SF<sub>6</sub> (0.00%);
- Total GHG including LULUCF (-0.36%);
- Total GHG excluding LULUCF (0.42%).

*Figure 10.3 Effects of recalculations (presented in the 2018 submission) for 1989, by gas*

Emissions changes due to recalculations, for 2015, are as follows:

- CO<sub>2</sub> including LULUCF (-9.49%), CO<sub>2</sub> excluding LULUCF (-0.29%);
- CH<sub>4</sub> including and excluding LULUCF (-0.03%);
- N<sub>2</sub>O including LULUCF (2.15%), N<sub>2</sub>O excluding LULUCF (0.25%);
- HFC (0.00%);
- PFC (0.00%);
- SF<sub>6</sub> (0.00%);
- Total GHG including LULUCF (-5.41%);
- Total GHG excluding LULUCF (-0.19%).

**Figure 10.4 Effects of recalculations (presented in the 2018 submission) for 2015, by gas**

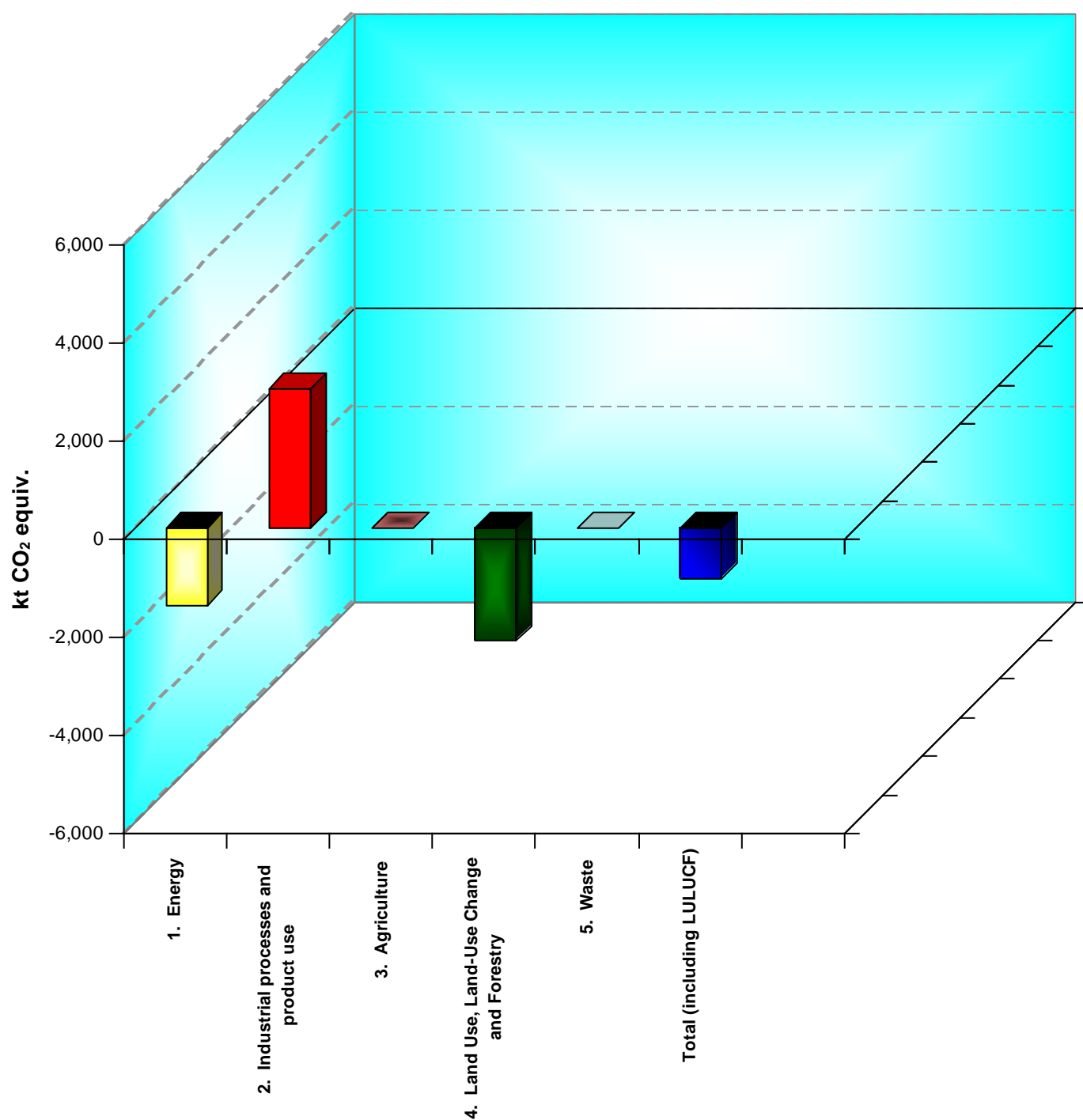


## Impacts on 1989 emissions levels

Total emissions in 1989 including LULUCF have decreased by 0.36% compared to the 2017 submission.

