REPUBLIC OF BULGARIA
MINISTRY OF ENVIRONMENT AND WATER

EXECUTIVE ENVIRONMENT AGENCY

NATIONAL INVENTORY REPORT 2019

GREENHOUSE GAS EMISSIONS IN BULGARIA 1988-2017

April, 2019

Reporting Entity

Executive Environment Agency at the Ministry of Environment and Water

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EXECUTIVE SUMMARY

ES 1 Background information on greenhouse gas inventories and climate change

Over the past century, atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and halogenated hydrocarbons, i.e. greenhouse gases, have increased as a consequence of human activity. Greenhouse gases prevent the radiation of heat back to space and cause warming of the climate. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (AR4) (IPCC 2007)[1], the atmospheric concentrations of CO_2 have increased by 35%, CH_4 concentrations have more than doubled and N_2O concentration has risen by 18%, compared with the pre-industrial era.

Changing climate has effects on both human and natural systems (e.g. human settlements, human health, water and food resources, ecosystem and biodiversity). Some of the effects on environmental and socio-economic systems will be beneficial, some damaging. The larger changes and the rate of changes in climate, the more adverse effects will predominate. In Bulgaria the adverse impacts are related, for example, the winter tourism, increased floodings and droughts and the prevalence of pests and diseases. Positive impacts could be possible growth of productivity in agriculture and forestry and decreased need for heating energy. According to the "Fifth National Communication of Bulgaria on Climate Change"[2] from the year 2010 the average temperature in the country could rise. Extreme weather events, such as storms, droughts and heavy rains, are likely to increase.

According to the HadCM3[3] model significant summer warming in the Western Balkan countries were projected for 2080. Air temperatures during this time of the year are expected to increase between 5°C and 8°C over most of the countries in the peninsula. Summer precipitation is projected to decrease in the region.

Acknowledging the importance of the climate change issue and the need for international cooperation to address this problem, Bulgaria signed the UNFCCC in Rio de Janeiro in June 1992 and the Parliament ratified it in March 1995. In compliance with Article 4.6 and 4.2(b) of the UNFCCC, Bulgaria as a country in transition has adopted 1988[4] as a base year for the implementation of the Convention instead of 1990. As an Annex I Party of the UNFCCC the Republic of Bulgaria adopted the target to stabilize emissions of greenhouse gases by 2000 at a level not exceeded that in 1988. The same year was used when comparing, evaluating and projecting greenhouse gas emissions. The 2000 target was successfully achieved.

The Kyoto Protocol (KP) is adopted at the III-rd Session of the Conference of the Parties (COP) to the Convention (December 1997, Kyoto). The KP is ratified by Bulgaria in August 2002. After Russia ratified the KP in November 2004, it entered into force on 16 February 2005.

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[1] Fourth Assessment Report of the Intergovernmental Panel on Climate Change (AR4) (IPCC 2007): Working Group I Report "The Physical Science Basis"; Working Group II Report "Impacts, Adaptation and Vulnerability"; Working Group III Report "Mitigation of Climate Change";

http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm

[2] http://unfccc.int/resource/docs/natc/bgr_nc5.pdf

[3] http://www.ipcc-data.org/sres/hadcm3_info.html

[4] FCCC/CP/1996/15/Add.1/Corr.17 June 1999 http://unfccc.int/resource/docs/cop2/15a01c01.pdf#page=1

With the KP, the Parties to the Convention took the commitment not only to stabilize the GHG emissions, but also to reduce them by percentage, defined with respect to the base year of each Party.

Bulgaria ratified the the KP in August 2002 taking the commitment to reduce its national GHG emissions for the first commitment period (2008-2012) by 8% compared to 1988 (base year). Under these international agreements Bulgaria is committed to provide annually information on its national anthropogenic greenhouse gas emissions by sources and removals by sinks for all greenhouse gases not controlled by the Montreal Protocol.

The inventories started with the country base year – 1988. The first inventories covered the period 1988-1994 as a part of the international project "Country Study to Address Climate Change[5]".

ES 2 Summary of national emission and removal-related trends

The annual inventory and reporting of greenhouse gas emissions and removals provide an information base for the planning and monitoring of climate policy. The Kyoto Protocol obliges its parties to establish a national greenhouse gas inventory system by the end of 2006. Bulgaria's National Greenhouse Gas Inventory System was set up at the beginning of 2007.

The national system produces data and background information on emissions and removals for the UNFCCC, the Kyoto Protocol and the EU Commission. In addition, the scope of the system covers the archiving of the data used in emission estimations, the publishing of the results, participation in inventory reviews and the quality management of the inventory.

The Regulation[6] of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol obliges the Member States (MS) of the European Union (EU) to participate in the compilation of the EU's common greenhouse gas inventory and other climate policy, as well as in the monitoring and evaluation of its detailed measures. This procedure causes a two-phased submission of MS inventory reporting to the Commission with annual deadlines for submission 15 January and 15 March.

This National Inventory Report (NIR) of Bulgaria for the 2019 submission to the EU, the UNFCCC and the Kyoto Protocol includes data of the anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHG_S) not controlled by the Montreal Protocol, i.e. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFC_S), hydrofluorocarbons (HFC_S), nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6).

Each of these gases has a different warming effect. As an example, the gases HFCs, PFCs and SF_6 (so called F-gases) have much greater warming effect, in some cases over one hundred times, compared to methane (25), nitrous oxide (298) and carbon dioxide (1).[7]

Because of that, a common assessment criterion for the effect of each GHG on the atmosphere warming should be introduced. This criterion is the so-called Global Warming Potential (GWP),

[5] http://www.gcrio.org/CSP/pdf/bulgaria_snap.pdf

[6] Regulation No 525/2013

[7] Global Warming Potential referenced to the updated decay response for the Bern carbon cycle model and future CO_2 atmospheric concentrations held constant at current levels. http://unfccc.int/ghg_data/items/3825.php

representing GHG emissions as CO_2-eq. emissions. It allows totalling the effect of all GHGs, adjusted to a common base.

For defining of GWP, the Parties to the Convention and Kyoto Protocol accept values, over a time horizon of 100 years, as mentioned in the IPCC Fourth Assessment Report of 2007[8].

Indirect CO_2 emissions resulting from atmospheric oxidation of CH_4 and NMVOC emissions from non-biogenic sources are also included in the inventory. These have been separately estimated for fugitive emissions in the Energy sector and sources in the Industrial Processes and Product Use sectors using the methodology given in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006, see Section 7.2.1.5). For fossil fuel combustion, indirect emissions are included in the methodology to estimate CO_2 emissions.

The NIR includes also estimates of so-called indirect greenhouse gases carbon monoxide (CO), nitrogen oxides (NO_X) and non-methane volatile organic compounds ($NMVOC_S$) and sulphur dioxide (SO_2) meaning sulphur oxides and other sulphur emissions calculated as SO_2. Indirect greenhouse gases and sulphur dioxide do not have a direct warming effect, but influence on the formation or destruction of direct greenhouse gases, such as troposheric ozone. These gases are not included in Annex A of the Kyoto Protocol.

Other gases have indirect warming effect to the atmosphere (as NO_X, CO and NMVOCs), or cooling effect as SO_X. These gases are precursors of the greenhouse gas – troposphere ozone, and are subject of regional control protocols. They do not have global effect on the climate changes as the main GHG. That is why in the NIR only the total GHG emissions – precursors, as well as the total SO_X emissions were reported.

The emission estimates and removals are presented by gas and by source category and refer to the year 2017. Full time series of the emissions and removals (with exception of F-gases) from 1988 to 2017 are included in the submission.

The structure of this NIR was reelaborated in order to follow the Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (Decision 15/CP.17). The annotated outline of the NIR'[9], and the guidance contained therein, developed by the UNFCCC secretariat in 2011, has been followed. Chapter 1 provides an introduction to the background of greenhouse gas inventories and the inventory preparation process and Chapter 2 presents the overall emission trend in Bulgaria from the year 1988 to the year 2017. In Chapters 3 to 9 more detailed information of GHG emission estimates are given for the seven sectors:

- CRF 1: Energy
- CRF 2: Industrial processes and product use
- CRF 3: Agriculture
- CRF 4: Land use, land-use change and forestry
- CRF 5: Waste
- CRF 6: Other
- CRF 7: Indirect CO_2 and nitrous oxide emissions

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[8] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14

[9]http://unfccc.int/files/national_reports/annex_i_ghg_inventories/reporting_requirements/application/pdf/annotated_nir_outline.pdf

In Chapter 10 improvements and recalculations since the previous submission are summarised. Chapter 11 provides description of KP-LULUCF, Chapter 12 information on accounting of KYOTO units, Chapter 13 information on changes in national system and Chapter 14 information on changes in national registry. Chapter 15 gives information on minimisation of adverse impacts in accordance with Article 3, paragraph 14.

Annex 1 contains the mandatory key category reporting tables. A national reference calculation for CO_2 emissions from energy combustion can be found in Annex 4 (Comparison of CO_2 emissions calculated from the Energy balance with fuel combustion emissions as reported in the CRF tables). Annex 7 contains the mandatory uncertainty reporting table . Annex 6 includes 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.

As an Annex I Party to the UNFCCC Bulgaria reports annually its GHG inventory from the base year to the year proceeding the year of reporting.

Annex I Parties to the KP should report also additional elements as assigned amount information, changes in national system, changes in national registry and submission of information relating to activities under Articles 3, paragraphs 3, of the Kyoto Protocol.

The inventories are prepared according to the UNFCCC Guidelines[10] and establishing the NIR structure in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.[11]

The general objective regarding the preparation of the annual GHG inventories is to improve „TACCC" in emission estimates. The Report presents the National GHG inventory for 2017. The following are described as well:

- Methods and indices for uncertainty assessment of the annual GHG emissions and trends;
- Key GHG emission sources according to method of the type Approach 1 and Approach 2, specified in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories;
- Assessment of the quality assurance and control system.
- Activity data and emission tables for 1988-2017 in the Common Reporting Format (CRF) for annual GHG inventories are submitted together with the Report and are uploaded on:

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8812.php

http://cdr.eionet.europa.eu/bg/un/unfccc

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

In 2017 Bulgaria's greenhouse gas emissions totalled 61 497 Gg CO_2 without reporting of sequestration from LULUCF sector. The emissions decreased by 47.33 % compared with the base year. Emissions in 2017 were 4.1 % increased in comparison with the emissions of the previous year.

The net emissions including reporting of sequestration from LULUCF sector were 52 246 Gg CO_2 eq. The emissions decreased by 49.48 % compared with the base year.

The main reasons for the declining GHG emission trend in Bulgaria are the structural economic changes due to the radical transition process from a centrally-planned economy to a market-based

[10] http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf

[11] http://unfccc.int/files/national_reports/annex_i_ghg_inventories/reporting_requirements/items/2759.php

economy. This led to a decrease of power production from thermal power stations (and an increase of the shares of hydropower and nuclear power), structural changes in industry (including a decline in production by energy-intensive enterprises and energy-efficiency improvements), introduction of energy efficiency measures in the residential sector and a shift form solid and liquid fuels to natural gas in energy consumption. This also led to a decrease in GHG emissions from the agricultural sector stemming from the decline in the cattle and sheep populations and the use of fertilizers.

Bulgaria experienced a steady declining population trend during the period 1990-2017, which resulted in the reduction of population by 21.5%.

ES 4 Background information of the Kyoto Protocol

Bulgaria has made a commitment to follow the UNFCCC that entered into force on 21 March 1994. The Kyoto Protocol negotiated in 1997 under the UN Framework. The Kyoto protocol took effect on 16 February 2005 and became legally binding.

The Kyoto Protocol (Article 5.1) requires that the parties have in place a National System by the end of 2006 at the latest for estimating anthropogenic greenhouse gas emissions by sources and removals by sinks not controlled by the Montreal Protocol. The guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol (Decision 19/CMP.1[12]) provide the requirements for the general and specific functions of the national systems. Bulgaria's inventory system was reviewed as part of the review of the Bulgaria's initial report under Convention in 2007 (FCCC/IRR/2007/BGR)[13].

Under the UNFCCC and the Kyoto Protocol, Bulgaria is required to submit annually to secretariat of the Convention a national greenhouse gas inventory covering emissions and removals of direct greenhouse gases from the five sectors (Energy, Industrial processes and product use, Agriculture, Land Use, Land-Use change and Forestry and Waste) and for all years from the base year or period to the most recent year. The preparation and reporting of the inventories are guided by the UNFCCC guidelines (UNFCCC 2014) and are based on the following IPCC methodologies to ensure the transparency, accuracy, comparability, consistency and completeness of the inventories;

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006 GL)[14]
- 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP supplement)
- 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement)
- EMEP/EEA air pollutant emission inventory guidebook – 2016.

The national greenhouse gas inventory for 2017 is submitted to the European Commission by Bulgarian Ministry of Environment and Water in fulfillment of Bulgaria's obligation under Article 7 of Regulation 525/2013[15] of the European Parliament and of the Council of 21 May 2013 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. The purpose of Regulation 525/213 is to monitor all anthropogenic greenhouse gas

[12] http://www.ciesin.columbia.edu/repository/entri/docs/cop/Kyoto_COP001_019.pdf

[13] Report of the review of the initial report of Bulgaria: http://unfccc.int/resource/docs/2008/irr/bgr.pdf

[14] http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

[15] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:165:0013:0040:EN:PDF

emissions not controlled by the Montreal Protocol and to evaluate the progress towards meeting the commitments under the UNFCCC and the Kyoto Protocol.

PART 1: ANNUAL INVENTORY SUBMISSION

1 INTRODUCTION

1.1 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES, AND CLIMATE CHANGE

1.1.1 BACKGROUND INFORMATION ON CLIMATE CHANGE

Over the past century, atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and halogenated hydrocarbons, i.e. greenhouse gases, have increased as a consequence of human activity. Greenhouse gases prevent the radiation of heat back to space and cause warming of the climate. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007), the atmospheric concentrations of CO_2 have increased by 35%, CH_4 concentrations have more than doubled and N_2O concentration has risen by 18%, compared with the pre-industrial era.

Changing climate has effects on both human and natural systems (e.g. human settlements, human health, water and food resources, ecosystem and biodiversity). Some of the effects on environmental and socio-economic systems will be beneficial, some damaging. The larger changes and the rate of changes in climate, the more adverse effects will predominate. In Bulgaria the adverse impacts are related, for example, to the winter tourism, increased floodings and droughts and the prevalence of pests and diseases. Positive impacts could be possible growth of productivity in agriculture and forestry and decreased need for heating energy. According to the Fifth National Communication of Bulgaria on Climate Change from the year 2010 the average temperature in the country could rise. Extreme weather events, such as storms, droughts and heavy rains, are likely to increase.

Significant summer warming in the western Balkan countries, were projected by the HadCM3 model for 2080. Air temperatures during this time of the year are expected to increase between 5ºC and 8ºC over most of the countries in the peninsula. Summer precipitation is projected to decrease in the region.

Acknowledging the importance of the climate change issue and the need for international cooperation to address this problem, Bulgaria signed the UNFCCC in Rio de Janeiro in June 1992 and the Parliament ratified it in March 1995. In compliance with Article 4.6 and 4.2(b) of the FCCC, Bulgaria as a country in transition has adopted 1988 as a base year for the implementation of the Convention instead of 1990. As an Annex I Party of the UNFCCC the Republic of Bulgaria adopted the target to stabilize emissions of greenhouse gases by 2000 at a level not exceeded that in 1988. The same year was used when comparing, evaluating and projecting greenhouse gas emissions. The 2000 target was successfully achieved.

The Kyoto Protocol (KP) is adopted at the III-rd Session of the Conference of the Parties to the Convention (December 1997, Kyoto). KP is ratified by Bulgaria in August 2002. After Russia ratified the KP in November 2004, it entered into force on 16 February 2005.

With the KP, the Parties to the Convention took the commitment not only to stabilize the GHG emissions, but also to reduce them by percentage, defined with respect to the base year of each Party.

Bulgaria ratified the KP in August 2002 taking the commitment to reduce its national GHG emissions for the first commitment period (2008-2012) by 8% compared to 1988 (base year). Under these international agreements Bulgaria is committed to provide annually information on its national anthropogenic greenhouse gas emissions by sources and removals by sinks for all greenhouse gases not controlled by the Montreal Protocol.

The inventories started with the country base year – 1988. The first inventories covered the period 1988-1994 as a part of the international project "Country Study to Address Climate Change".

1.1.2 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES

The annual inventory and reporting of greenhouse gas emissions and removals provide an information base for the planning and monitoring of climate policy. The Kyoto Protocol obliges its parties to establish a national greenhouse gas inventory system by the end of 2006. Bulgaria's National Greenhouse Gas Inventory System was set up at the beginning of 2007.

The national system produces data and background information on emissions and removals for the UNFCCC, the Kyoto Protocol and the EU Commission. In addition, the scope of the system covers the archiving of the data used in emission estimations, the publishing of the results, participation in inventory reviews and the quality management of the inventory.

The Regulation of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol obliges the Member States (MS) of the European Union (EU) to participate in the compilation of the EU's common greenhouse gas inventory and other climate policy, as well as in the monitoring and evaluation of its detailed measures. This procedure causes a two-phased submission of MS inventory reporting to the Commission with annual deadlines for submission 15 January and 15 March.

This National Inventory Report (NIR) of Bulgaria for the 2019 submission to the EU, the UNFCCC and the Kyoto Protocol includes data of the anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, i.e. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6).

Indirect CO_2 emissions resulting from atmospheric oxidation of CH_4 and NMVOC emissions from non-biogenic sources are also included in the inventory. These have been separately estimated for fugitive emissions in the Energy sector and sources in the Industrial Processes and Product Use sectors using the methodology given in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006, see Section 7.2.1.5). For fossil fuel combustion, indirect emissions are included in the methodology to estimate CO_2 emissions.

The NIR includes also estimates of so-called indirect greenhouse gases carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2) meaning sulphur oxides and other sulphur emissions calculated as SO_2. Indirect greenhouse gases and sulphur dioxide do not have a direct warming effect, but influence on the formation or destruction of direct greenhouse gases, such as troposheric ozone. These gases are not included in Annex A of the Kyoto Protocol.

The emission estimates and removals are presented by gas and by source category and refer to the year 2017. Full time series of the emissions and removals (with exception of F-gases) from 1988 to 2017 are included in the submission.

The structure of this NIR was reelaborated in order to follow the Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (Decision 24/CP.19). The annotated outline of the NIR, and the guidance contained therein, developed by the UNFCCC secretariat in 2014, has been followed. Chapter 1 provides an introduction to the background of greenhouse gas inventories and the inventory preparation process and Chapter 2 presents the overall emission trend in Bulgaria from the year 1988 to the year 2017. In Chapters 3 to 9 more detailed information of GHG emission estimates are given for the seven sectors: (i) energy, (ii) industrial processes and product use, (iii) agriculture, (iv) land use, land-use change and forestry, (v) waste, (vi) other and (vii) indirect CO_2 and nitrous oxide emissions. In Chapter 10 improvements and recalculations since the previous submission are summarised. Chapter 11 provides description of KP-LULUCF, Chapter 12 information on accounting of KYOTO units, Chapter 13 information on changes in national system and Chapter 14 information on changes in national registry. Chapter 15 gives information on minimisation of adverse impacts in accordance with Article 3, paragraph 14.

Annex 1 contains the mandatory key category reporting tables. A national reference calculation for CO_2 emissions from energy combustion can be found in Annex 4 (Comparison of CO_2 emissions calculated from the Energy balance with fuel combustion emissions as reported in the CRF tables). Annex 7 contains the mandatory uncertainty reporting table (table 3.3 of 2006 IPCC GL). Annex 6 includes 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.

As an Annex I Party to the Convention Bulgaria reports annually its GHG inventory/emissions from the base year to the year proceeding the year of reporting.

Annex I Parties to the KP should report also additional elements as assigned amount information, changes in national system, changes in national registry and voluntary submission of information relating to activities under Articles 3, paragraphs 3 and 4, of the Kyoto Protocol.

The main greenhouse gases to be reported pursuant to UNFCCC are as follows:

- Carbon dioxide - CO_2;
- Methane - CH_4;
- Nitrous oxide - N_2O;
- Hydrofluorocarbons – HFCs;
- Perfluorocarbons – PFCs;
- Sulphur hexafluoride - SF_6;
- Nitrogen trifluoride - NF_3.