*Table 10.2 Recalculation of total emissions/removals, by sector, for all gases, for 1989*

Differences for 1989 estimates	Differences		2018	2017
	Gg CO <sub>2</sub> eq.	%	Gg CO <sub>2</sub> eq.	Gg CO <sub>2</sub> eq.
1. Energy	-1,581.69	-0.73	215,313.14	216,894.83
2. Industrial Processes and Product Use	2,853.31	6.82	44,672.97	41,819.65
3. Agriculture	0.00	0.00	37,508.85	37,508.85
4. Land Use, Land-Use Change and Forestry	-2,308.67	14.14	-18,635.55	-16,326.88
5. Waste	0.00	0.00	5,135.66	5,135.66
<b>Total (including LULUCF)</b>	-1,037.04	-0.36	283,995.08	285,032.12

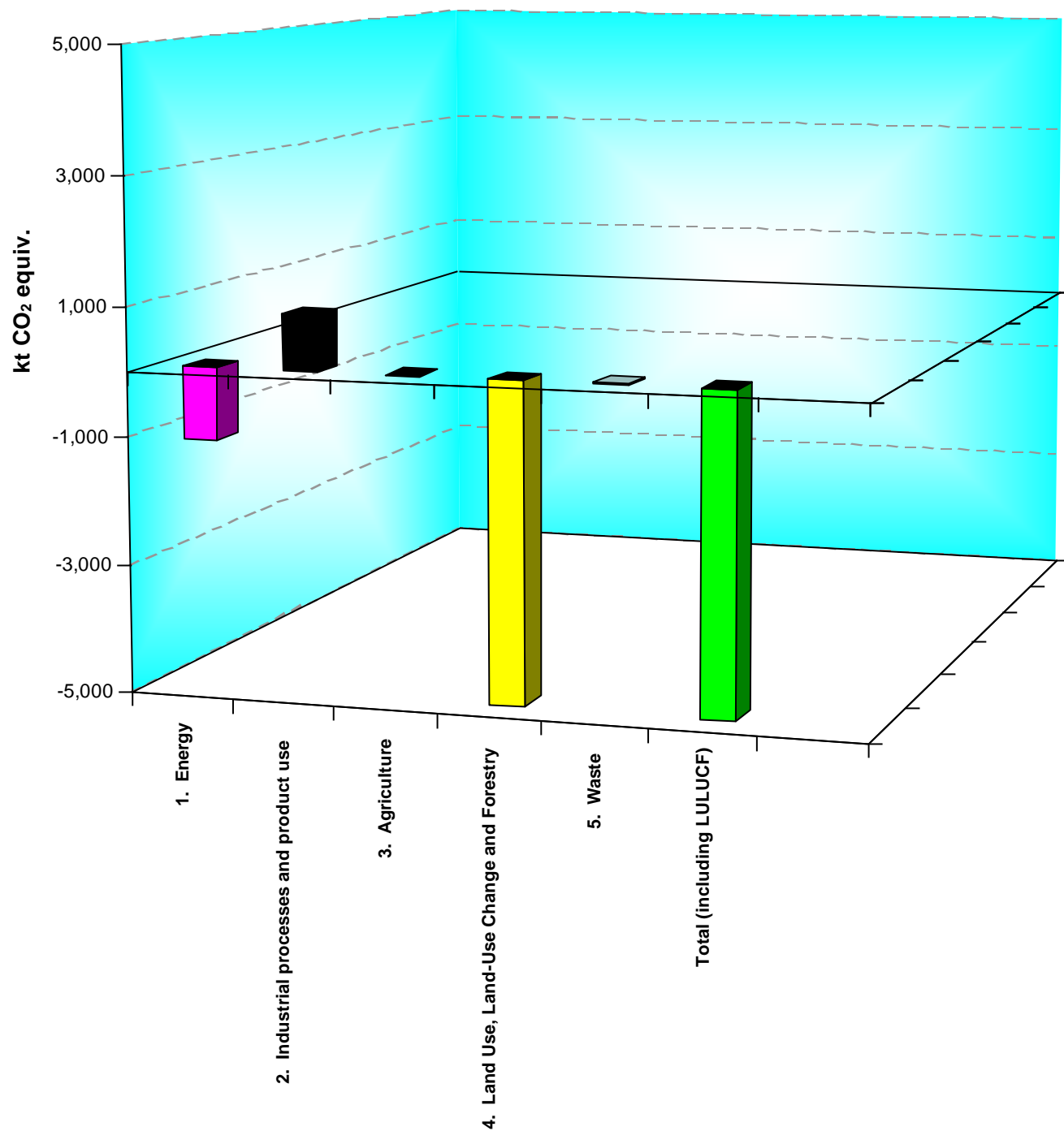
*Figure 10.5 Changes of 1989 emissions/removals, in respect to the 2018 figures*

Total emissions in 2015, including LULUCF have decreased by 5.41% compared to the 2017 submission

*Table 10.3 Recalculation of total emissions/removals, by sector, for all gases, for 2015*

<b>Differences for 2014 estimates</b>	<b>Differences</b>		<b>2018</b>	<b>2017</b>
	<b>Gg CO<sub>2</sub> eq.</b>	<b>%</b>	<b>Gg CO<sub>2</sub> eq.</b>	<b>Gg CO<sub>2</sub> eq.</b>
1. Energy	-1,121.13	-1.40	78,977.04	80,098.16
2. Industrial Processes and Product Use	888.47	7.48	12,760.70	11,872.23
3. Agriculture	-1.16	-0.01	18,611.87	18,613.03
4. Land Use, Land-Use Change and Forestry	-5,093.17	27.90	-23,351.35	-18,258.18
5. Waste	18.40	0.31	5,861.71	5,843.31
<b>Total (including LULUCF)</b>	<b>-5,308.58</b>	<b>-5.41</b>	<b>92,859.96</b>	<b>98,168.54</b>



*Figure 10.6 Changes of 2014 emissions/removals, in respect to the 2018 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
<b>Energy</b>		
<b>1.</b>	Fuel combustion (CRF 1.A)	<b><i>Activity Data:</i></b> 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
		<p>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.</p> <p>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.</p> <p>Annually analysis on the EU-ETS reporting in comparison with Large Combustion Plants reporting, in order to check the consistency of the reported data, will be performed. For the current submission no necessary resources were available for these activities.</p> <p><b><i>Emission Factors:</i></b></p> <p>Following the same procedure used until now, based on EU-ETS operators reporting, the country-specific CO<sub>2</sub> emission factors will be calculated and included in the next inventory submission.</p> <p>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</p>

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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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 higher tier approach in the estimation of the CO <sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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.
<b>Industrial Processes</b>		
1.	Non-energy products from fuels and solvent use (CRF 2.D)	Improve in the estimation of CO <sub>2</sub> emissions from urea use in SCR systems under 2.D.3.
<b>Agriculture</b>		
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 lost 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.
<b>Waste</b>		
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.
<b>LULUCF</b>		
1.	Forest Land (CRF sector 4.A.)	<p>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.</p> <p>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</p>



No.	Category subject to improvement	Description of improvement
		<p>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.</p> <p>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).</p>
2.	Cropland (CRF sector 4.B.)	<p>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.</p>
3.	Grassland (CRF sector 4.C.)	<p>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</p>

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
<b>KP - LULUCF</b>		
<b>1.</b>	Harvested wood products – CO <sub>2</sub>	Recalculations affect the entire time series estimates taking into account that Romania changed the abordation associated to this category, in accordance with IPCC 2006 and KP Supplement for LULUCF sector.