Each of these gases has a different warming effect. As an example, the gases HFCs, PFCs, NF_3 and SF_6 (so called F-gases) have much greater warming effect, in some cases over one hundred times, compared to methane (25), nitrous oxide (298) and carbon dioxide (1).

Because of that, a common assessment criterion for the effect of each GHG on the atmosphere warming should be introduced. This criterion is the so-called Global Warming Potential (GWP), representing GHG emissions as CO_2-eq. emissions. It allows totalling the effect of all GHGs, adjusted to a common base.

For defining of GWP, the Parties to the Convention and Kyoto Protocol accept values, over a time horizon of 100 years, as mentioned in the IPCC Fourth Assessment Report of 2007.

Other gases have indirect warming effect to the atmosphere (as NOx, CO and NMVOCs), or cooling effect as SOx. These gases are precursors of the greenhouse gas – troposphere ozone, and are subject of regional control protocols. They do not have global effect on the climate changes as the main GHG. That is why in the NIR only the total GHG emissions – precursors, as well as the total SOx emissions were reported.

The inventories are prepared according to the UNFCCC Guidelines and establishing the NIR structure in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The general objective regarding the preparation of the annual GHG inventories is to improve „TACCC" in emission estimates. The Report presents the National GHG inventory for 2017. The following are described as well:

- Methods and indices for uncertainty assessment of the annual GHG emissions and trends;
- Key GHG emission sources according to Approach 1 and Approach 2, specified in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories;
- Assessment of the quality assurance, control system and verification.
- Activity data and emission tables for 1988-2017 in the Common Reporting Format (CRF) for annual GHG inventories are submitted together with the Report and are uploaded on:

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8812.php

http://cdr.eionet.europa.eu/bg/un/unfccc

1.1.3 BACKGROUND INFORMATION ON SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1, OF THE KYOTO PROTOCOL AND INTERNATIONAL AGREEMENTS

Bulgaria has made a commitment to follow the United Nations Framework Convention on Climate Change that entered into force on 21 March 1994. The Kyoto Protocol negotiated in 1997 under the UN Framework. The Kyoto protocol took effect on 16 February 2005 and became legally binding.

The Kyoto Protocol (Article 5.1) requires that the parties have in place a National System by the end of 2006 at the latest for estimating anthropogenic greenhouse gas emissions by sources and removals by sinks not controlled by the Montreal Protocol. The guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol (Decision 19/CMP.1) provide the requirements for the general and specific functions of the national systems. Bulgaria's inventory system was reviewed successfully as part of the review of the Bulgaria's initial report under Protocol in 2007.

Under the UNFCCC and the Kyoto Protocol, Bulgaria is required to submit annually to secretariat of the Convention a national greenhouse gas inventory covering emissions and removals of direct greenhouse gases from the five sectors (Energy, Industrial processes and product use, Agriculture, Land use, Land use change and Forestry and Waste) and for all years from the base year or period to the most recent year. The preparation and reporting of the inventories are guided by the UNFCCC guidelines (UNFCCC 2014) and are based on the following IPCC methodologies to ensure the transparency, accuracy, consistency, comparability and completeness of the inventories:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC GL)
- 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP supplement)
- 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement)
- EMEP/EEA air pollutant emission inventory guidebook – 2016.[15]

[15] In the following referred as EMEP/EEA Guidebook (2016)

The national greenhouse gas inventory for 2017 is submitted to the European Commission by Bulgarian Ministry of Environment and Water in fulfilment of Bulgaria's obligation under Article 7 of Regulation 525/2013 of the European Parliament and of the Council of 21 May 2013 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. The purpose of Regulation 525/2013 is to monitor all anthropogenic greenhouse gas emissions not controlled by the Montreal Protocol and to evaluate the progress towards meeting the commitments under the UNFCCC and the Kyoto Protocol.

1.2 DESCRIPTION OF THE NATIONAL INVENTORY ARRANGEMENTS

1.2.1 INSTITUTIONAL, LEGAL AND PROCEDURAL ARRANGEMENTS

REQUIREMENTS FOR NATIONAL SYSTEMS FOR GREENHOUSE GAS INVENTORIES AS SPECIFIED IN THE GUIDELINES FOR ARTICLE 5.1 OF THE KYOTO PROTOCOL

The Bulgarian National Inventory System (BGNIS) is developed following the requirements of the provisions of Decision 19/CMP.1 Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol.

In order to reinstate the eligibility under Kyoto Protocol a Compliance Action Plan for ensuring the effective and timely functioning of BGNIS in accordance with the requirements of Article 5.1 of the Kyoto Protocol and Decision 19/CMP 1 was developed and implemented in 2010.

The conclusions and recommendations of ERT set out in the Report of the individual review of the 2010 annual submission of Bulgaria (FCCC/ARR/2010/BGR) indicate that all activities for improvements of institutional, legal and procedural arrangements within the National Inventory System as well as for improvement of quality of inventory are adequately planned and implemented by the Bulgarian government in 2010.

The main results are written in the paragraph §203 from the annual review report FCCC/ARR/2010/BGR - "The ERT concludes that the national system of Bulgaria is performing its required general and specific functions, as set out in the annex to decision 19/CMP.1 with respect to the institutional, legal and procedural arrangements to perform these functions; that the institutional, legal and procedural arrangements established and formalized by the "Ordinance on the way and order of organization of the national inventories of hazardous substances from greenhouse gases in the ambient air" (Ordinance No. 215) that entered into force on 21 September 2010 are fully operational; and that Bulgaria has in place the institutional arrangements and the capacity, including the arrangements for the technical competence of staff involved in the national system, to plan, prepare and manage inventories on an annual basis". As a result from implemented activities for improvements "No questions of implementation were identified by the ERT during the review" (FCCC/ARR/2010/BGR § 207).

In accordance with Decision of Enforcement Branch CC-2010-1-17/Bulgaria/EB from 4 February 2011 Bulgaria is now fully eligible to participate in the mechanisms under Articles 6, 12, and 17 of the Kyoto Protocol.

The activities for improvement of quality of GHGs inventory are planned in order to implement the recommendations of the Expert Review Team set out in the annual review report FCCC/ARR/2014/BGR.

HISTORY OF GHG INVENTORY PREPARATION

The Bulgarian National Inventory System changed over time two times because of decisions of the particular government. In the following table the national circumstances are outlined:

BGNIS until 2007 (submission 2007)	Present BGNIS (submission 2008-2019)	Prospected BGNIS
←	Centralized inventory	→
Single institute	Single agency	→
Out-sourced inventory	In-sourced inventory	→
Private consultants	**Public/Governmental** (submission with cooperation of consultants)	→
National Inventory Focal Point: Private consultants	National Inventory Focal Point: ExEA	→
←	National Focal Point: MoEW	→

Until 2007 the national emissions inventory as well as the relevant NIR under UNFCCC was prepared by an external company through an open tender procedure under the rules of the Public Procurement Law.

Since 2008 the Executive Environment Agency (ExEA) is responsible for the whole process of inventory planning, preparation and management.

The national system defines the “road map” in which Bulgaria prepares its inventory. This is outlined in the national inventory preparation cycle (see below part Fulfilment of paragraph 10(a) from Decision 19/CMP.1 Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol).

As it is illustrated in figure 1 and outlined in the following chapters the preparation of the inventory has an institutional “home” that is ultimately responsible for managing the process and has a legal authority to collect data and submit it on behalf of the Bulgaria.

Bulgaria's reporting obligations to the UNFCCC, UNECE and EC are being administered by the MoEW. All activities on preparation of GHG inventory in Bulgaria are coordinated and managed on the state level by MoEW.

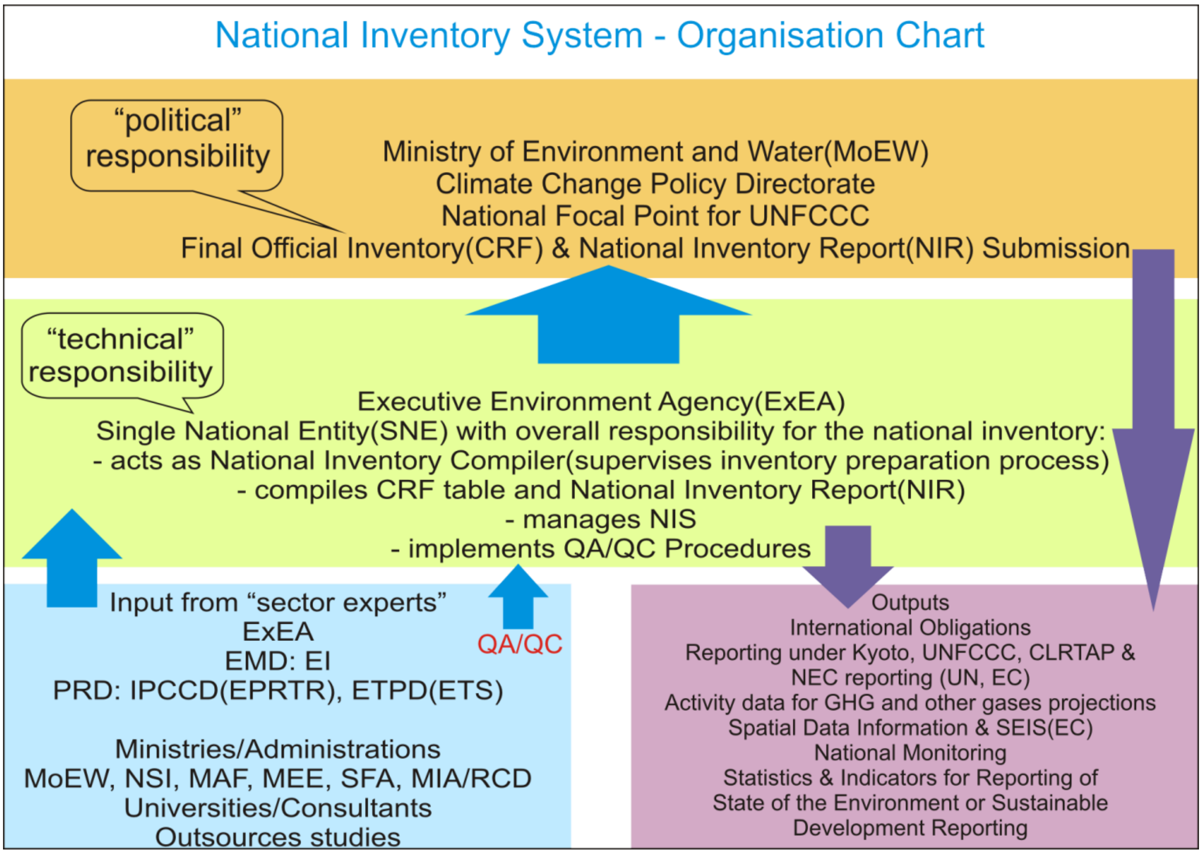

Figure 1 Organizational Chart of the Bulgarian National Inventory System

The Bulgarian Government by MoEW (Climate Change Policy Directorate) has the political responsibility for compliance with commitments under the UNFCCC and the Kyoto Protocol, including for functioning of BGNIS in accordance with the requirements of Decision 19/CMP.1 under Article 5, paragraph 1, of the Kyoto Protocol. In order to meet all challenges in this sphere, the Climate Change Policy has been transformed in a separate directorate. Now, it consists of 12 persons in total.

The following strategic goals in climate change area were achieved by the Ministry of Environment and Water in 2017:

Climate change mitigation law

Climate change mitigation law adopted on first reading in the National Assembly on 23.10.2013, the in order to incorporate the requirements of the new legislation in 2013. It regulates public relations in implementation of the policy on climate change - powers and duties of the competent authorities and individuals. Absolute prerequisite for the timely implementation of Bulgaria's obligations as a party to the UNFCCC and the Kyoto Protocol and as a country - member of the European Union, is the effective involvement of the competent authorities and private operators in the procedures, which requires clear and comprehensive regulation of their powers, rights and obligations. As a member of the European Union the Republic of Bulgaria has a number of obligations on the legislative package "Climate & Energy" and participating in the scheme for trading greenhouse gas emissions within the European Union (EU ETS), introduced by Directive 2003/87/EC. This fact is linked to the performance of many obligations that form the whole sector in climate policy and the implementation of which our country should strike a balance between the interests of industry and the ambitious EU targets for the progressive reduction of greenhouse gases.

National Green Investment Scheme

In order to exploit the possibilities for financing projects to reduce greenhouse gas emissions through the National Green Investment Scheme is a decision of the Council of Ministers № 546/12 September 2013 for addition to the agreement with Austria for the purchase of AAUs in Scheme green investments. It is accepted and a decision of the Council of Ministers № 547/12 September 2013 in connection with the implementation of projects under the Green Investment Scheme.

The funds from the sale of AAUs of the Republic of Austria have implemented projects for energy efficiency of the 77 public facilities state and municipal property in Bulgaria. Public projects to improve energy efficiency in municipal buildings, kindergartens and primary schools. Realized are energy efficiency projects at 13 public sites throughout the country.

In 2015 was started the Investment Climate Programme, which is a kind of continuation of the National Green Investment Scheme. The new programme is implemented by Trust Eco-Fund and it is financed by the revenues from so called “early auctions” of greenhouse gas emissions allowances from installations paid into the budget of the Ministry of Environment and Water by 31st December 2012. The funds are designated to be used for financing of the projects aiming at improving of energy efficiency of state and municipal public buildings, as well as for promoting the use of electric and hybrid vehicles by public institutions (since 2016).

National adaptation strategy

Steps have been taken to prepare national adaptation strategies in order to determine the necessary adaptation measures for vulnerable sectors to the impacts of changing climatic conditions in the region and climatic zone (due to climate change). As a first step was draft document "Analysis of the contribution of the insurance sector and financial instruments to the prevention of risks posed by climate change and the management of loss and damage in Bulgaria" prepared by the Ministry, with the support of the World Bank. His purpose is to analyze the role and importance of the insurance business for the prevention of risks that occur as a result of climate change and taking measures to adapt. The analysis will be included in the national adaptation strategy.

The ExEA has been identified as the responsible organization for preparation of Bulgaria's National GHG Inventory under the UNFCCC and the Kyoto Protocol and designated as single national entity (see below Legal bases; Chapter 1.2.11).

The ExEA is represented and managed by an Executive Director. The organizational chart of the ExEA is presented in Figure 2.

The ExEA's directorates and departments, which are directly involved in operation of the BGNIS are Environmental Monitoring and Assessment Directorate with the Emission Inventory Department (EID) and Waste Department (WD) and Permit Regime Directorate with the Integrated Pollution Prevention and Control Department (IPPCD) and Emission Trading Permit Department (ETPD).

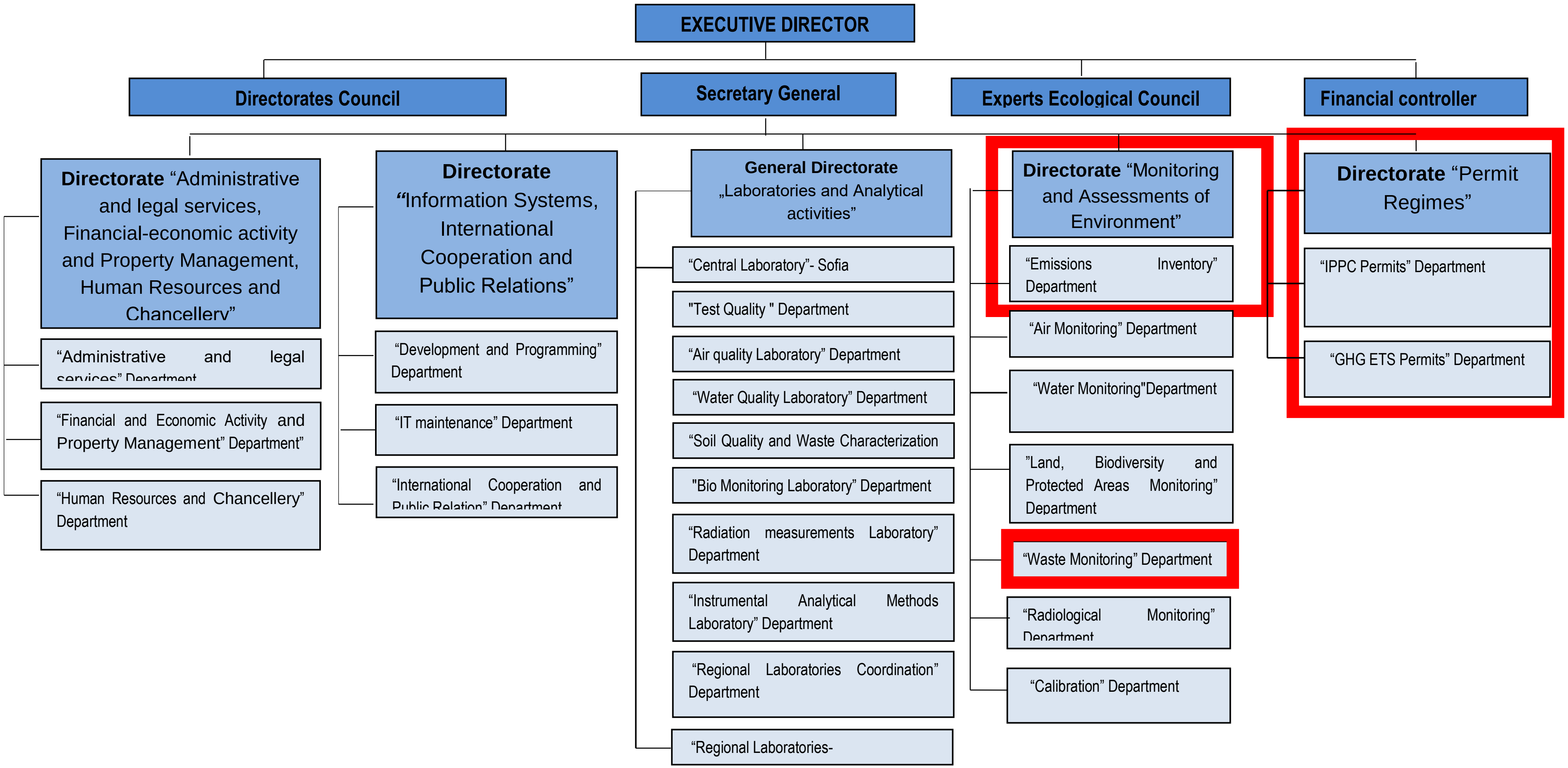

Figure 2 Organizational Chart of the Executive Environmental Agency (ExEA)

Since 1 January 2012, the Emissions Inventory Unit, responsible for preparation of the GHG Inventory, has been promoted as Emissions Inventory Department (see Figure 2).

The specific responsibilities of the different departments are presented below in part Legal arrangements of the Bulgarian National Inventory System (Figure 4: Bulgarian National Inventory System – Responsibilities).

The definitions provisions of Decision 19/CMP.1 Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol, are incorporated in BGNIS which is outlined below.

The overall objective of the BGNIS is annually to produce a high quality inventory (National CRF, Kyoto and SEF tables and NIR) for compliance with its Kyoto commitment and to submit it by the required deadline.

The objective of a BGNIS is annually to produce a high quality inventory, with "quality" being defined by the TCCCA criteria. (see also chapter 1.2.12)

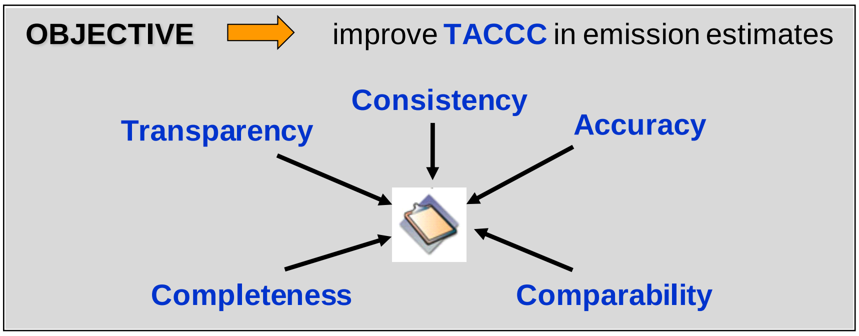

Figure 3 Objectives of the Bulgarian National Inventory System

1.2.2 OVERVIEW OF INVENTORY PLANNING, PREPARATION AND MANAGEMENT

Legal basis of the Bulgarian NIS – General functions

Fulfillment of paragraph 10(a)

The Republic of Bulgaria joined the UNFCCC in 1992 and the Parliament ratified it in March 1995. As an Annex I Party to the Convention, Bulgaria is committed to conduct annual inventories on greenhouse gas (GHG) emissions by sources and removals by sinks, using the GHG inventory methodology, approved by the UNFCCC. The inventories started with the country base year – 1988. The first inventories covered the period 1988-1994 as a part of the international project "Country Study to Address Climate Change".