## **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<sub>2</sub> 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, 2013-2016 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**

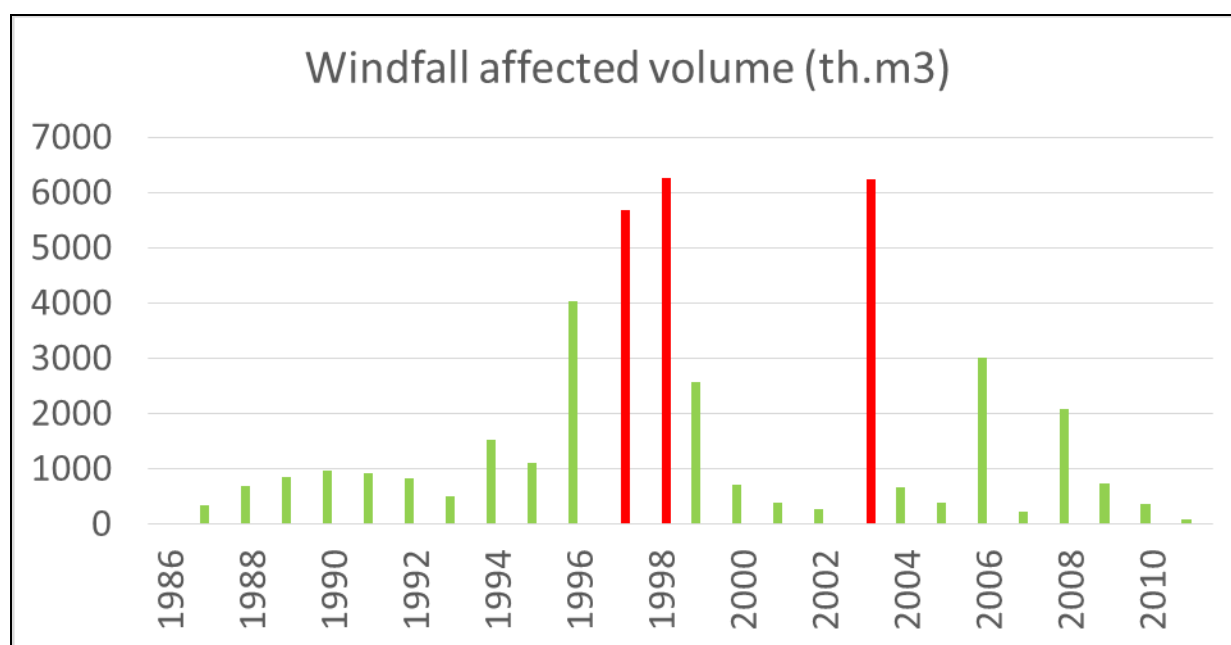
##### *11.2.1 Definition of the forest and any other criteria*

Area under forest management matches the area of forests and are included in the national forest fund, land with a surface area of at least 0.25 ha, covered with trees; the trees must reach a minimum height of 5m in maturity under normal vegetation conditions. It does not include land used predominantly for agricultural purposes.

### 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. m<sup>3</sup> (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<sub>2</sub>/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 windstorms/ Background group for wildfires 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<sub>2</sub>eq/year, reported by national GHG inventory) of the annual net CO<sub>2</sub> removals. Associated GHG emissions are calculated using Equation 2.27 and default factors (combustion factor, emission factors for CH<sub>4</sub>, N<sub>2</sub>O) 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O. For *windfalls* annual estimates of standing volume affected are available

for a historical period starting 1986 to 2010. Estimation of CO<sub>2</sub> 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.m<sup>3</sup> 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<sub>2</sub> 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<sub>2</sub>/CO<sub>2eq</sub> 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<sub>2</sub> 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<sub>2</sub> equivalent (assuming instantaneous oxidation).

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](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).

The amounts of volume that are accounted for as input to the HWP pool exclude firewood.

Changes in the carbon stocks in the harvested wood products (HWP) pool were recalculated based on the methodological guidance of the IPCC 2006 GL and the IPCC 2013 KP Supplement.

*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 2013-2016.

#### *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 1990-2016.

### ***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 1<sup>st</sup> NFI (mid-year 2010). In order to derive time series for 1990-2016, 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 2<sup>nd</sup> NFI cycle started. Similar approach applied to Litter pool, modeled data is validated against sampled

data from 1<sup>st</sup> 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 2016 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 were 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  $\pm 9\%$  (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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>eq 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  $\pm 14\%$ ;

- net removals for the Kyoto I commitment period (2008-2014) coinciding with the 2<sup>nd</sup> project verification period is also available, as follows:
  - Claimed verified amount for 2<sup>nd</sup> verification was 229641 tCO<sub>2</sub> with an uncertainty of  $\pm 8.5\%$ . Largest contribution is given by removals of living biomass, DOM and SOM pools of 240361 MgCO<sub>2</sub>;
  - JI project's non-CO<sub>2</sub> 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, ICERs, AAUs and RMUs for the year 2017 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 31.12.2017 as well as information on transfers of the units in 2017 to and from other Parties of the Kyoto Protocol (Table 12.1). Neither AAUs, nor RMUs have been issued in the Romanian Registry in 2017.