Legal basis of the BGNIS

As illustrated in Figure 1 and outlined shortly the Bulgaria's reporting obligations to the UNFCCC, UNECE and EC are being administered by the MoEW. All activities on preparation of GHG inventory in Bulgaria are coordinated and managed on the state level by MoEW. The Bulgarian Government by MoEW has the political responsibility for compliance with commitments under the Kyoto Protocol, including for functioning of BGNIS in accordance with the requirements of Decision 19/CMP.1 under Article 5, paragraph 1, of the Kyoto Protocol:

National Focal Point;

QA experts from Climate Change Policy Directorate;

Approval of inventory;

Submission of CRF / NIR / Kyoto Tables / SEF.

The ExEA has been identified as the responsible organization for preparation of Bulgaria's National GHG Inventory under the UNFCCC and the Kyoto Protocol and designated as single national entity. ExEA has the technical responsibility for the national inventory:

- acts as National Inventory Compiler (supervises inventory preparation process);
- manages BGNIS;
- compiles CRF tables and NIR;
- coordinates the work of engaged consultants for supporting inventory;
- coordinates and implements the activity of National QA/QC Plan;
- National Inventory Focal Point.

The bases for BGNIS are:

Environmental Protection Act (EPA, State Gazette No. 91/25.09.2002; corrected, SG No. 96/2002; last amendment September 2017);

Statute on the organization and structure of ExEA (Decision of Council of ministers 162/03.08.2012 – final update 1.10.2017);

Order № 296/04.12.2015 by the Executive Director of ExEA (Sector experts/QC experts);

Order № RD-218/05.03.2010 by the Minister of Environment and Water (QA experts).

Regulation of the Council of Ministers 227/16.10.2017 SG 84/2017 on the way and order of organization of the National Inventories of hazardous substances and greenhouse gases in the ambient air

Add 1.

EPA (State Gazette No. 91/25.09.2002; corrected, SG No. 96/2002; last amendment November 2012), which establishes the National Environmental Monitoring System, make clear the responsibility for preparation inventories under both conventions and lists of its tasks:

Chapter One: GENERAL DISPOSITIONS

Article 11: The Minister of Environment and Water shall perform the following functions:

direct the National Environmental Monitoring System through the **Executive Environment Agency;**

Article 13:

The Executive Environment Agency with the Minister of Environment and Water shall direct the National Environmental Monitoring System.

The Executive Environment Agency shall be a legal person.

The Executive Environment Agency shall be managed and represented by an Executive Director.

The operation, the structure, the organization of work and the staffing of the Executive Environment Agency shall be determined by Rules of Organization adopted by the Council of Ministers.

Chapter Eight: NATIONAL ENVIRONMENTAL MONITORING SYSTEM

Article 144:

The National Environmental Monitoring System shall comprehend:

1. the national networks for:

2. a system for information on, and control of, air emissions and the state of waste waters;

Add 2.

EPA establishes the national Executive Environment Agency (ExEA) according to **Regulation on the organization and structure of ExEA** (Decision of Council of ministers 162/03.08.2012 - final update 1.10.2017), which regulate it's responsibilities for monitoring of environment as well as the responsibility for preparation of emission inventories.

The Emissions Inventory Department of ExEA prepares and annually updates the air emissions inventories [according to article 14 (12) of the above Regulation].

Add 3.

To increase the capacity in ExEA for adequate planning, preparation and management of emissions inventory an Order № 296/04.12.2015 by the Executive Director of ExEA has been issued. The order regulates the name and responsibilities of experts from different departments within the ExEA, which are engaged in preparation of National GHGs emission inventory (Sector experts/QC experts).

Add 4.

To assure the quality of information reported to UNFCCC and UNECE and to support the single national entity, the Minister of Environment and Water has issued an order № RD-218/05.03.2010. The order regulates the names and responsibilities of the MoEW and ExEA QA experts for implementation of the requirements of National QA/QC Plan in emission inventory of sectors Energy, Industry, Solvents, Agriculture, LULUCF and Waste.

Add 5.

The BGNIS has been enshrined in law through a special Regulation of the Council of Ministers 227/16.10.2017 SG 84/2017. The regulation establishes and maintain the institutional, legal and procedural arrangements necessary to perform the general and specific functions of BGNIS, defined in Decision 19/CMP.1 for national systems. The regulation reinforces the existing institutional agreements by specifying the roles of all data providers.

INSTITUTIONAL ARRANGEMENTS

In order to strengthen the institutional arrangements and to fulfil the required general and specific functions of BGNIS an official agreements between MoEW and the main data providers were signed in 2010:

- National Statistical Institute (RD21-35/12.02.2010);
- Ministry of Agriculture and Food and its body Executive Forest Agency (04-00-517/26.02.2010 and RD 50-47/15.03.2010);
- Ministry of Economy, Energy and Tourism (14/06/2010);
- Ministry of Interior (MI) (08/06/2010).

The agreements ensure the support from these organisations regarding the choice of the activity data and EFs and methods, in the compilation of emission estimates and QA/QC of these estimates.

The ExEA as Single National Entity coordinates all activities, related to collecting inventory data and aggregates the data relevant for GHG emissions on a national level by the following state authorities:

- National Statistics Institute (NSI);
- Ministry of Agriculture, Food and Forestry (MAFF) and their relevant services (Agrostatistic Directorate and Executive Forest Agency);
- Ministry of Energy (ME);
- Ministry of Interior (MI);
- Ministry of Environment and Water (MoEW);
- Ministry of Transport, Information Technologies and Communications (MTITC).

OTHER ARRANGEMENTS OF THE BULGARIAN NATIONAL INVENTORY SYSTEM

The Executive Environment Agency (ExEA) coordinates all activities, related to the large industrial plants and Branch Business Associations.

- Large industrial plants – official letters (questionnaire)
- Branch Business Associations – official letters (questionnaire)

For validation of the activity data we gather reliable country specific data from Branch Business Associations in Bulgaria and aggregate the data relevant for GHG emissions on a national level. Please see the list of all branch business associations in Bulgaria: http://www.bia-bg.com/memberCategory/278. The data must be representative for the whole period since 1988 (base year for Bulgaria).

EXPERT CAPACITY

Expert capacity in ExEA - Emission Inventory Department

The EID has the main role in BGNIS as National Inventory Compiler (supervises inventory preparation process, compiles CRF tables and NIR, manages BGNIS implements QA/QC procedures on a national level)

The responsibilities of the Sector experts

Within the inventory system specific responsibilities for the different emission source categories are defined ("sector experts"), as well as for all activities related to the preparation of the inventory, including QA/QC, data management and reporting.

The sector experts are in charge of specific responsibilities related to choice of methods, data collection, processing and archiving. Sector experts are also responsible for performing Quality Control (QC) activities that are incorporated in the Quality Management System (QMS) (see below).

Engaged departments within ExEA

In order to improve the capacity of the BGNIS in planning, preparation and managing its annual submissions the extension of the ExEA staff has been realised in the beginning of 2010.

TECHNICAL CAPACITY

Training of Bulgarian experts

Workshops and Training on the job

To raise the technical competence of staff involved in the inventory development process, a training programme for Bulgarian inventory experts was updated within the Twinning project with the Federal Environment Agency of Austria[16]. The program covered all inventory sectors in a series of workshops realised in the period December 2009 to September 2010.

Further collaboration with Austrian Environment Agency for training of Bulgarian staff is envisaged for the next submissions.

Online training

To raise the technical competence of staff involved in the inventory development and review process, sector experts from ExEA applied for having an access to the Online training by the UNFCCC and GHG Management Institute (GHGMI)[17].

Basic Course[18]

This course covers technical aspects of the review of GHG inventories of Annex I Parties. It consists of seven modules: one general module, "Overview of UNFCCC Review Process and General IPCC Inventory Guidance" and individual modules on the review of individual IPCC sectors: Energy (Fuel Combustion and Fugitive Emissions), Industrial Processes, Agriculture, LULUCF and Waste. Each of the modules provides important background information and references for the sector, instruction on general procedures for review, exercises on key topics and specific emission categories, and practical case studies that simulate an actual review.

The courses are also available to trainees all year round, without instructor.

[16] The Twinning Partner "Austrian Federal Environment Agency" has already experience as supporting role / expert in preparing GHG and air emission inventory and reporting (UNFCCC, UNECE/LRTAP and NEC); FCCC/ARR/2008/LUX para 8: "…. The ERT noted that three relevant studies have been outsourced to external experts and that the improvements are mainly the result of research activities and intensive cooperation with the Austrian Federal Environment Agency."

[17] http://ghginstitute.org/2010/03/03/the-unfccc-expert-reviewer-training-programme-is-ongoing

[18] http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_training/items/2763.php
http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_training/items/2764.php

Fulfilment of paragraph 10(c)

See above and below

UNFCCC reporting guidelines

Fulfilment of paragraph 10(d);

Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention following incorporation of the provisions of decision 24/CP.19"

Fulfilment of paragraph 10(c)

See below

LEGAL BASIS OF THE Bulgarian NIS – SPECIFIC FUNCTIONS

SINGLE NATIONAL ENTITY

Fulfilment of paragraph 12(a)

An overview of the general responsibilities in the inventory development and reporting process is given in Fulfilment of paragraph 10a.

Bulgaria's reporting obligations to the UNFCCC, UNECE and EC are being administered by the Ministry of Environment and Water (MoEW). All activities on preparation of GHG inventories in Bulgaria are coordinated and managed on the state level by MoEW. The MoEW (Climate Change Policy Directorate) has the political responsibility for compliance with commitments under the Kyoto Protocol, including for functioning of BGNIS in accordance with the requirements of Decision 19/CMP.1 under Article 5, paragraph 1, of the Kyoto Protocol.

The Executive Environment Agency (ExEA) has been identified as the responsible organization for preparation of Bulgaria's National GHG Inventory under the UNFCCC and the Kyoto Protocol and designated as single national entity. ExEA has the technical responsibility for the national inventory:

- acts as National Inventory Compiler (supervises inventory preparation process);
- compiles CRF tables and NIR;
- manages BGNIS;
- implements QA/QC procedures.

Fulfilment of paragraph 12(b)

The postal and electronic addresses of the single national entity are:

Executive Environment Agency at the Ministry of Environment and Water

136 "Tzar Boris III" Blvd

Sofia 1618, Bulgaria

P.O.Box 251

Tel.:+359 2 9559011

Fax: +359 2 9559015

E-mail: iaos@eea.government.bg

http://eea.government.bg/en

National Focal Point (NFP): Diana Todorova

Organization: Ministry of Environment and Water

Address: 22 "Maria Luiza" blvd., 1202 Sofia, Bulgaria

E-mail: dtodorova@moew.government.bg

Tel.: +359 2 940 62 85

National Inventory Focal Point (NIFP):

Detelina Petrova

Organization: Ministry of Environment and Water

Address: 22 "Maria Luiza" blvd., 1202 Sofia, Bulgaria

E-mail: dpetrova@moew.government.bg

Tel.: +359 2 940 61 44

Head of Emission Inventory Department & National Inventory Compiler:

Rosen Yordanov

Organization: Executive Environment Agency

Address: 136, "Tsar Boris III" blvd., 1618 Sofia, Bulgaria

e-mail: rosen@eea.government.bg

Tel.: +359 2 940 64 88

Fax: +359 2 955 90 15

Name of Quality Manager: Valeri Serafimov

Director of Environmental Monitoring and Assessment Directorate
Organization: Executive Environment Agency

Address: 136, "Tsar Boris III" blvd., 1618 Sofia, Bulgaria

e-mail: serafimov@eea.government.bg

Tel.: +359 2 940 64 87

Fax: +359 2 955 90 15

Fulfilment of 12(c)

An overview of the general responsibilities in the inventory development and reporting process is given in Fulfilment of paragraph 10a. As mentioned before, the ExEA has the overall responsibility for the national inventory, comprising greenhouse gases as well as other air pollutants. Within the inventory system specific responsibilities for the different emission source categories are defined ("sector experts"), as well as for all activities related to the preparation of the inventory, including QA/QC, data management and reporting.

The sector experts are in charge of specific responsibilities related to choice of methods, data collection, processing and archiving. Sector experts are also responsible for performing Quality Control (QC) activities that are incorporated in the Quality Management System (QMS) (see below).

1.3 INVENTORY PREPARATION, DATA COLLECTION, PROCESSING AND STORAGE

Collection of activity data by ExEA

The information is collected on the annual basis.

The ExEA sends every year letters with request for provision of the necessary activity data to every one of the information sources, including the deadline for response.

For NSI, MAFF, MI and ME the type of the necessary data, as well as the deadlines for submissions to the ExEA are regulated by the official agreements mentioned above as well as by the Regulation of the Council of Ministers 227/16.10.2017 (SG 84/2017).

The annual national energy and material balances as well as the data related to the solid waste generation and the wastewater treatment are prepared by NSI. NSI uses up-to-date statistical methods and procedures for data collection, summarizing and structuring that are harmonized with EUROSTAT.

The GHG inventory use data, received directly from large point sources in the energy sector and in the industry and these data are summarized by ExEA.

Table 1 Sources of activity data for preparation of national GHGs emission inventory

Sectors	Data Source of Activity Data	Activity Data supplier	
1. Energy			
1.A Fuel Combustion	Energy balance (IEA - EUROSTAT – UNECE Energy Questionnaire)	NSI	National Statistical Institute
1.A.3 Transport	Energy balance (IEA - EUROSTAT – UNECE Energy Questionnaire)	NSI	National Statistical Institute
	Statistics vehicle fleet	MI/RCD	Ministry of Interior/ Road Control Department
	Country specific parameters used in the COPERT IV related to car fleet and vehicle split	MTITC	Ministry of Transport, Information Technologies and Communications
1.B Fugitive emissions	Energy balance (IEA - EUROSTAT – UNECE Energy Questionnaire)	NSI	National Statistical Institute
	National statistics	ME	Ministry of Energy
2. Industrial processes and product use	National production statistics	NSI	National Statistical Institute
	National registers (EPRTR and ETS)	ExEA	Executive Environment Agency
	National studies	MoEW /ExEA	Ministry of Environment and Water/ Executive Environment Agency
	National VOC register	ExEA	Executive Environment Agency
3. Agriculture	National agriculture statistics	MAFF	Ministry of Agriculture,

Sectors	Data Source of Activity Data	Activity Data supplier	
			Food and Forestry /Statistics Department
	Synthetic fertilizers	NSPP	National service for Plant Protection
4. LULUCF	National Forest Inventory	EFA	Executive Forest Agency
	National statistics of the balance of territory of Bulgaria	MAFF	Ministry of Agriculture, Food and Forestry
5. Waste	National statistics	NSI	National Statistical Institute
	National database	ExEA	Executive Environment Agency/ Waste Monitoring Department

Inventory preparation

The inventory preparation process covers:

- Identification key source categories[19];
- Prepare estimates[20] and ensure that appropriate methods are used to estimate emissions from key source categories;
- 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;
- Make a quantitative estimate of inventory uncertainty[21] for each source category and for the inventory in total recalculations[22] of previously submitted estimates of anthropogenic GHG emissions by sources and removals by sinks;
- Compile the national inventory in accordance with Article 7, paragraph 1, and relevant decisions of the COP and/or COP/MOP;
- Implement general inventory QC procedures (tier 1) in accordance with its QA/QC plan following the 2006 IPCC GL;
- Apply source category specific QC procedures[23] (tier 2) for key source categories and for those individual source categories in which significant methodological and/or data revisions have occurred;
- Collection of all data collected together with emission estimates in a database (see below), where data sources are well documented for future reconstruction of the inventory.

The Figure 4 presents the general responsibilities of all engaged institutions in functioning of Bulgarian National Inventory System.

The ExEA coordinates all activities on preparation of inventory under UNFCCC.

[19] following the methods described in the 2006 IPCC GL (chapter 4, section 4.2);

[20] in accordance with the methods described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

[21] following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

[22] prepared in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and relevant decisions of the COP and/or COP/MOP;

[23] in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

The Executive director of the ExEA through internal administrative order and based on the Regulation on the organization and structure of ExEA appoints sector experts for preparation of emission inventory in Energy, Industrial processes and products use, Agriculture, LULUCF and Waste.

The ExEA, agreed with the MoEW engages external consultants for preparation of tasks, which are out of competence of the Agency and are related with improvement of the inventory (see Table 10).

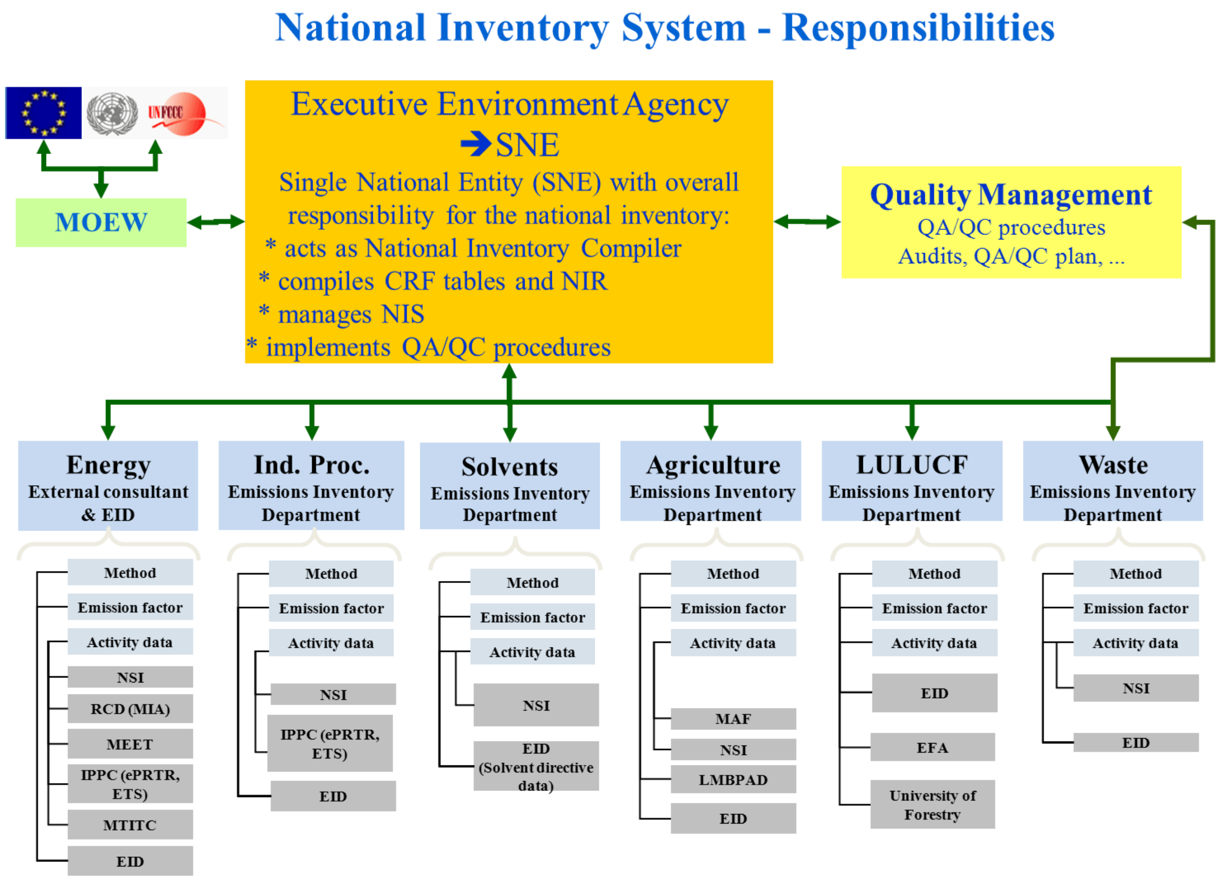

Figure 4 Bulgarian National Inventory System – Responsibilities

The following table presents the responsibilities of all engaged institutions for preparation of GHGs emission inventory for 2019 submission.

Table 2 Preparation of GHGs emission inventory for 2019 submission

Sector CRF	Activity data	Methodology and selection of emission factors	Preparation of Sector inventories
Energy CRF1A1 CRF1A2 CRF1A4	NSI	ExEA, NSI	Sector expert ExEA External consultants
Energy/Transport CRF1A3	NSI MI MTITC	ExEA, NSI MI, MTITC	Sector expert ExEA External consultants
Energy CRF1B	NSI ME	ExEA, NSI, ME	Sector expert ExEA External consultants

Sector CRF	Activity data	Methodology and selection of emission factors	Preparation of Sector inventories
Industry processes and product use CRF2	NSI	ExEA, NSI, Installations operators	Sector expert ExEA
	ExEA		
	MOEW		
	NSI		
	ExEA		
Agriculture CRF3	MAFF	ExEA, MAFF	Sector expert ExEA
	NSPP		
LULUCF CRF4	EAF	ExEA, EAF	Sector expert ExEA
	MAFF		
Waste CRF5	NSI	ExEA, NSI	Sector expert ExEA
	ExEA		

The National Inventory Compiler compiles the national GHGs inventory (CRF-tables and NIR) for the submission under the UNFCCC.

Documentation and data archiving

In August 2010 a new system for sector expert workflow organization, inventory documentation and data archiving has been implemented in the ExEA.

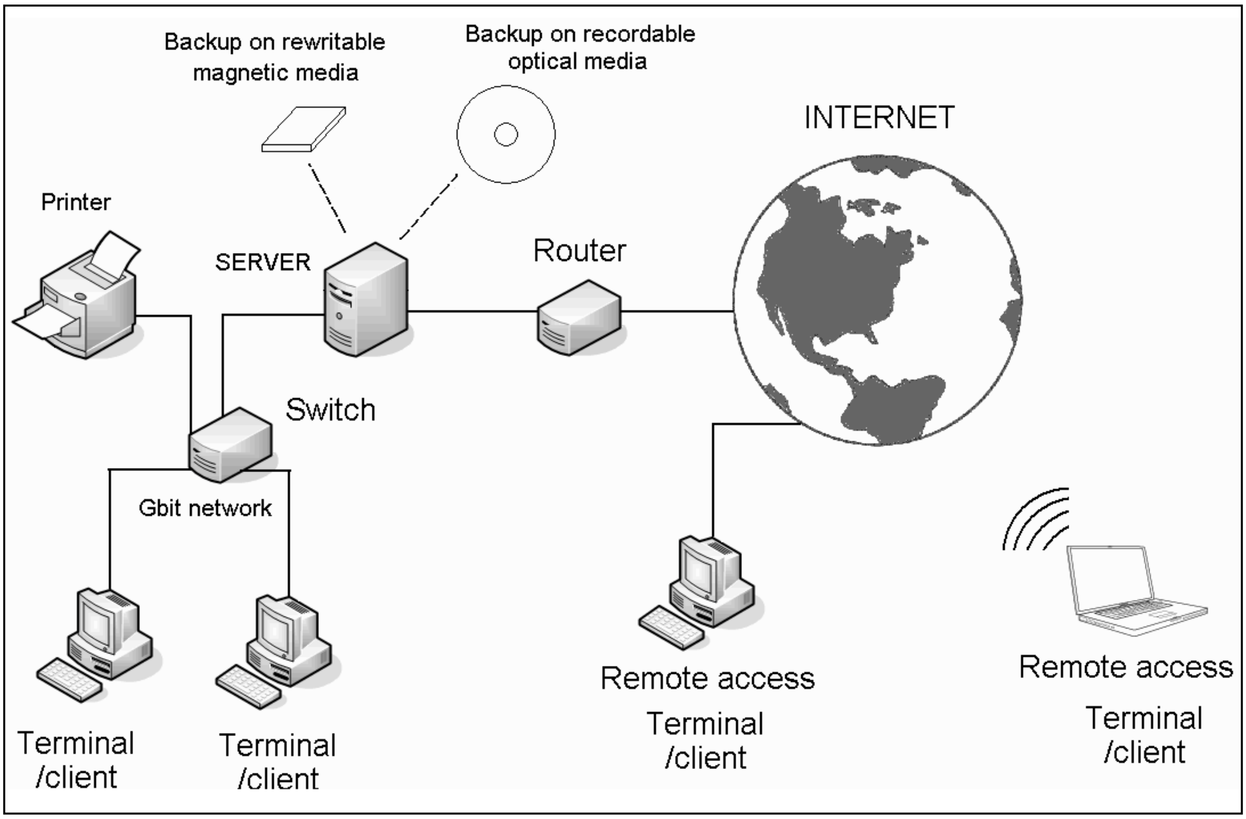

Figure 5 Documentation and data archiving in ExEA

1.3.1 QUALITY ASSURANCE, QUALITY CONTROL AND VERIFICATION

Fulfilment of paragraph 12(d)

As it is written above the Executive Environment Agency is responsible for the preparation of the GHGs Emission Inventory and the relevant National Inventory Reports under UNFCCC.

The ExEA is also responsible for coordination and implementation of QA/QC activities for the national inventory. A quality manger is in place.

The Bulgarian Quality Management System was established in the frame of project with Bulgarian Academy of Science, Geophysical Institute. The project was carried out and finished in 2008.

The QA/QC plan is an internal document to organise, plan and implement QA/QC activities. Once developed for the next submission, it is referenced and used in subsequent inventory preparation, or modified as appropriate.

The QA/QC plan has been updated in 2014 in order to implement the new established legal, institutional and procedural arrangements within the BGNIS. The updated National QA/QC Plan was approved by the Ministry of Environment and Water in December 2014.

National QA/QC Plan includes following elements:

- Responsible institutions;
- Data collection;
- Preparation of inventory;
- Category-specific QC procedures;
- QA and review procedures;
- Uncertainty analyses;
- Organisation of the activities in quality management system;
- Verification activities;
- Reporting, documentation and archiving.

<table>
<tr><th>does NOT require knowledge of the emission source category</th><th>requires knowledge of the emission source category</th><th rowspan="2"></th></tr>
<tr><th>general</th><th>source specific</th></tr>
<tr><td colspan="2">QC procedures
sector experts (1st party)
performed throughout preparation of inventory</td><td rowspan="7">must</td></tr>
<tr><td>TIER 1</td><td>TIER 2</td></tr>
<tr><td>data validation, calculation sheet
(check of formal aspects)</td><td>preparation of NIR, comparison with Guidelines
(check of applicability, comparisons)</td></tr>
<tr><td colspan="2">QA procedures
quality manager (2nd or 3rd party; staff not directly involved, preferably independent)
performed after inventory work has finished</td></tr>
<tr><td colspan="2">TIER 1
basic, before submission</td></tr>
<tr><td></td><td>MOEW experts
Internal audit / EU 'Initial check'
(Expert Peer Review)</td></tr>
<tr><td></td><td>evaluate if TIER2 QC is effectively performed (check if methodologies are applicable)</td></tr>
<tr><td colspan="2">TIER 2
extensive</td><td></td></tr>
<tr><td>System audit (Audit)</td><td>ICR by UNFCCC (Expert Peer Review)</td><td></td></tr>
<tr><td>evaluate if TIER 2 QC is effectively performed</td><td>evaluate if TIER 2 QC is effectively performed
(Check if methodologies are applicable)</td><td></td></tr>
</table>

Figure 6 National quality assurance and quality control program

The legal and institutional arrangements within the BGNIS regulate the responsibilities of all engaged institutions for implementation of the requirements of the National QA/QC Plan.

The QC procedures are performed by the sectors, who are directly involved in the process of preparation of inventory with their specific responsibilities.

The QC procedures are implemented by all activity data provider and ExEA's sector experts (Order № 296/04.12.2015 by the Executive Director of ExEA) and/or external consultants.

Table 3 QC experts within the BGNIS

Responsibility	QC experts
Activity data	MAFF, MI, MTITC, ME, NSI, EAF, ExEA, MOEW
Methodology and selection of emission factors	ExEA, MAFF, MI, MTITC, ME, NSI, EAF, MOEW
Sector inventories preparation	Sector experts ExEA and/or external consultants

The QC experts are:

- experts, responsible for activity data provision;
- experts, involved in the choice of method and selection of emission factors;
- sector experts and/or consultants, who prepare the sector inventories, including preparation of reporting tables and respective chapters from the national reports;

All institutions, engaged in the functioning of BGNIS are responsible for quality of information, which are provided by their competence to the ExEA for preparation of national emission inventories. The institutions are obligated to implement all requirements of the international and national standards for collection, processing and provision of activity data from them competence.

Quality Assurance (QA) is a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. The quality assurance process includes expert review was conducted in two stages: a review of the initial set of emission estimates and, a review of the estimates and text of the Inventory Report.

QA experts could be:

- Sector experts from the MoEW, which are engaged through internal administrative order by the minister of environment and water ;
- Experts from research institutes in accordance with them competence;
- Other external reviewer (national and/or international).

The QA procedures include the following checks in accordance with FCCC/SBSTA/2006/9:

Transparency means that the data sources, assumptions and methodologies used for an inventory should be clearly explained, in order to facilitate the replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of the information. The use of the common reporting format (CRF) tables and the preparation of a structured national inventory report (NIR) contribute to the transparency of the information and facilitate national and international reviews;

Accuracy means that emission and removal estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies should be used, in accordance with the 2006 IPCC Guidelines, to promote accuracy in inventories;

Consistency means that an annual GHG inventory should be internally consistent for all reported years in all its elements across sectors, categories and gases. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. Under certain circumstances referred to in paragraphs 16 to 18 below, an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner, in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories;

Comparability means that estimates of emissions and removals reported by Annex I Parties in their inventories should be comparable among Annex I Parties. For that purpose, Annex I Parties should use the methodologies and formats agreed by the COP for making estimations and reporting their inventories. The allocation of different source/sink categories should follow the CRF tables provided in annex II to decision 24/CP.19 at the level of the summary and sectoral tables;

Completeness means that an annual GHG inventory covers at least all sources and sinks, as well as all gases, for which methodologies are provided in the 2006 IPCC Guidelines or for which supplementary methodologies have been agreed by the COP. Completeness also means the full geographical coverage of the sources and sinks of an Annex I Party.

For 2017 submission the QA procedures are implemented by sector experts within the MoEW and experts from the ExEA, who are not directly involved in the preparation of inventory (Order № RD-218/05.03.2010 by the minister) or external reviewers.

The expert peer review present opportunity to uncover technical issues related to the application of methodologies, selection of activity data, or the development and choice of emission factors. The comments received during these processes are reviewed and, as appropriate, incorporated into the National Inventory Report or reflected in the inventory estimates.

The project for "Improvement of National Quality Management System for GHG Inventories" in 2011-2012 can be seen as expert peer review.

Information of the QA/QC activities

According to the 2006 IPCC GL the QA/QC system, that should be implemented for GHG Inventories consists of an inventory agency responsible for coordinating QA/QC activities, a QA/QC plan, general QC procedures (Tier 1), source category-specific QC procedures (Tier 2), QA review procedures and verifications as well as procedures regarding reporting, documentation and archiving.

The QA/QC plan is a basic element of the QA/QC system. The plan outlines QA/QC activities that are implemented and includes the scheduled time frame for inventory preparation from its initial development through the final reporting in any year. It contains an outline of the processes and schedule to review of all source categories.

The QA/QC plan is an internal document to organise, plan and implement QA/QC activities. Once developed for the next submission, it is referenced and used in subsequent inventory preparation, or modified as appropriate.

The main parts of the National QA/QC Plan for emissions inventories are presented in the next table:

Table 4 Comparison of 2006 IPCC GL and ISO 9001

	2006 IPCC GL	ISO 9001
1. Scope	✓	✓
2. Definitions	✓	✓
3. Administrative requirements	✓	✓
4. Organisation and management	✓	✓
5. Quality system	✓	✓
6. Personnel	✓	✓

	2006 IPCC GL	ISO 9001
7. Facilities and equipment	✓	✓
8. Handling of inspection samples and items	✓	✓
9. Records	✓	✓
10. Reports	✓	✓
11. Sub-contracting	✓	✓
12. Complaints and appeals	✓	✓

The cycle of QA/QC activity for inventory consists of the following steps:

The QA/QC Manager prepares a Plan for implementation of QA/QC activities for the current submission. The check list with all specific QA/QC procedures are part of the plan;

The plan for QA/QC is sent to all engaged QC and QA experts for implementation;

In the process of preparation of inventory the QC experts (activity data provider and ExEA's sector experts) apply each of the specific procedures set in the check list for each of the sources categories they are responsible for.

The QA/QC Manager coordinate the exchange of the check lists between the QC experts for correction of the findings with input data for calculation of emissions (activity data and EF).

The QA/QC Manager send to the QA experts the prepared by ExEA's sector expert and/or external consultants CRF tables and respective chapters from NIR;

The QA/QC Manager coordinate the exchange of the check lists between the QA experts and ExEA's sector expert and/or external consultants for correction of the findings with quality of the inventory (CRF and NIR);

The QA/QC Manager prepares a summary of the results from implemented QA/QC checks.

The QA/QC Manager prepares an attendant file for implemented procedures;

The QA/QC Manager prepares a report to the executive director of the ExEA for results of the performed QA/QC procedures and improvement plan for the next reporting round;

The QA/QC Manager is responsible for documentation and archiving of all documents, related to performed QA/QC procedures in the national System for documentation and archiving of inventory in ExEA.

QA/QC activities of data provider

The QA/QC Plan is provided for implementation to all institutions, which are engaged in the process of preparation of emissions inventories under UNFCCC as provision of the relevant activity data.

Based on the National QA/QC Plan each of the institutions has nominated experts, responsible for preparation of the required information as well as for implementation of QA/QC procedures.

The QC experts are all experts from the institutions, who are engaged to participate in the activity of BGNIS and to implement the requirements of National QA/QC Plan

All institutions, engaged in the functioning of BGNIS are responsible for quality of information, which are provided by their competence to the ExEA for preparation of national emission inventories. The institutions are obligated to implement all requirements of the international and national standards for collection, processing and provision of activity data from them competence.

The QC experts fill in a check-list, which is an annex to the National QA/QC plan. The QC experts fill the check-list for the sector they are responsible for and in the part "Review of input data for calculation of emissions", "Activity data" and/or "Method and EF".

The check list contains all general and specific procedures for QC. It consist information for carried out review by the QC experts, including findings and corrections made.

The check lists are filled in by QC experts in accordance with them responsibilities and for each category (CRF).

The check lists are exchange between QC experts for correction of the findings with input data for calculation of emissions in the respective sectors.

Table 5 Responsibilities in the exchange of check lists between QC experts for 2019 submission

Sector CRF	Activity data		Methodology/ emission factors		Emission calculations	
	Check	**Correction**	**Check**	**Correction**	**Check**	**Correction**
Energy CRF1	ExEA NSI ME external consultant	NSI ME	ExEA NSI ME	external consultant	ExEA NSI ME	external consultant
Transport CRF1A3	ExEA NSI MI MTITC external consultant	MTITC MI NSI	ExEA NSI MI MTITC	ExEA external consultant	ExEA NSI MI MTITC	Sector expert ExEA and external consultant
Industry processes and product use CRF2	NSI ExEA	NSI ExEA	NSI ExEA	ExEA	NSI ExEA	Sector expert ExEA
Agriculture CRF3	ExEA MAFF	MAFF	ExEA MAFF	ExEA	ExEA MAFF	Sector expert ExEA
LULUCF CRF4	ExEA EAF	EAF	ExEA EAF	ExEA	ExEA EAF	Sector expert ExEA
Waste CRF5	NSI ExEA	NSI ExEA	NSI ExEA	ExEA	NSI ExEA	Sector expert ExEA

General (QC) procedures are described in Checklists that is part of QA/QC Plan.

As it is written above for 2019 submission the QA procedures are implemented by sector experts within the MoEW and experts from the ExEA, who are not directly involved in the preparation of inventory (Order № RD-218/05.03.2010 by the minister) or external reviewers

The QA experts fill a check list in the part "Review of reporting tables and National report" in the sector of them competence.

The check list contains all general and specific procedures for QA. It consist information for carried out review by the QA experts, including findings and corrections made.

The check lists are filled out by QA experts in accordance with them responsibilities for each category (CRF).

The check lists are exchanged between QA experts and sector expert in ExEA and/or external consultant for correction of the findings with reporting tables and respective chapters from national reports.

Table 6 Responsibilities in exchange of the check lists between QA experts and sector experts for 2019 submission

Sector - CRF	Reporting Tables - CRF		National Report - NIR	
	Check	Correction	Check	Correction
Energy CRF1	MOEW ExEA	external consultant	MOEW ExEA	external consultant
Industry processes and product use CRF2	MOEW ExEA	Sector expert ExEA	MOEW ExEA	Sector expert ExEA
Agriculture CRF3	MOEW ExEA and/or external auditor	Sector expert ExEA	MOEW ExEA and/or external consultant	Sector expert ExEA
LULUCF CRF4	MOEW ExEA	Sector expert ExEA	MOEW ExEA	Sector expert ExEA
Waste CRF5	MOEW ExEA	Sector expert ExEA	MOEW ExEA	Sector expert ExEA

Quality management of the sources of initial data

Each organization – data source, solves the quality management issues in accordance with its internal rules and provisions. With some of the sources as NSI, MAFF, etc., those rules follow strictly the international practices. For example, quality assessment/quality control procedures with NSI have been harmonized with the relevant instructions and provisions of EUROSTAT. Strict rules on data processing and storage, harmonized with international organizations. Some of the large enterprises – GHG emission sources, have well arranged and effective quality management systems. Most of them have introduced quality management systems on the basis of ISO 9001:2000 standard.

Fulfilment of paragraph 12(e)

Official consideration and approval of the inventory

Bulgaria's reporting obligations to the UNFCCC, UNECE and EC are being administered by the MoEW. All activities on preparation of GHG inventory in Bulgaria are coordinated and managed on the state level by MoEW. The ExEA is the responsible organization for preparation of Bulgaria's National GHG Inventory under the UNFCCC and the Kyoto Protocol and designated as single national entity (see Figure 1 Organizational Chart of the Bulgarian National Inventory System).

Quality improvement

Fulfilment of paragraph 13

Since November 2011, a project for **"Improvement of National Quality Management System for GHG Inventories"** had been started together with the Austrian Environmental Agency. The project is funded by the **German Federal Ministry for the Environment, Nature Conservation and Nuclear**

Safety and **German Federal Environment Agency** with means of the Advisory Assistance Programme for Environmental Protection in the Countries of Central and Eastern Europe, the Caucasus and Central Asia.

The objectives of the project are:

Third-party audit[24] of the current QMS according to ISO 19011 Guidelines for quality and/or environmental management system auditing (and ISO 17020 General criteria for the operation of various types of bodies performing inspection):

- To analyze/review the current QMS (in accordance with the IPCC GPG)
    1. system audit
    2. procedures audit
- Identification of improvements
    1. QMS Manual
    2. Quality Policy
    3. Roles and responsibilities
    4. QC activities
    5. Quality assurance (QA) activities
    6. Documentation and archiving System within NIS.
    7. Development of Procedures and Checklists
    8. Improvement plan for the QMS and GHG Inventory
- Proposal on implementation of the improvements
- Training of the quality manager and the sectoral experts (within the QMS) according to 2006 IPCC GL Chapter 6 and following the ISO 9000 standards

The outcome of the project is development of an efficient and optimal aligned QMS, that fulfils every quality requirement of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Chap. 6).

WORK PLAN FOR SUBMISSION 2020

Fulfilment of Para 16(a) (b) (c) and 17 Inventory management

The next table presents the responsibilities of all engaged institutions for preparation of GHGs emission inventory for 2020 submission.

[24] Audits are used to determine the extent to which the quality management system requirements are fulfilled. Audit findings are used to assess the effectiveness of the quality management system and to identify opportunities for improvement.

- First-party audits are conducted by, or on behalf of, the organization itself for internal purposes and can form the basis for an organization's self-declaration of conformity.
- Second-party audits are conducted by customers of the organization or by other persons on behalf of the customer.
- Third-party audits are conducted by external independent organizations.