***Table 12.1 Information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Romanian registry at 31.12.2017***

Annual Submission Item	Reporting
15/CMP.1 annex I.E paragraph 11: Standard Electronic Format (SEF)	<b>12.2.</b> The Standard Electronic Format report for 2017 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	<b>12.3.</b> No discrepant transaction occurred in 2017
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2017

Annual Submission Item	Reporting
15/CMP.1 annex I.E paragraph 15: List of non-replacement	No non-replacement occurred in 2017
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2017
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	<b>12.4.</b> The information based on the requirements in the annex to decision 13/CMP is publicly available on the Romanian registry website: <a href="http://rnges.anpm.ro/">http://rnges.anpm.ro/</a>
15/CMP.1 annex I.E paragraph 18: CPR Calculation	<b>12.5.</b> 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.<sup>5</sup>

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<sub>3</sub>) 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

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<sup>5</sup>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).

joint assigned amount of the members determined in accordance with Article 3 (7bis), (8) and (8bis) of the Kyoto Protocol. This is not the case for Romania. More information on this is provided below under the chapter on the calculation of the assigned amount.

Pursuant to Annex I to Decision 3/CMP.11, section I, B para 2 those Parties that have reached an agreement in accordance with Article 4 to fulfil their commitments under Article 3 jointly shall use the respective emission level allocated to each of the Parties in that agreement instead of the percentage inscribed for it in the third column of Annex B.

This emission level (the assigned amount) is for Romania 656,059,490 tonnes of carbon dioxide equivalent.

The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8.

For the purposes of the joint fulfilment, the commitment period reserve applies to the EU, its Member States and Iceland individually.

The calculations of the commitment period reserve for Romania are follows:

Method 1: 90 % of assigned amount results in:

$0.90 * 656,059,490 = 590,453,541$  tonnes of carbon dioxide equivalent

Method 2: 100% of most recently reviewed inventory, taken the 2018 submission as the most recently reviewed inventory, multiplied by 8 results in:

$112,542,364 * 8 = 900,338,916$  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 2017 NGHGI are presented in Annex 6.8.

#### **Changes implemented after submitting the 2017 NGHGI**

No changes occurred after submitting the 2017 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	<p>Romanian Registry team was established in a new Decision approved by President of National Environmental Protection Agency, no 764/07.07.2017, as follows:</p> <ul style="list-style-type: none"> <li>• Mr. Cătălin DULGHERU - national administrator of the Romanian Registry;</li> <li>• Mrs. Adriana Cornelia CRISTEA - authorized representative of the Romanian Registry;</li> <li>• Mr. Alin Daniel ȘERBAN - authorized representative of the Romanian Registry;</li> <li>• Mrs. Georgiana Izabela FRANGA - authorized representative of the Romanian Registry.</li> </ul>
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	<p>The version of the EUCR released after 8.0.7 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database.</p> <p>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.</p> <p>No change to the capacity of the national registry occurred</p>

Reporting Item	Description
	during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	<p>Changes introduced since version 8.0.7 of the national registry are listed in Annex 6.2.3.</p> <p>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).</p> <p>No other change in the registry's conformance to the technical standards occurred for the reported period.</p>
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	<p>In accordance with SIAR recommendations Romanian Registry nominated a new National Administrator by Decision approved by President of National Environmental Protection Agency no. 764/07.07.2017; the contact information was published and is available at <a href="http://rnges.anpm.ro/content.aspx?id=90">http://rnges.anpm.ro/content.aspx?id=90</a>. The public information in accordance with decision 13/CMP.1, annex, paragraph 45(d), and information on current holdings of ERUs, CERs, AAUs and RMUs in each account in accordance with decision 13/CMP.1, annex, paragraph 47(l) are published now on the registry website:</p> <p>(<a href="http://rnges.anpm.ro/content.aspx?id=100">http://rnges.anpm.ro/content.aspx?id=100</a>).</p>



Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 8.0.7 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.

## **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 communautaire*.

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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