Such organizations, usually accredited, provide certification or registration of conformity with requirements such as those of ISO 9001.

ISO 19011 provides guidance on auditing.

Table 7 Preparation of GHGs emission inventory for 2020 submission

Sector CRF	Activity data	Methodology and selection of emission factors	Preparation of Sector inventories
Energy CRF1A1 CRF1A2 CRF1A4	NSI	ExEA, NSI	External consultant
Energy/Transport CRF1A3	NSI	ExEA, NSI MI, MTITC	External consultant
	MI		
	MTITC		
Energy CRF1B	NSI	ExEA, NSI, ME	External consultant
	MEE		
Industry processes and product use CRF2	NSI	ExEA, NSI, Installations operators	Sector expert ExEA
	ExEA		
	MOEW		
	ExEA		
Agriculture CRF3	MAF	ExEA, MAF	Sector expert ExEA
	NSPP		
LULUCF CRF4	EAF	ExEA, EAF	Sector expert ExEA
	MAFF		
Waste CRF5	NSI	ExEA, NSI	Sector expert ExEA
	ExEA		

The Work plan for preparation and submission of National GHGs inventory in 2020 is presented in the next table.

Table 8 Work plan for GHGs inventory preparation and submission 2020

Action	Responsible organization	Initial Deadline	Final Deadline	Comment
Sending of statistic questionnaire to all enterprises in the country	NSI with its regional inspectorates	31.03.19	15.06.19	NSI uses statistical methods and procedures for data collection, summarizing and structuring that are harmonized with EUROSTAT
Sending of letters to the responsible organizations for provision of necessary activity data.	ExEA	31.03.19	15.06.19	
QA/QC Procedures - Implementation of the requirements of National QA/QC Plan.	NSI MAFF, ME, MEW, SFA, RCD	15.06.19	30.09.19	National QA/QC Plan
Provision of all collected activity	NSI	30.09.19	30.10.19	

Action	Responsible organization	Initial Deadline	Final Deadline	Comment
data by questionnaires and other sources of information to ExEA	MAFF, ME, MEW, EFA, MIA			
QA/QC Procedures - Implementation of the requirements of National QA/QC Plan	ExEA	30.10.19	15.11.19	QA/QC expert, responsible for implementation of all procedures laid down in the National QA/QC Plan
Provision of annual national energy and material balances to ExEA	NSI		30.11.19	
Preliminary estimation of emissions	ExEA, external consultants		15.12.19	
Provision of corrected activity data as a result of QA/QC procedures to ExEA	NSI MAFF, ME, MEW, EFA, MIA		20.12.19	
Recalculation of emissions, based on the corrected activity data of inventory in the required format for reporting	ExEA and external consultant		31.12.19	
Preparation of Preliminary national inventory report (NIR) to the EC.	ExEA		10.01.20	
Submission of national GHG inventory under the RMM with the short NIR.	ExEA		15.01.20	Delivered to Eionet Central Data Repository
Submission of final national GHG inventory and NIR.	ExEA		15.03.20	Delivered to Eionet Central Data Repository
Submission of the final GHG inventory and NIR after the European Commission comments	MEW ExEA		15.04.20	Official submission to UNFCCC Delivered to Eionet Central Data Repository
Documentation and archiving of inventory. Preparation of inventory management report	ExEA		15.05.20	
Preparation of QA/QC plan for the next inventory.	ExEA		15.06.20	

Fulfilment of Para 14(d) Make a quantitative estimate of inventory uncertainty for each source category and for the inventory in total, following the 2006 IPCC Guidelines

As a whole, the uncertainty assessment of the GHG inventories follows the methodology of the 2006 IPCC Guidelines. The overall uncertainty is closely related to the GHG emission sources data uncertainty (fuels, activities, processes, etc.) and to the emission factor uncertainty.

The uncertainties for all the emission sources (key and non-key) and emission factors are presented in Chapter 1.3.

Fulfilment of Para 15. As part of its inventory preparation, each Party included in Annex I should:

(a) Apply source-category-specific QC procedures (tier 2) for key source categories and for those individual source categories in which significant methodological and/or data revisions have occurred, in accordance with the IPCC good practice guidance;

(b) Provide for a basic review of the inventory by personnel that have not been involved in the inventory development, preferably an independent third party, before the submission of the inventory, in accordance with the planned QA procedures referred to in paragraph 12 (d) above;

(c) Provide for a more extensive review of the inventory for key source categories, as well as source categories where significant changes in methods or data have been made;

(d) Based on the reviews described in paragraph 15 (b) and (c) above and periodic internal evaluations of the inventory preparation process, re-evaluate the inventory planning process in order to meet the established quality objectives referred to in paragraph 12 (d).

VERIFICATION ACTIVITIES

Emission and activity data are verified by comparing them with other available data compiled independently of the GHG inventory system. These include data from research projects and other obligations for other purposes but producing information relevant to the inventory preparation. Verification activities that have been undertaken are described in the category-specific chapters.

TREATMENT OF CONFIDENTIALITY ISSUES

ExEA ensures confidentiality of sensitive information that is data declared as confidential obtained in the course of preparing the national GHG inventory. ExEA is a member of the National Statistics Institute (NSI).

Confidentiality of statistics: The strict confidentiality provisions concerning handling of sensitive data relating to individuals and organisations are regulated by the Statistics Law.

Security of data: Confidentiality of sensitive data used to calculate the emissions is a legal obligation.

Furthermore a checklist with the following items is elaborated:

Outlines what information is to be treated as confidential;

Identify sectoral expert who is dealing with the information;

Identify the use to which the information can be put;

Specify the publishment of confidentiality data on an aggregated level.

1.4 BRIEF GENERAL DESCRIPTION OF METHODOLOGIES (INCLUDING TIERS USED) AND DATA SOURCES USED

Fulfilment of Para 14(b) (c) (e) (f)

The most recent greenhouse gas inventory for the period 1988 to 2017 (NIR 2019) was compiled according to the recommendations for inventories set out in the UNFCCC reporting guidelines according to Decision 24/CP.19, the Common Reporting Format (CRF) and the 2006 IPCC Guidelines.

The GHG inventory represents a process, covering the following main activities:

- Collecting, processing and assessment of input data on used fuels, produced output, materials and other GHG emission sources;
- Selection and application of emission factors for estimating the emissions;
- Determination of the basic (key) GHG emission sources and assessment of the results uncertainty.

Each year during inventory, some changes occur that affect directly the activities above enlisted. Important inventory stage is the process of data transformation into a form, suitable for CRF Tables format. During this process, aggregation of the fuels by type is made (solid, liquid and gaseous), and further data is added, regarding parameters and indices, specifying the systems for transportation and distribution of oil and natural gas, the systems for fertilizer processing, etc. These activities are just a part of additional data, filled in the CRF Tables.

National Inventory Methodology

According to Clean Air Act, article 25 (6) The Minister of Environment and Water in co-ordination with the interested ministers issues an order for the approval of a Methodology for the calculation, with balance methods, of the emissions of harmful substances (pollutants), emitted in the ambient air. The national Methodology (approved with Order RD 77 from 03.02.2006 of MEW) is harmonized with CORINAIR methodology for calculation of the emissions according to the UNECE/LRTAP Convention.

During 2007, MEW/ExEA had a project for development of Common methodology for emissions inventory under UNECE/LRTAP Convention and UNFCCC, i.e. to update the present Methodology under article 25 (6) CAA. (Approved with Order RD 40 from 22.01.2008 of MEW). The aim of the project was harmonization of the national Methodology with IPCC, including the three main greenhouse gases – CO_2, CH_4 and N_2O (plus relevant ODS and SF_6).

The Bulgarian national GHGs inventory and NIR are compiled according to requirements of the following documents:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC GL)
- EMEP/EEA air pollutant emission inventory guidebook – 2016.

The emission factors are mainly from:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC GL)
- EMEP/EEA air pollutant emission inventory guidebook – 2016.
- Country-specific

The following tables summarise the 'Applied method' and 'Emission factor' of the inventory 2017, submission 2019.

Table 9 Methods and the emission factors applied (CO_2, CH_4, N_2O)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	T1,T2	CR,CS,D	OTH,T1,T2	CR,D,OTH	T1,T2	CR,D
A. Fuel combustion	T1,T2	CR,CS,D	T1,T2	CR,D	T1,T2	CR,D
1. Energy industries	T1,T2	CS,D	T1	D	T1	D
2. Manufacturing industries and construction	T1,T2	CS,D	T1	D	T1	D
3. Transport	T1,T2	CR,CS,D	T1,T2	CR,D	T1,T2	CR,D
4. Other sectors	T1,T2	CS,D	T1	D	T1	D
5. Other	NA	NA	NA	NA	NA	NA
B. Fugitive emissions from fuels	T1	D	OTH,T1	D,OTH	T1	D
1. Solid fuels	NA	NA	OTH,T1	D,OTH	NA	NA
2. Oil and natural gas	T1	D	T1	D	T1	D
C. CO_2 transport and storage	NA	NA				
2. Industrial Processes	D,T1,T2	CR,CS,D,PS	NA	NA	T1,T3	CS,D,PS
A. Mineral industry	T1,T2	CS,D,PS	NA	NA	NA	NA
B. Chemical industry	T2	CS,PS	NA	NA	T3	PS
C. Metal industry	T1,T2	CS,D,PS	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
D. Non-energy products from fuels and solvent use	T1,T2	CR,D	NA	NA	NA	NA
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	T1	D	NA	NA	T1	CS,D
H. Other	D	D	NA	NA	NA	NA
3. Agriculture	T1	D	D,T1,T2	CS,D	D,T1,T2	D
A. Enteric fermentation			T1,T2	CS,D		
B. Manure management			T1,T2	CS,D	T1,T2	D
C. Rice cultivation			T1	D		
D. Agricultural soils(3)					T1,T2	D
E. Prescribed burning of savannas			NA	NA	NA	NA
F. Field burning of agricultural residues			D	D	D	D
G. Liming	NA	NA				
H. Urea application	T1	D				
I. Other carbon-containing fertilizers	NA	NA				
J. Other	NA	NA	NA	NA	NA	NA
4. LULUCF	T1,T2,T3	CS,D	T1	D	T1	D
A. Forest land	T1,T2,T3	CS,D	T1	D	T1	D
B. Cropland	T1,T2	CS,D	NA	NA	T1	D
C. Grassland	T1,T2	CS,D	NA	NA	NA	NA
D. Wetlands	T1	D	NA	NA	T1	D
E. Settlements	T1,T2	CS,D	NA	NA	T1	D
F. Other land	T2	CS	NA	NA	T1	D
G. Harvested wood products	T2	D				
H. Other	NA	NA	NA	NA	NA	NA
5. Waste	T1	D	T1,T2	CS,D	T1	D
A. Solid waste disposal	NA	NA	T2	CS,D		
B. Biological treatment of solid waste			T1	D	T1	D
C. Incineration and open burning of waste	T1	D	T1	D	T1	D
D. Waste water treatment and discharge			T2	D	T1	D
E. Other	NA	NA	NA	NA	NA	NA
7. Other (specified in Summary 1.A)	NA	NA	NA	NA	NA	NA

Table 10 Methods and the emission factors applied: HFCs, PFCs, SF_6

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	HFCs		PFCs		SF_6		NF_3	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
2. Industrial processes	NO,T2	D,NO	NO,T2	D,NO	NO,T2	D,NO	NO	NO
A. Mineral industry								
B. Chemical industry								
C. Metal industry								
D. Non-energy products from fuels and solvent use								
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	NO,T2	D,NO	NO,T2	D,NO	NO	NO	NO	NO
G. Other product manufacture and use	NO	NO	NO	NO	NO,T2	D,NO	NO	NO
H. Other								

The following notation keys were used to specify the method applied:		
D (IPCC default)	**T1a, T1b, T1c** (IPCC Tier 1a, Tier 1b and Tier 1c, respectively)	**CR** (CORINAIR)

RA (Reference Approach)	**T2** (IPCC Tier 2)	**CS** (Country Specific)
T1 (IPCC Tier 1)	**T3** (IPCC Tier 3)	**OTH** (Other)
If using more than one method within one source category, list all the relevant methods. Explanations regarding country-specific methods, other methods or any modifications to the default IPCC methods, as well as information regarding the use of different methods per source category where more than one method is indicated, should be provided in the documentation box. Also use the documentation box to explain the use of notation OTH.		
Use the following notation keys to specify the emission factor used:		
D (IPCC default)	**CS** (Country Specific)	**OTH** (Other)
CR (CORINAIR)	**PS** (Plant Specific)	

1.5 BRIEF DESCRIPTION OF KEY CATEGORIES

Fulfilment of paragraph 14(a)

The key category analysis follows the Approach 1 and Approach 2 is performed according to the 2006 IPCC Guidelines (IPCC 2006, chapter 4).

According to method of the Approach 2 assessment of the key sources is made by identifying the uncertainty of each source. The uncertainty is the combined uncertainty of the assessment, which is a mean quadratic assessment of the uncertainty of the data and of the emission factors.

The key source identification of the Bulgarian inventory includes all reported greenhouse gases CO_2, CH_4, N_2O, HFC, PFC, NF_3 and SF_6, and all IPCC source categories, including LULUCF. The key source analysis is performed by the ExEA with data for greenhouse gas emissions of the corresponding current submission and comprises a level assessment for all years between 1988 and the last reported year and trend assessments for the trend of the latest reported years with respect to base year emissions.

Emissions and removals from LULUCF are included in the key category analysis which is performed according to the 2006 IPCC Guidelines.

The key category analysis is used to prioritize improvements that should be taken into account for the next inventory submissions. First of all, it is important that emissions of key categories, being the most significant in terms of absolute weight and/or combined uncertainty, are estimated with a high level of accuracy.

The Key Category analysis Approach 1 and Approach 2 method including and excluding LULUCF is provided in Annex 1.

1.6 GENERAL UNCERTAINTY EVALUATION, INCLUDING DATA ON THE OVERALL UNCERTAINTY FOR THE INVENTORY TOTALS

This section provides an overview of the approach to uncertainty analysis adopted for the Bulgarian inventory. The mandatory, detailed reporting table of the analysis for all the emission sources (key and non-key) and emission factors is provided in as Approach 1 Uncertainty calculation and reporting'.

The present approach consists of two levels: screening and detailed analysis. Screening is done with Approach 1 uncertainty analysis. The key categories are discussed with the sectoral experts during the annual quality meetings.

Separate uncertainty calculation was performed using a spreadsheet prepared specifically according to the Approach 1 (2006 IPCC GL).

GHG INVENTORY

As a whole, the uncertainty assessment of the GHG inventories follows the methodology of the 2006 IPCC GL.

The overall uncertainty is closely related to the GHG emission sources data uncertainty (fuels, activities, processes, etc.) and to the emission factor uncertainty.

The uncertainty of the GHG emission sources can be defined during data collection and processing and it is a part of procedures, applied by the statistical authorities, differences between the production, import, export and consumption of fuels, expert assessment, etc.

The uncertainty of emission factors depends on the origin of the factors applied. In case the emission factors result from direct periodical measurements, the uncertainty is determined by the relevant methodology, related to the measuring methods and apparatuses.

The overall uncertainty of the GHG inventory is determined by combining the emission sources uncertainty and the emission factors uncertainty.

Two rules are applied in this process:

Rule A - combination of the uncertainty by summing;

Rule B - combination of the uncertainty by multiplying.

Since the GHG inventories are sums of the products of emission sources, multiplied by emission factors, the two rules above can be used for determining the overall uncertainty of the inventory.

Rules A and B represent the foundation of the Approach 1 method, recommended in the IPCC Guidance.

The uncertainties for all the emission sources (key and non-key) and emission factors are presented in Table 11.

Combined uncertainty as a part of overall emissions for 2015 for every source has been calculated as following equation:

$$\mathbf{MCU_i = (EM_i/EM_{total})x\ CU_i}$$

where MCUi – measured combined uncertainty,

EM_i - source emissions for 2017,

EM_{total} – total country emissions for 2017,

CN_i – combined uncertainty of the i-th source.

Uncertainty of the overall emissions trend for 2017 for every source has been calculated as HTi – overall emissions trend uncertainty brought in by the i-th source. This uncertainty calculates in column M of Table 3.2 of p.3.31 of the 2006 IPCC GL.

The calculated uncertainties, in %, of the overall national GHG emissions for the year 2017 (row 7, column H in Table 3.2 of the 2006 IPCC GL), and the overall emission trend related to the base inventory year until 2017 (row 7, column M in Table 6.1.) are given in Table 11. The relevant data for the previous inventory for 2016 are given for comparison (NIR 2018 and NIR 2019).

Table 11 Uncertainty in total GHG emissions, %

Uncertainty	Uncertainty NIR 2018	Uncertainty NIR 2019
Uncertainty in total GHG emissions	14.89 %	14.51 %
Overall uncertainty into the trend in total GHG emissions	2.33	2.38

The respective sectoral uncertainties are documented in detail in the sectoral chapters of this report. The complete uncertainty information and other background information are presented in Annex 2.

1.7 GENERAL ASSESSMENT OF THE COMPLETENESS

GHG INVENTORY

Completeness by source and sink categories and gases

Bulgaria has provided estimates for all significant IPCC source and sink categories according to the detailed CRF classification. Estimates are provided for the following gases: CO_2, N_2O CH_4, F-gases (HFC, PFC, NF_3 and SF_6), NMVOC, NOx, CO and SO_2. In accordance with the IPCC Guidelines, international aviation and marine bunker fuel emissions are not included in national totals. However, CO_2, CH_4 and N_2O emissions from lubricants from International bunkers are included in emissions from feedstock and non-energy use of the fuels. Lubricants are not split between domestic and international, as only information on total sales of lubricants is available in fuel statistics.

CRF - Table 9 (Completeness) has been used to give information regarding completeness. An assessment of completeness for each sector is given in the Sector Overview part of the corresponding subchapters.

All sources and sinks included in the IPCC Guidelines are addressed. No additional sources and sinks specific to Bulgaria have been identified.

Completeness by geographical coverage

The geographic coverage is complete. There is no part of the Bulgarian territory not covered by the national inventory.

Completeness by timely coverage

A complete set of CRF tables are provided for all years and the estimates are calculated in a consistent manner.

Notation keys

The sources and sinks not considered in the inventory but included in the IPCC Guidelines are indicated, the reasons for such exclusion are explained. In addition, the notation keys presented below are used to fill in the blanks in all the tables in the CRF. Notation keys used in the NIR are consistent with those reported in the CRF. Notation keys are used according to the UNFCCC guidelines (UNFCCC 2014).

Allocations to categories may differ from Party to Party. The main reasons for different category allocations are different allocations in national statistics, insufficient information on the national statistics, national methods, and the impossibility to disaggregate emission declarations.

IE (included elsewhere):

“IE” for emissions by sources and removals by sinks of GHGs estimated but included elsewhere in the inventory instead of under the expected source/sink category. Where “IE” is used in an inventory, the Annex I Party should indicate, in the CRF completeness table (Table 9), where in the inventory the emissions or removals for the displaced source/sink category have been included, and the Annex I Party should explain such a deviation from the inclusion under the expected category, especially if it is due to confidentiality. .

NE (not estimated):

“NE” for AD and/or emissions by sources and removals by sinks of GHGs which have not been estimated but for which a corresponding activity may occur within a Party.6 Where “NE” is used in an inventory to report emissions or removals of CO_2, N_2O, CH_4, HFCs, PFCs, SF_6 and NF_3, the Annex I Party shall indicate in both the NIR and the CRF completeness table why such emissions or removals have not been estimated. Furthermore, a Party may consider that a disproportionate amount of effort would be required to collect data for a gas from a specific category that would be insignificant in terms of the overall level and trend in national emissions and in such cases use the notation key “NE”. The Party should in the NIR provide justifications for exclusion in terms of the likely level of emissions. An emission should only be considered insignificant if the likely level of emissions is below 0.05 per cent of the national total GHG emissions and does not exceed 500 kt CO_2 eq. The total national aggregate of estimated emissions for all gases and categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions.9 Parties should use approximated AD and default IPCC EFs to derive a likely level of emissions for the respective category. Once emissions from a specific category have been reported in a previous submission, emissions from this specific category shall be reported in subsequent GHG inventory submissions.

NA (not applicable):

“NA” for activities under a given source/sink category that do occur within the Party but do not result in emissions or removals of a specific gas. If the cells for categories in the CRF tables for which “NA” is applicable are shaded, they do not need to be filled in.

“NO” (not occurring):

“NO” for categories or processes, including recovery, under a particular source or sink category that do not occur within an Annex I Party;

C (confidential):

“C” is used for emissions which could lead to the disclosure of confidential information if reported at the most disaggregated level. In this case a minimum of aggregation is required to protect business information.

KP-LULUCF INVENTORY

All activities according to Article 3.3 and 3.4 of the Kyoto Protocol are provided in the relevant chapter (see also Chapter 11).

2 TRENDS IN GREENHOUSE GAS EMISSIONS

Description and interpretation of emission trends for aggregated greenhouse gas emissions

In 2017 Bulgaria's greenhouse gas emissions totalled 61 367 Gg CO_2 without reporting of sequestration from LULUCF sector. The emissions decreased by 47.44 % compared with the base year. Emissions in 2017 were 3.9% increased in comparison with the emissions of the previous year.

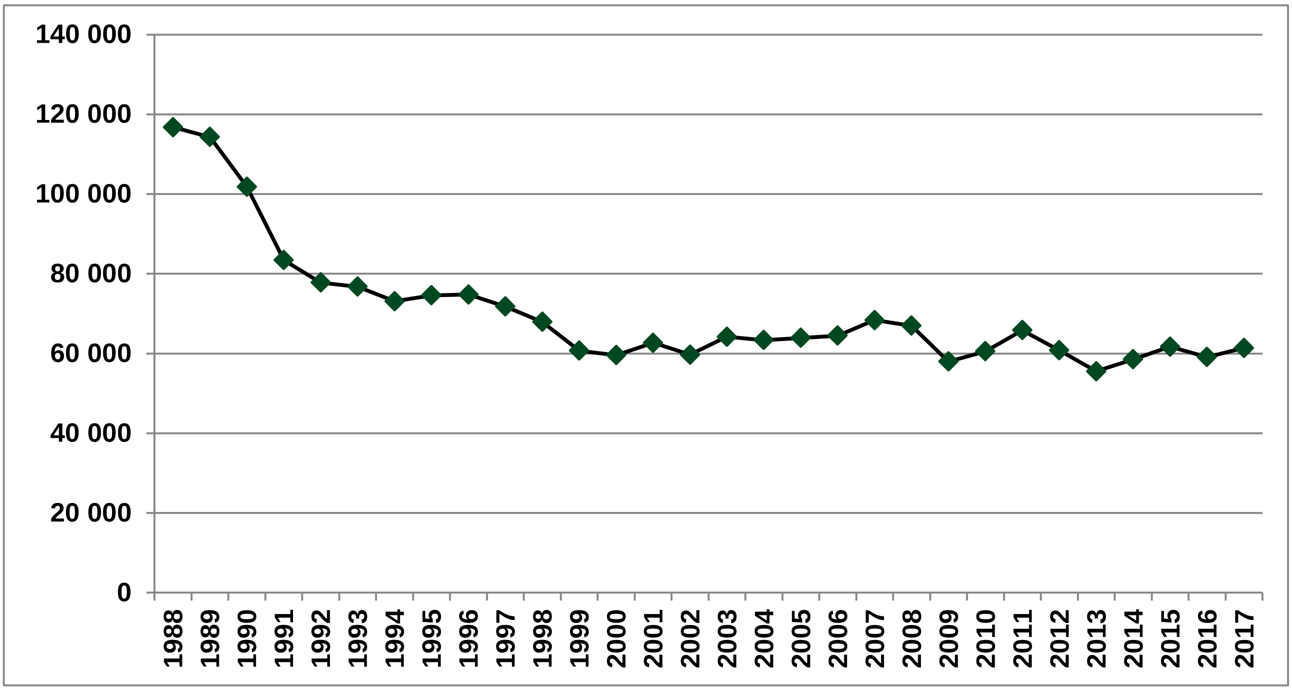

Figure 7 Total GHG emissions (without LULUCF) for 1988 – 2017, Gg CO_2 eq.

The net emissions including reporting of sequestration from LULUCF sector were 53 327 Gg CO_2 eq. The emissions decreased by 48.76 % compared with the base year.

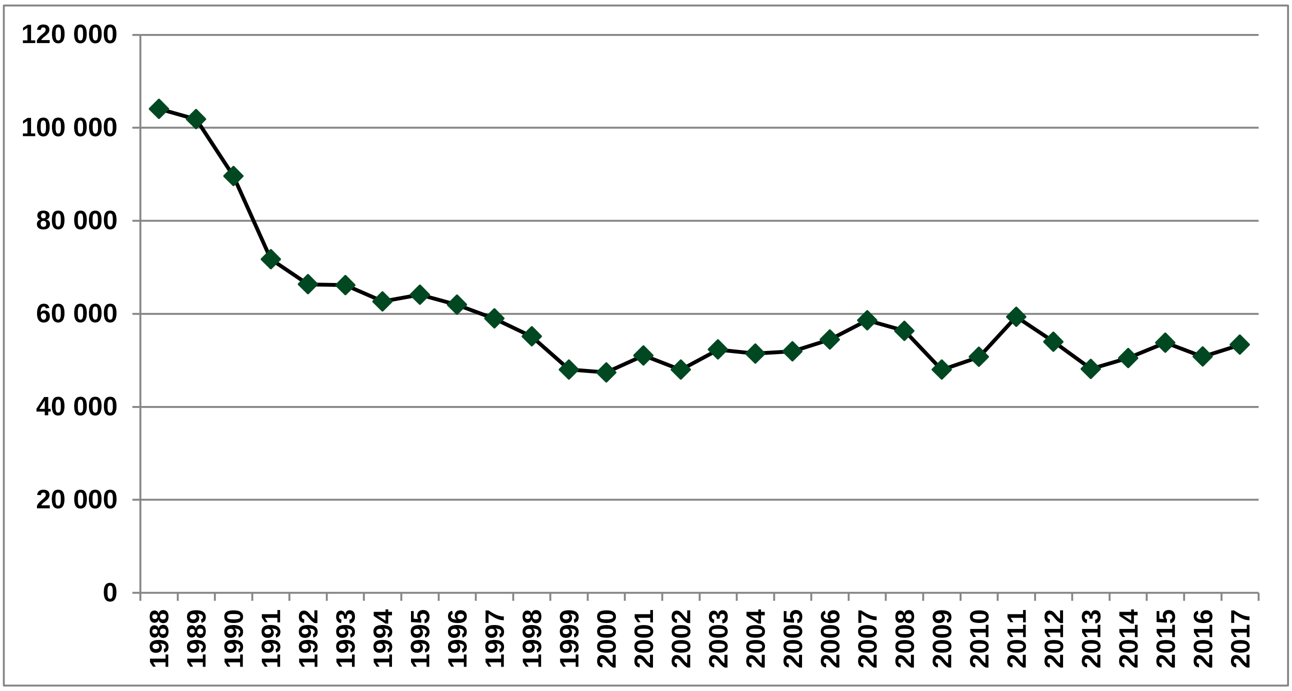

Figure 8 Total GHG emissions (with LULUCF) for 1988 – 2017, Gg CO_2 eq.

The main reasons for the declining GHG emission trend in Bulgaria are the structural economic changes due to the radical transition process from a centrally-planned economy to a market-based economy. This led to a decrease of power production from thermal power stations (and an increase of the shares of hydropower and nuclear power), structural changes in industry (including a decline in production by energy-intensive enterprises and energy - efficiency improvements), introduction of energy efficiency measures in the residential sector and a shift form solid and liquid fuels to natural gas in energy consumption. This also led to a decrease in GHG emissions from the agricultural sector stemming from the decline in the cattle and sheep populations and the use of fertilizers.

Bulgaria experienced a steady declining population trend during the period 1988-2017, which resulted in the reduction of population by 21.5%.

2.1 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GHG EMISSIONS

The most important greenhouse gas in Bulgaria is carbon dioxide. The share of CO_2 emissions from the total greenhouse gas emissions varies around 77.24% excluding LULUCF and 72.77% including LULUCF. In absolute terms CO_2 emissions have decreased 47% since 1988. Around 72.7% of total CO_2 eq emissions originate from the Energy sector. The amount of energy-related CO_2 emissions has fluctuated much according to the economic trend, the energy supply structure (including electricity exports) and climate conditions.

Methane emissions (CH_4) have decreased by 60% from the 1988 level. This is mainly due to the improvements in waste collection and treatment and a reduction in animal husbandry in the Agriculture sector. Correspondingly, emissions of nitrous oxide (N_2O) have also decreased by 49% which has been occasioned mostly by the reduced nitrogen fertilisation of agricultural fields, the biggest decline was in the beginning of time series.

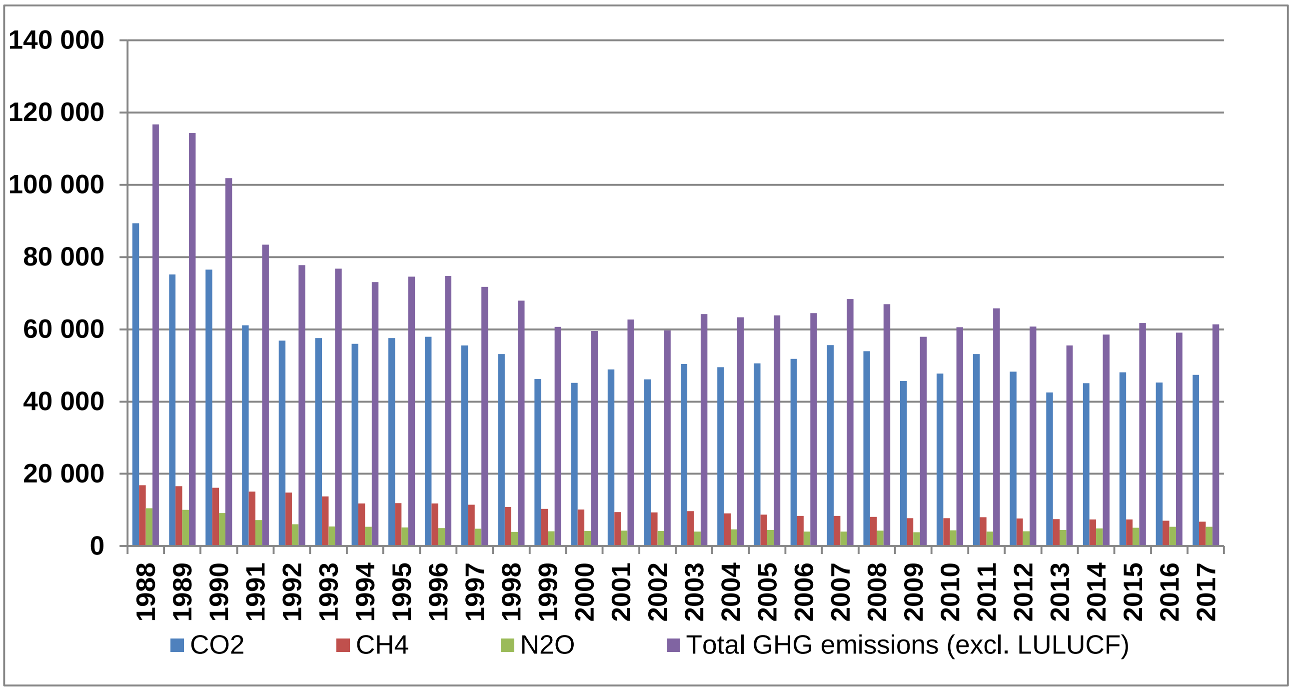

Figure 9 Total GHG emissions in Gg CO_2 eq. for 1988 – 2017

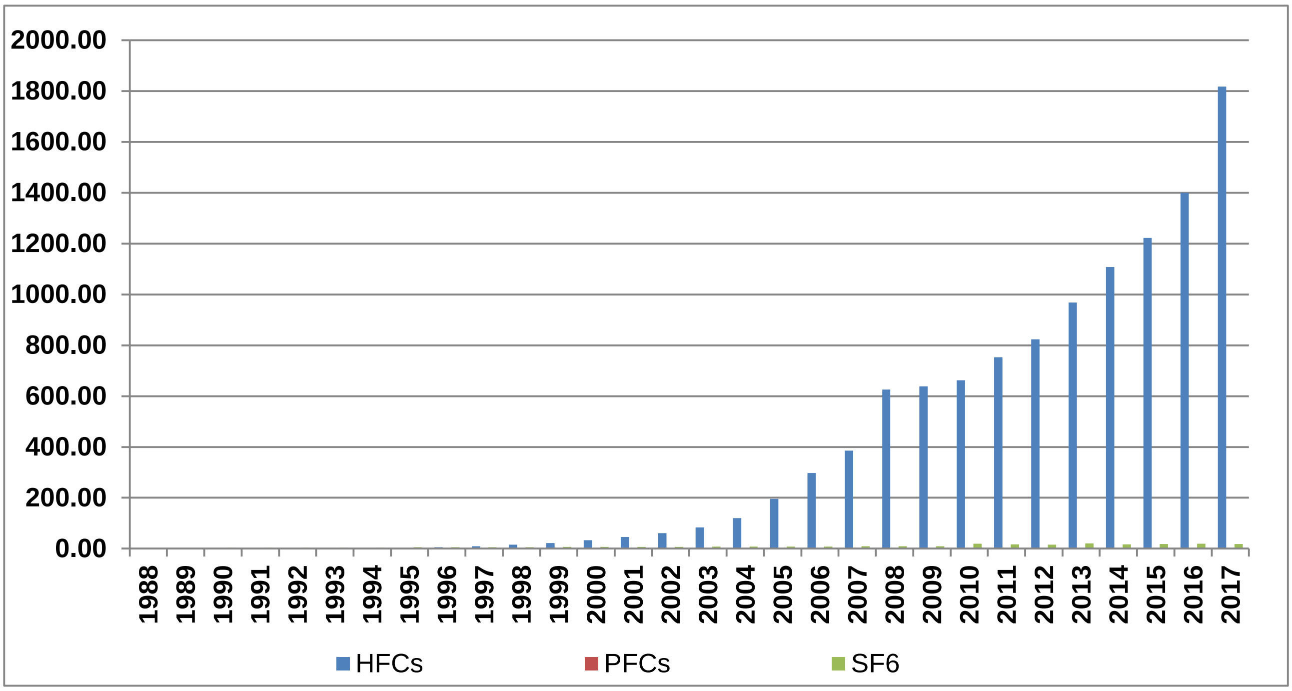

Figure 10 Actual emissions of HFCs, PFCs and SF_6 for 1988 – 2017, Gg CO_2 eq.

The emissions of F-gases have increased over tenfold during 1995-2017. A key driver behind the trend has been the substitution of ozone depleting substances (ODS) by F-gases in many applications.

2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY SECTOR

Figure below shows the GHG aggregated emission trends by IPCC sectors. The Energy sector, where GHG emissions come from fuel combustion, headed the list in 2017 with the biggest share – 72.7%. Sector Agriculture ranked the second place with 10.7% and sectors IP ranked the third place with 10.4 % and Waste with 6.2%.

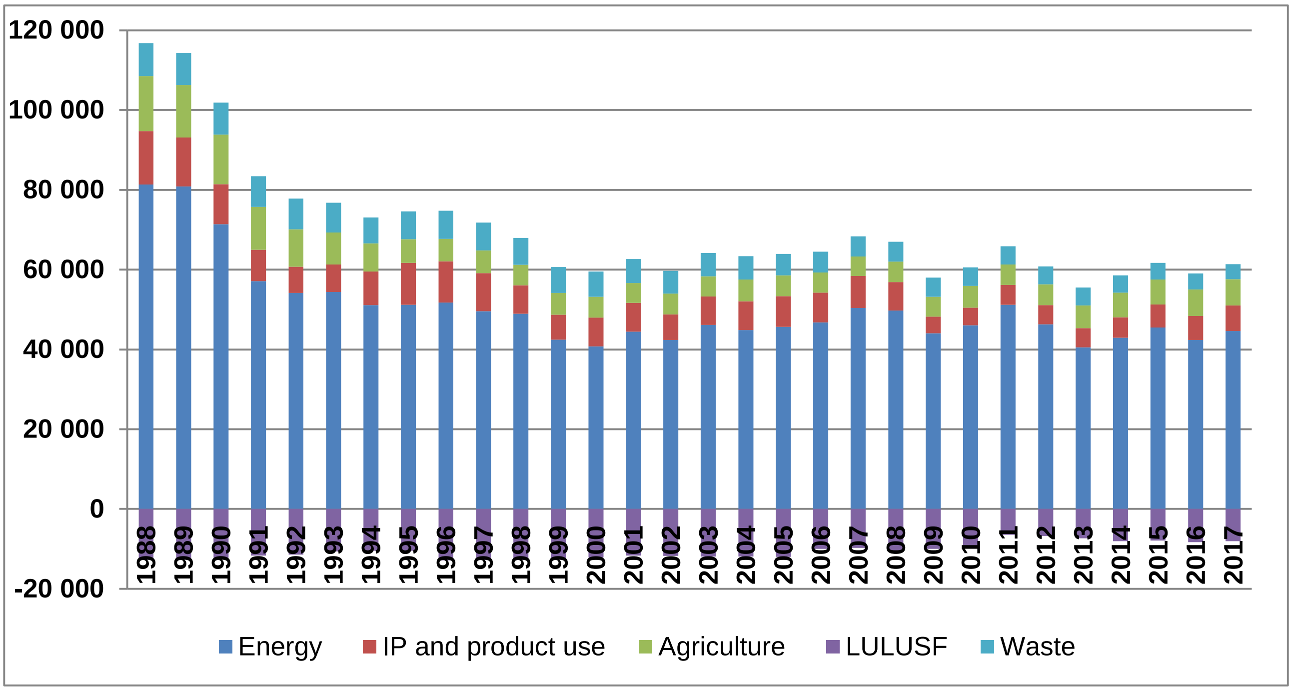

Figure 11 Total greenhouse gas emissions in CO_2-eq. per IPCC sector 1988-2017

Table 12 The reductions of GHG emissions by sectors by base year

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Change from base to latest reported year
1. Energy	-45.14
2. Industrial Processes and product use	-52.29
3. Agriculture	-52.35
4. Land Use, Land-Use Change and Forestry(5)	-36.64
5. Waste	-54.01
6. Other	0.00
Total (including LULUCF)	-48.76

Energy

Emissions from the energy sector in 2017 decreased by 45.14% compared to the base year (44 610 Gg CO2e in 2017 compared to 81 320 Gg CO2e in 1988). Compared to previous year, the emissions in 2017 increased with 5.3% mostly due to the decrease in electricity production from fossil fuels in the energy industries sector.

Main source of emissions in the energy sector is fuel combustion of solid fuels, which is responsible for 59.9% of the emissions from fuel combustion in 2017, followed by liquid fuels with 28.0% and gaseous fuels with 11.1%.

The main reasons for the decrease of the GHG emission trend in energy sector are the transition from a centrally-planned economy to a market-based economy, reconstructing of the economy and subsequent economic slowdown. This led to a sharp drop in demand for electricity production from thermal power production.

The trend of GHG emissions between 1988 and 2017 was defined by a substantial decrease of emissions from fuel combustion in energy industries (34.4%) and energy use in manufacturing industry and construction (79.4%) and in other sectors (commercial, residential, agriculture and forestry) (71.0%), as well as a clear increase in GHG emissions from transport (31.8%).

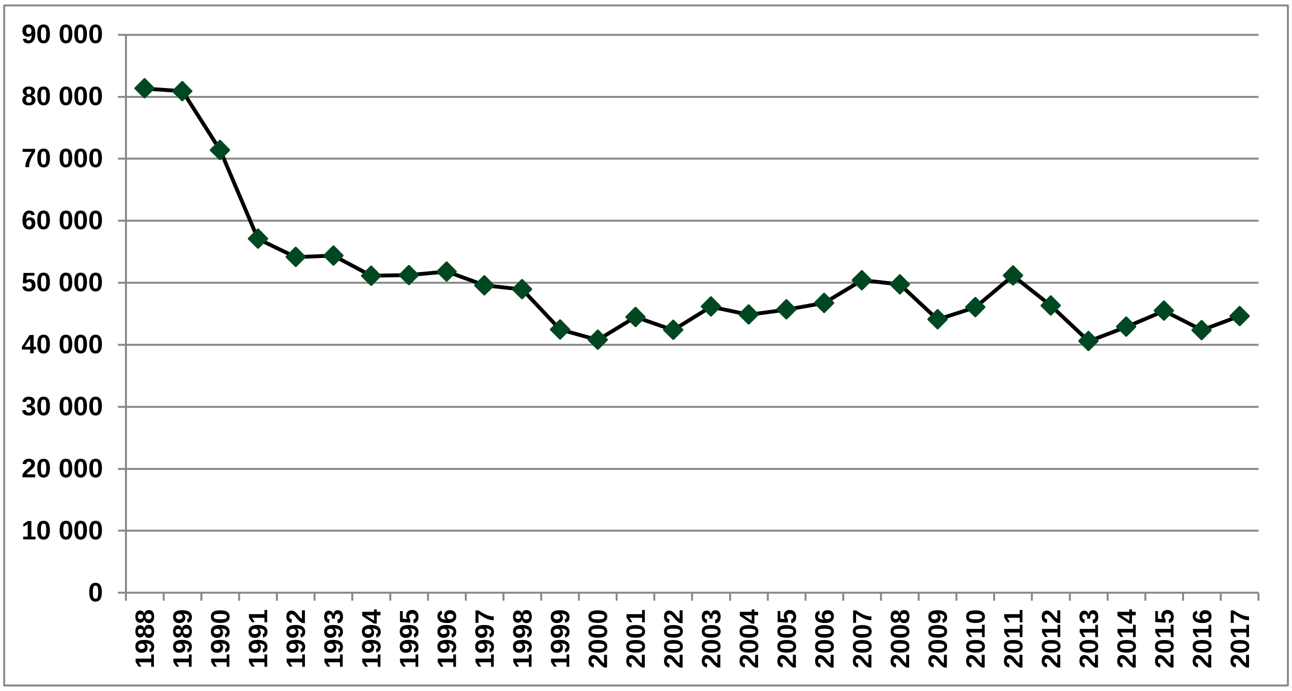

Figure 12 GHG emissions from Energy sector for 1988 – 2017, Gg CO_2 eq.

Chapter 3 of this Report contains a more detailed analysis of GHG emissions in the sector.

Industrial Processes and Product use

A steady trend towards emission reduction in this sector is observed since 1988. The emissions in 2017 decreased with 52.29% compared to the base year.

In the year 2017, 10.45% of national total greenhouse gas emissions (without LULUCF) originated from industrial processes and product use, compared to 11.51% in the base year 1988. In 2017, greenhouse gas emissions from Industrial Processes and Product use are 6412.50 CO_2 equivalent compared to 13 439.32 Gg CO_2 in the base year.

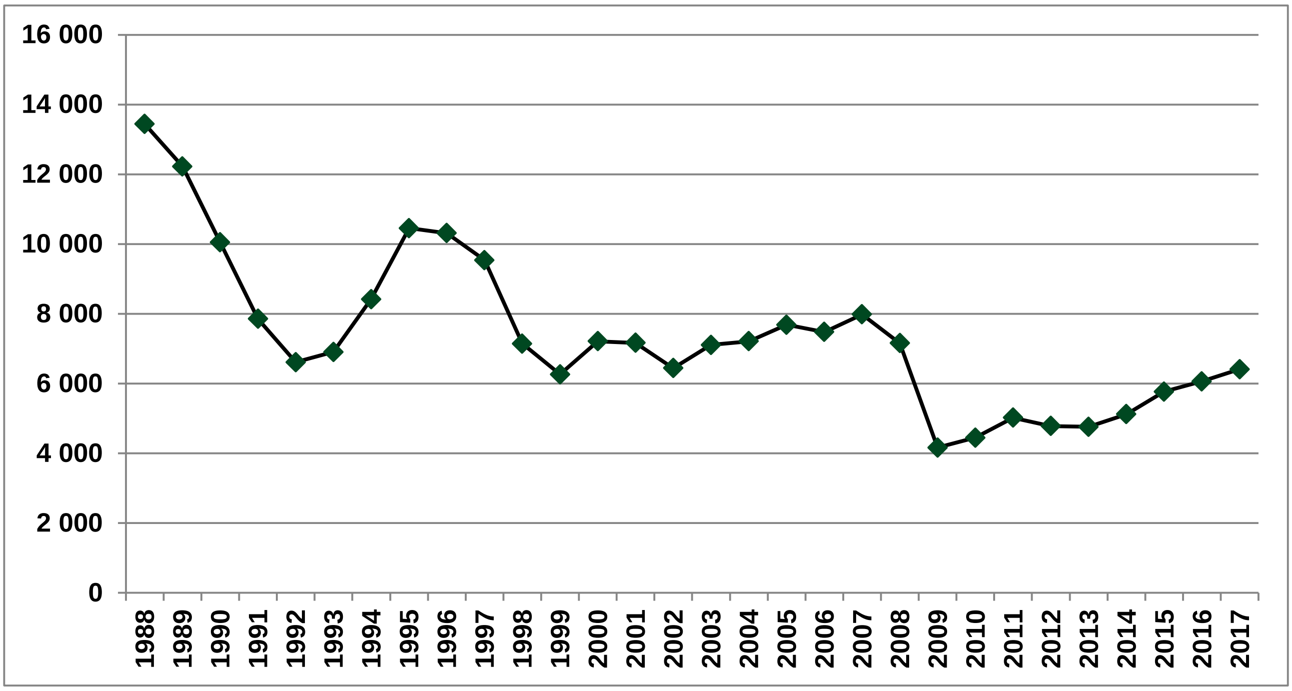

Figure 13 GHG emissions from Industrial processes sector for 1988 – 2017, Gg CO_2 eq.

In 2017 the most important emitting category is Mineral products (mainly production of clinker and quick lime), which share in the total Industrial processes and product use emissions is 39.3%. The second category by share is Product uses as ODS substitutes (Consumption of Halocarbons) with 28.4%, followed by Chemical Industry (ammonia and nitric acid production) with 27.2% share and finally Metal Production (steel) with 2.86%.

Greenhouse gas emissions from the Industrial Processes and product use sector fluctuate during the period and reach a minimum in 2009. The reduction in 2017 for the whole sector is 52.29% while the biggest reduction (compared to the base year) can be seen in Metal Production category – 95.45%.

This is mainly due to economic crisis and in particular the world economic crisis in 2009. The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.

The general reduction in the emissions in the later years of the time period is influenced also by the starting introduction of better technologies on plant level.

Agriculture

The overall emission reduction in the sector has amounted to 52.35% since 1988. In the year 2017 the sector agriculture contributed 10.69% to the total of Bulgaria's greenhouse gas emissions (without LULUCF).

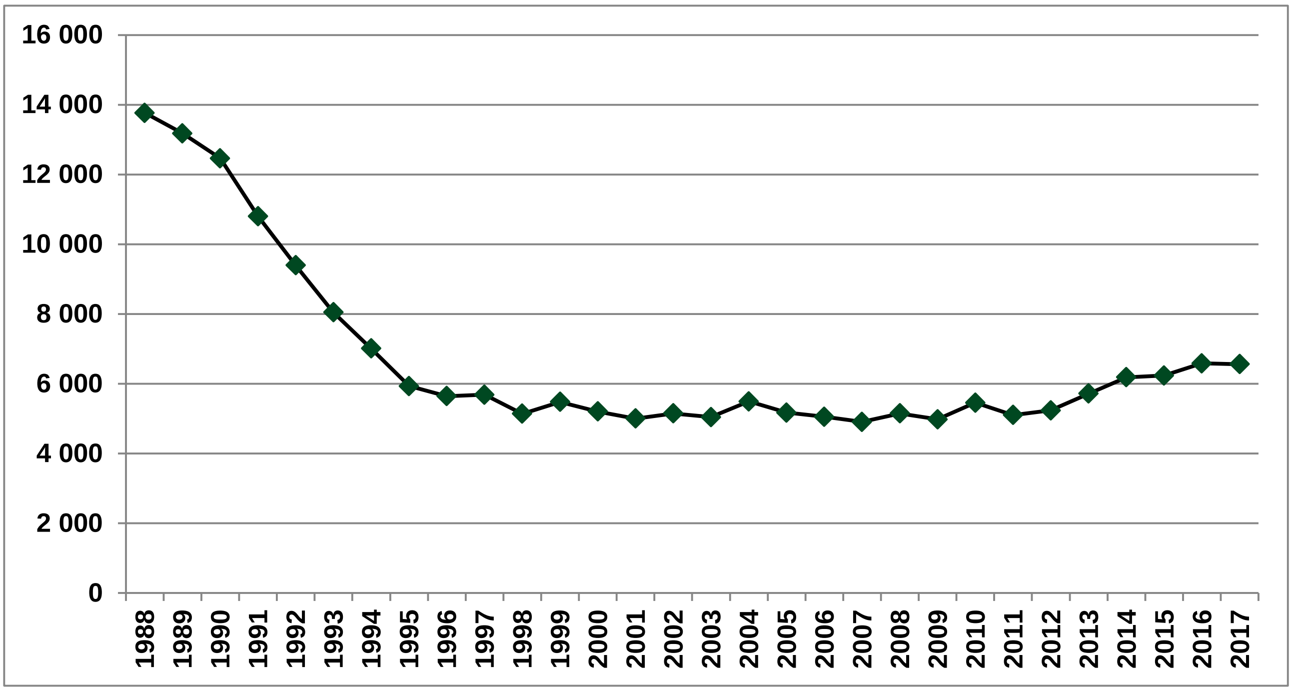

Figure 14 GHG emissions from Agriculture sector for 1988 – 2017, Gg CO_2 eq.

The emission reductions were mainly driven by systematic declines in the agricultural land area due to abandoning of arable lands and reduction in livestock population. Another driver for the emission reduction was the decline in the use of fertilizers.

Chapter 6 of this Report contains a more detailed analysis of GHG emissions in the sector.

Land-Use Change and Forestry

The LULUCF sector is serving as a sink of greenhouse gases for Bulgaria. The two categories – "Forest land" and "Grassland" are removals of CO_2. All other categories are sources of CO_2 emissions. The trend of net CO_2 removals (CO_2 eq) from LULUCF decreases by 36.6% compared to the base year. The main reason for the overall decrease of the uptakes of CO_2 emissions from LULUCF is due to the fall in removals from category Forest land and the slight increase in emissions from CL, WL and SM categories. The key driver for the fall in removals from FL is the observed decline in the rate of forest growth as the average age of the forest stands increases steadily over the reporting period. In spite of the decrease observed, the share of the removals from the total GHG emissions (in CO_2eq) is still remarkable. The reason for this is that the emissions in the other sectors have dropped dramatically. The share of the removals in the base year has the figure of -12.2% from the total GHG emissions in CO_2-eq, while in the inventoried year the share is -15.1%.

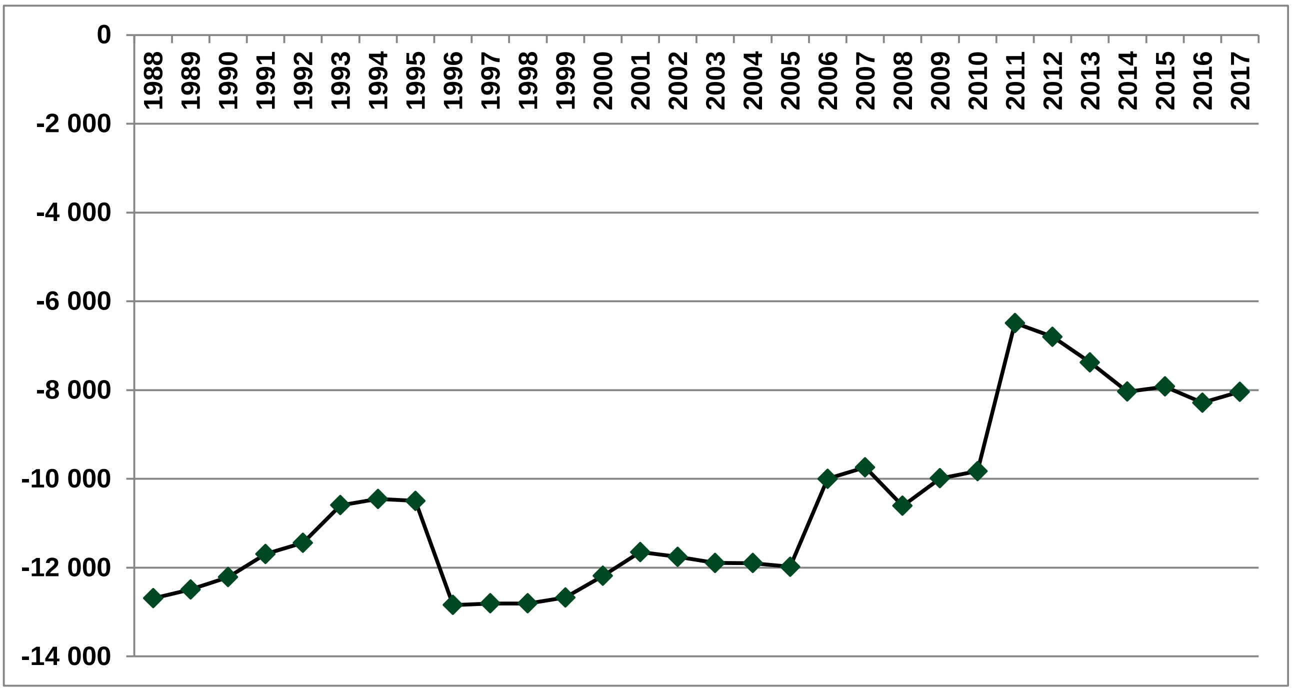

Figure 15 LULUCF emissions and removals for 1988 – 2017 CO2 eq.

Comparing with the base year an increase in the emissions in croplands, settlements and wetlands is observed. The total emissions from croplands fluctuate during the whole time series. The emissions from Settlements increase last couple of years due to changes from other land uses to Settlements according to the risen infrastructural activities since Bulgaria's joined the EU.

Chapter 7 of this Report contains a more detailed analysis of GHG emissions in the sector.

Waste

The total sector emission reduction from the base year is 54.0 %. The decline was mainly driven by a steady population decline over the past 10 years.

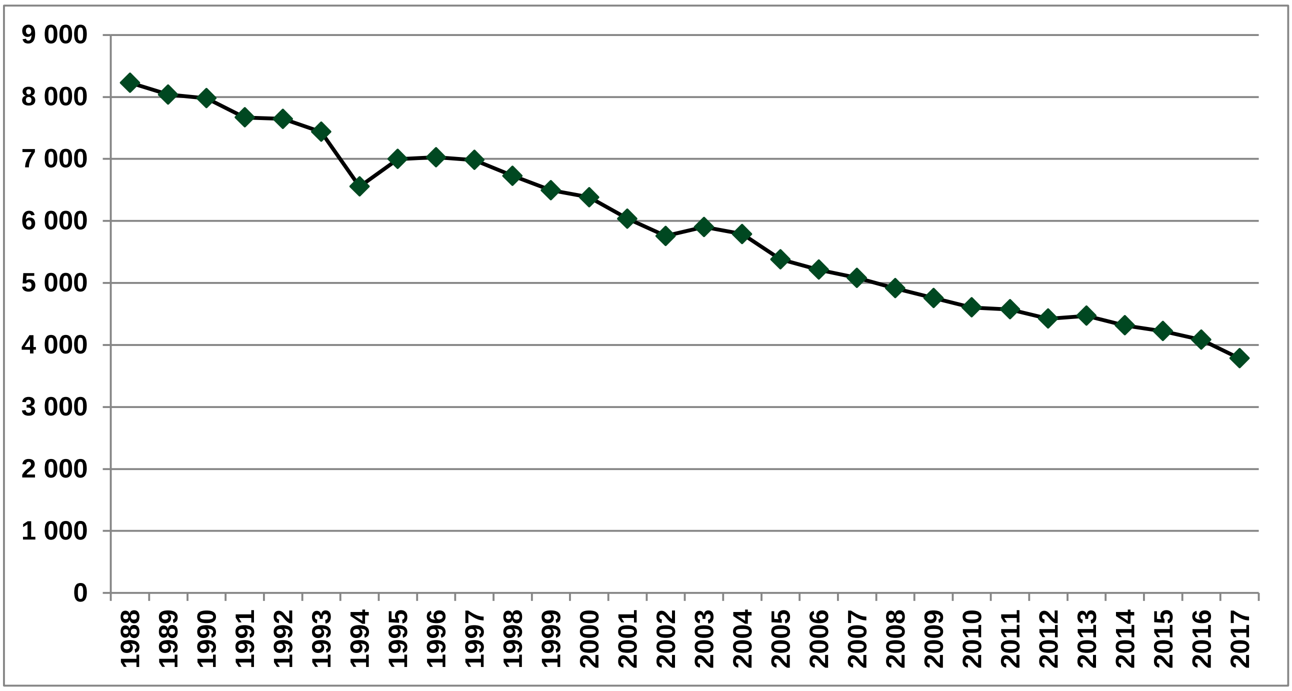

Figure 16 GHG emissions from Waste sector for 1988 – 2017, Gg CO2 eq.

Chapter 8 of this Report contains a more detailed analysis of GHG emissions in the sector.

2.3 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR INDIRECT GREENHOUSE GASES AND SULPHUR OXIDES

Compared to the base year the emissions of non-GHGs emissions decreased as follows:

- NO_x with 39.0%
- CO with 69.8% (increased)
- SO_x with 95.1%
- NMVOC with 58.8%

2.4 DESCRIPTION AND INTERPRETATION OF EMISSIONS AND REMOVALS FROM KP-LUCUCF INVENTORY

Emissions and removals from KP-LULUCF activities are described in Chapter 11.

3 ENERGY (CRF CATEGORY 1)

3.1 OVERVIEW OF SECTOR

The Energy sector accounts for all GHG emissions originating from stationary fuel combustion activities in the energy and manufacturing industries, commercial, agricultural and residential sectors, mobile fuel combustion activities resulting from aviation, road transportation, railways and navigation (CRF category 1A), as well as fugitive emissions from fuels (CRF category 1B).

According to the IPCC guidelines, the Energy sector consists of the following categories:

- 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
- 1.B. Fugitive Emissions from Fuels

Emissions from the energy sector are the main source of GHGs in Bulgaria: in 2017 the sector is responsible for 72.7% of national total GHG emissions (42 742 Gg CO_2e from sector 1A of the total 61 367 Gg CO_2e excl. LULUCF).

3.2 EMISSION TREND

Emissions from the energy sector in 2017 decreased by 45.1% compared to the base year (44 610 Gg CO_2e in 2017 compared to 81 320 Gg CO_2e in 1988). Compared to the year before, emissions in 2017 an increased by 5.3% mostly due to the increase of electricity production from fossil fuels in the energy industries sector and increase in chemical industry.

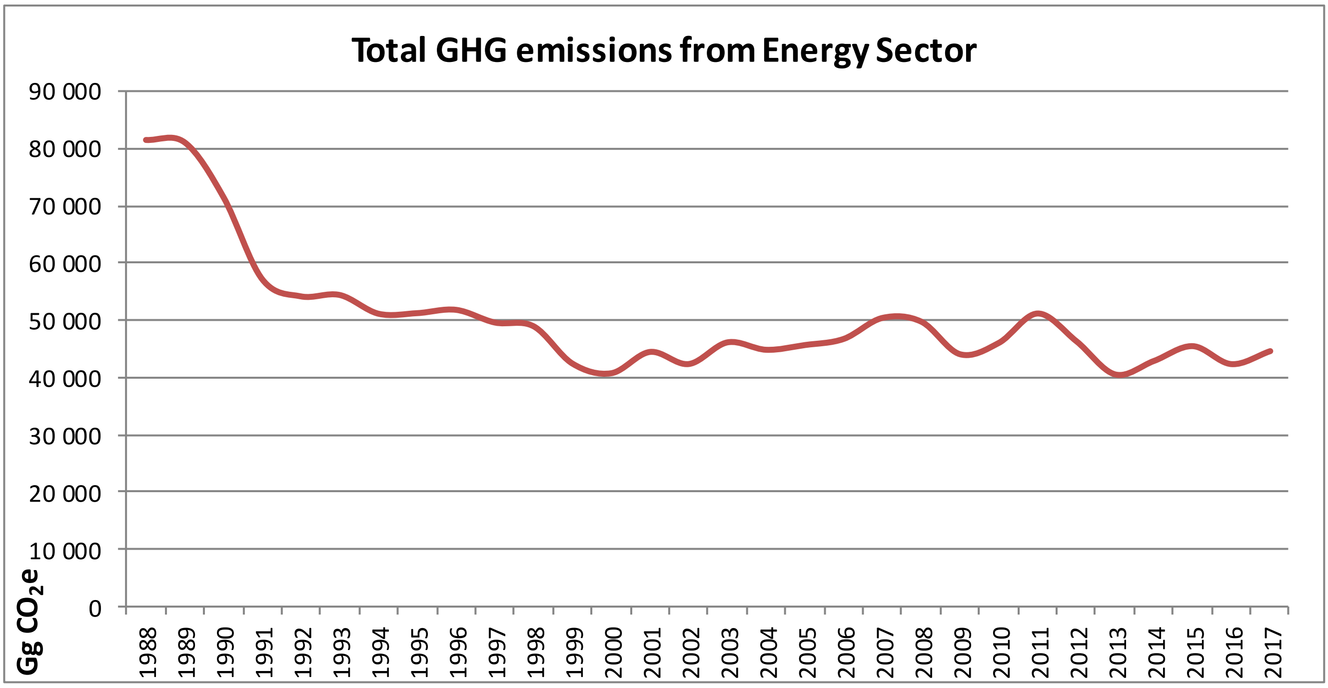

Figure 17 Total GHG emissions from Energy Sector

The main source of emissions in the energy sector is combustion of solid fuels, which is responsible for 59.9% of the emissions from fuel combustion in 2017, followed by liquid fuels with 28.0% and gaseous fuels with 11.1%.

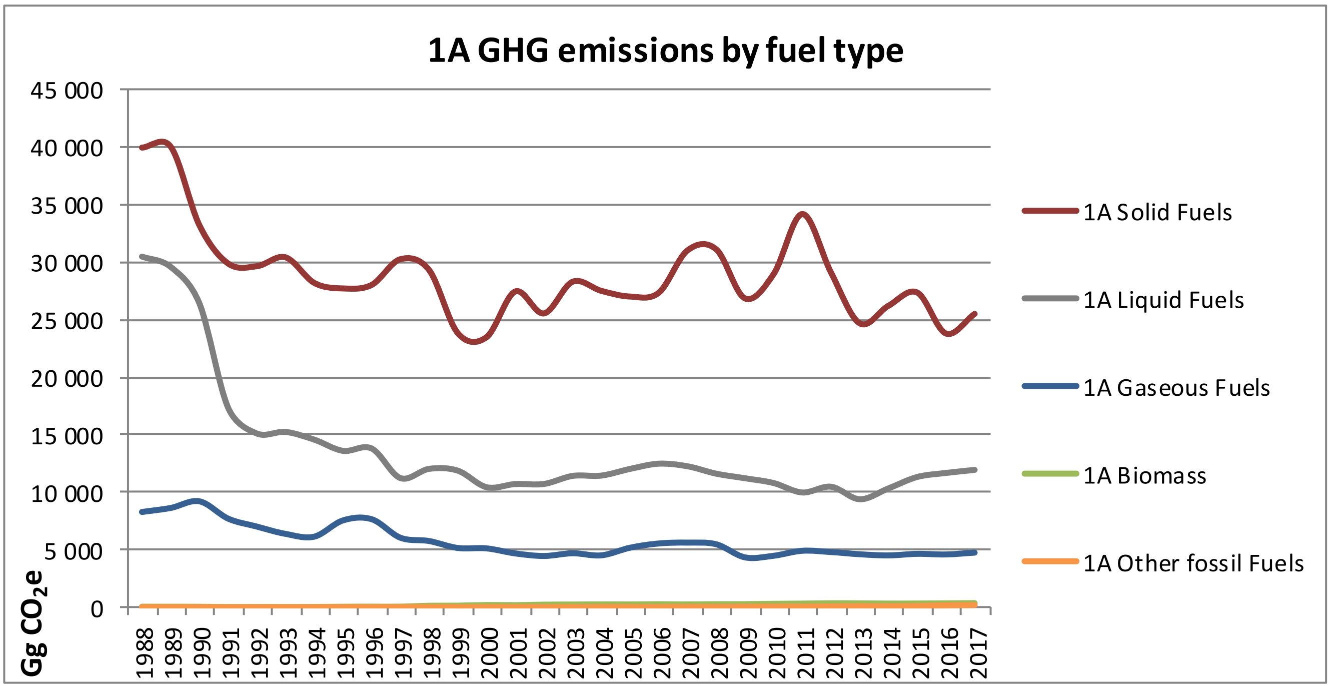

Figure 18 GHG emissions from fuel combustions by fuel type

On a subcategory level, the energy industries sector is the major source of emissions, responsible for 64.7% of the emissions from fuel combustion, followed by transport with 22.1% and manufacturing industries and construction with 8.4%.

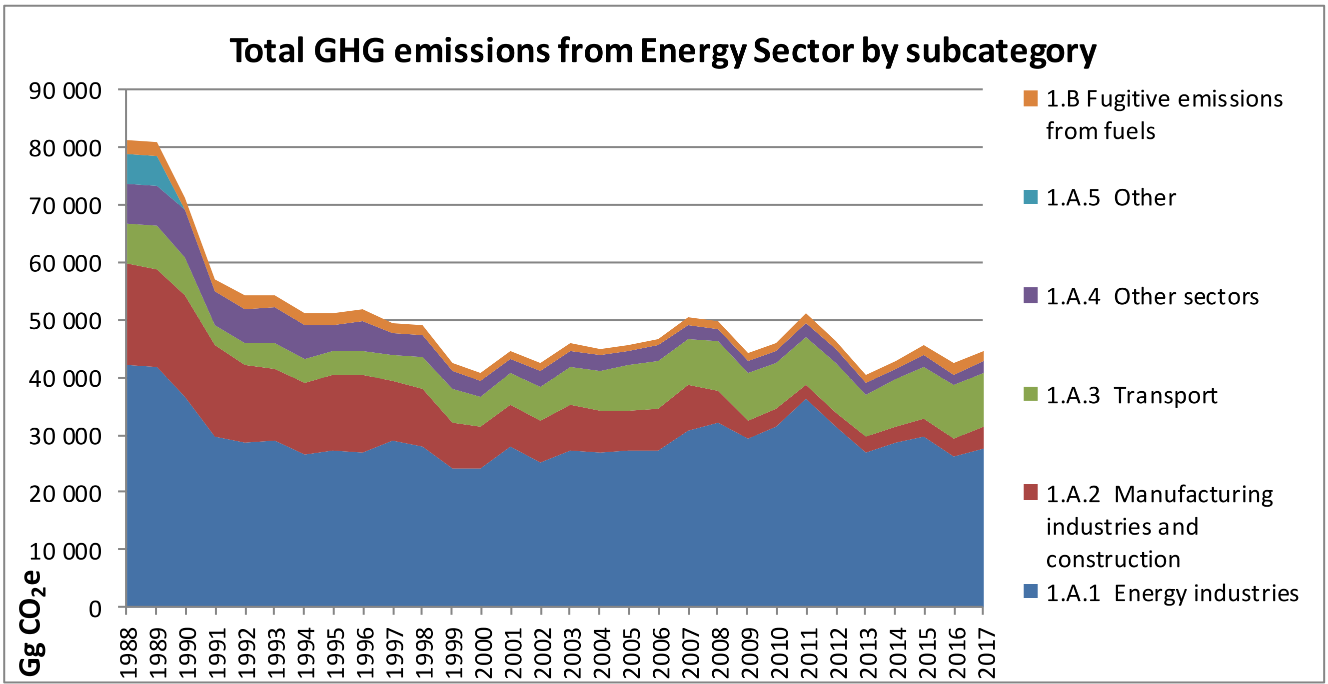

Figure 19 Total GHG emissions from Energy Sector by subcategory

Total emissions from the energy sector mainly consist of CO_2; with a total amount of 42 882 Gg for 2017, followed by CH_4 and N_2O, which only make up about 56.82 Gg and 1.03 Gg, respectively.

Table 13 Emissions of GHG and their trends for the years 1988 – 2017

Year	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	Total GHG [Gg CO_2e]
1988	77 906.98	115.57	1.76	81 319.66
1990	68 152.48	108.29	1.69	71 362.94
1995	48 522.81	95.19	1.06	51 218.97
2000	38 817.42	66.64	0.96	40 769.78
2005	43 977.60	55.06	1.07	45 672.91
2010	44 285.59	58.46	1.00	46 045.26
2011	49 083.60	69.76	1.09	51 152.35
2012	44 426.83	64.01	1.04	46 336.02
2013	38 856.95	57.03	0.95	40 564.81
2014	41 192.68	56.69	0.99	42 903.56
2015	43 664.66	60.16	1.05	45 481.03
2016	40 692.48	54.62	1.00	42 355.01
2017	42 881.94	56.82	1.03	44 610.45

3.3 FUEL COMBUSTION (CRF 1.A)

3.3.1 COMPARISON OF SECTORAL AND REFERENCE APPROACHES

Following the IPCC guidelines, two separate approaches are applied in order to estimate the emissions from fuel combustions activities: Reference approach (RA) and Sectoral approach (SA).

The Reference approach is a method for estimating CO_2 combustion emissions by a simplified top-down methodology, which considers reported quantities of primary and secondary fuels from the national energy balance, taking into account the non-energy use of fuels. For the purposes of the RA, the apparent consumption of each fuel is calculated on the basis of reported quantities for production, import, export, stock changes and international bunkers.

The Sectoral Approach (SA) is a more detailed bottom-up methodology, which considers fuel consumption in each of the following subcategories:

- Energy Industries, including Public Electricity and Heat Production, Petroleum Refining and Manufacture of Solid Fuels and Other Energy Industries;
- Manufacturing Industries and Construction, including Iron and Steel, Non-Ferrous Metals, Chemicals, Pulp, Paper and Print, Food Processing, Beverages and Tobacco, Non-metallic minerals and Other
- Transport, including Civil Aviation, Road Transportation, Railways, Navigation and Other Transportation
- Other Sectors, including Commercial/Institutional, Residential, Agriculture/Forestry/Fisheries
- Other Stationary and Mobile sources

3.3.1.1 Methodology

Default methodologies are applied based on the fuel type and according to 2006 IPCC Guidelines, Ch. 6, Equations 6.1 and 6.2.

3.3.1.2 Results of the reference approach

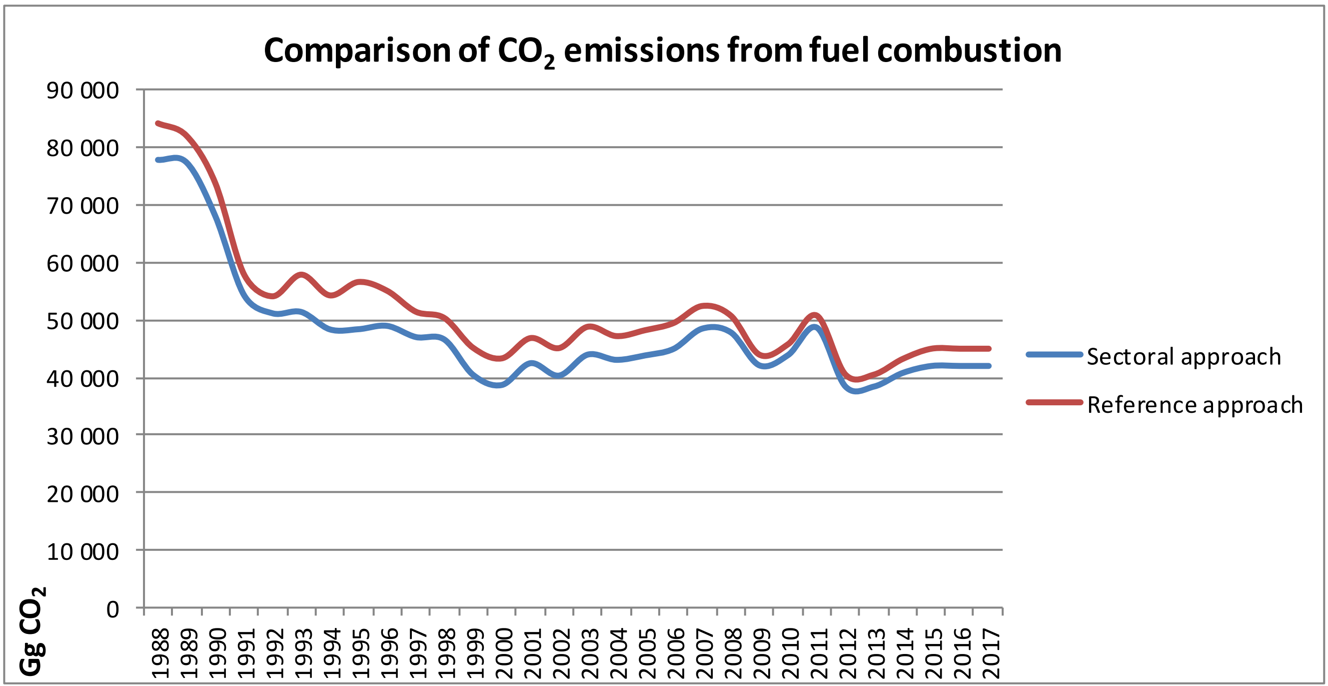

Figure 20 Comparison of the sectoral approach with the reference approach

The following tables compare the energy consumption and the emissions according to both approaches by fuel type.

Table 14 Comparison of the sectoral approach with the reference approach (all fuels)

Year	Energy consumption, PJ		Difference	CO_2 Emissions, Gg		Difference
	Reference approach	Sectoral approach		Reference approach	Sectoral approach	
1988	1 011.05	945.25	6.96%	84 209.45	77 901.99	8.10%
1990	894.21	848.17	5.43%	73 857.07	68 148.36	8.38%
1995	679.94	593.66	14.53%	56 688.49	48 467.91	16.96%
2000	503.76	466.16	8.07%	43 434.96	38 766.90	12.04%
2005	560.65	522.17	7.37%	48 315.83	43 904.39	10.05%
2010	519.68	506.54	2.59%	45 903.19	43 977.95	4.38%
2011	569.14	554.29	2.68%	50 862.26	48 748.53	4.34%
2012	467.17	449.31	3.97%	40 631.87	38 502.82	5.53%
2013	467.17	449.31	3.97%	40 631.87	38 502.82	5.53%
2014	495.13	475.03	4.23%	43 343.24	40 867.88	6.06%
2015	523.14	501.34	4.35%	45 682.50	43 136.12	5.90%
2016	492.27	471.26	4.46%	42 327.69	39 947.72	5.96%
2017	522.97	495.41	5.56%	45 114.67	42 077.75	7.22%

Table 15 Comparison of the sectoral approach with the reference approach (liquid fuels)

Year	Energy consumption, PJ		Difference	CO_2 Emissions, Gg		Difference
	Reference approach	Sectoral approach		Reference approach	Sectoral approach	
1988	459.41	402.65	14.10%	33 931.31	30 098.27	12.74%
1990	362.76	352.96	2.78%	26 775.59	26 010.68	2.94%
1995	222.87	182.91	21.85%	16 344.31	13 385.59	22.10%

Year	Energy consumption, PJ		Difference	CO_2 Emissions, Gg		Difference
	Reference approach	Sectoral approach		Reference approach	Sectoral approach	
2000	145.58	142.44	2.20%	10 640.67	10 272.75	3.58%
2005	178.79	163.22	9.53%	13 135.72	11 860.45	10.75%
2010	152.70	144.57	5.63%	11 267.48	10 679.34	5.51%
2011	143.87	135.23	6.39%	10 492.38	9 859.39	6.42%
2012	138.15	126.61	9.11%	10 148.66	9 283.15	9.32%
2013	138.15	126.61	9.11%	10 148.66	9 283.15	9.32%
2014	150.64	139.04	8.34%	11 048.57	10 221.22	8.09%
2015	163.99	153.30	6.98%	12 006.36	11 201.85	7.18%
2016	168.23	158.05	6.44%	12 415.00	11 554.64	7.45%
2017	174.94	161.40	8.39%	13 026.77	11 822.29	10.19%

Table 16 Comparison of the sectoral approach with the reference approach (solid fuels)

Year	Energy consumption, PJ		Difference	CO_2 Emissions, Gg		Difference
	Reference approach	Sectoral approach		Reference approach	Sectoral approach	
1988	400.64	391.60	2.31%	41 942.03	39 467.62	6.27%
1990	361.45	327.08	10.51%	37 697.21	32 856.19	14.73%
1995	313.87	273.30	14.85%	32 439.04	27 494.56	17.98%
2000	263.17	231.24	13.81%	27 549.12	23 388.99	17.79%
2005	284.71	265.41	7.27%	29 815.96	26 878.52	10.93%
2010	283.47	281.20	0.81%	30 016.45	28 827.99	4.12%
2011	333.58	330.31	0.99%	35 293.13	33 972.88	3.89%
2012	242.55	239.48	1.28%	25 675.72	24 589.36	4.42%
2013	242.55	239.48	1.28%	25 675.72	24 589.36	4.42%
2014	260.77	254.75	2.36%	27 635.80	26 123.38	5.79%
2015	269.24	264.36	1.85%	28 652.54	27 254.76	5.13%
2016	230.67	229.91	0.33%	24 690.48	23 729.49	4.05%
2017	250.31	247.29	1.22%	26 638.01	25 414.03	4.82%

Table 17 Comparison of the sectoral approach with the reference approach (gaseous fuels)

Year	Energy consumption, PJ		Difference	CO_2 Emissions, Gg		Difference
	Reference approach	Sectoral approach		Reference approach	Sectoral approach	
1988	151.00	151.00	0.00%	8 336.10	8 336.10	0.00%
1990	169.99	168.13	1.11%	9 384.27	9 281.48	1.11%
1995	143.20	137.45	4.18%	7 905.14	7 587.76	4.18%
2000	95.01	92.48	2.74%	5 245.17	5 105.16	2.74%
2005	97.12	93.50	3.87%	5 361.34	5 162.62	3.85%
2010	83.17	80.44	3.39%	4 594.27	4 445.63	3.34%
2011	91.38	88.44	3.32%	5 050.01	4 889.51	3.28%
2012	85.90	82.66	3.92%	4 755.96	4 578.78	3.87%
2013	85.90	82.66	3.92%	4 755.96	4 578.78	3.87%
2014	83.18	80.69	3.08%	4 610.95	4 475.36	3.03%
2015	89.14	82.92	7.50%	4 958.43	4 614.34	7.46%
2016	92.03	81.97	12.28%	5 120.27	4 561.65	12.25%
2017	96.07	85.07	12.93%	5 330.10	4 721.65	12.89%

3.3.1.3 Explanation of differences

A comparison between the Reference Approach (RA) and the Sectoral Approach (RA) indicates a difference of 5.56% in terms of energy consumption and 7.22% in terms of CO_2 emissions for 2017.

The main reason why these two approaches do not match most likely has to do with the significant statistical differences reported for some of the years in the national energy balances. The most notable differences are observed in the period 1993-1996, and particularly 1995. Analysis reveals that these differences in liquid fuels consumption are caused by significant amounts of refinery losses reported, e.g. 9.5% of total refinery intake in 1995 was reported as refinery losses, with an average of 4.0% for the period 1990-2017 and 6.6% for 2017 alone.

Another reason for potential discrepancies is the difference between the net calorific values of primary and secondary fuels in fuel transformation processes. This is especially valid for liquid fuels – the Reference approach calculation is based on the energy content of refined crude oil, whereas the Sectoral approach uses the energy content of produced secondary fuels. For solid fuels, the Reference approach is based on the net calorific value of lignite coal, used in BKB plants, whereas the Sectoral approach disregards the initial amount of lignite reported for transformation in BKB plants, instead using the net calorific value of the BKB fuel itself. The same note is also applicable to coking coal used for the production of coke oven coke and coke oven gas, even though this activity has not taken place since 2009.

In short, discrepancies in the emission estimates between the reference and the sectoral approach occur due to the fact, that the Energy balance is mass-balanced, but not energy-balanced, i.e. there are some differences in the energy content of the primary fuels and the secondary fuels produced.

A special case for solid fuels used in blast furnaces in the Iron & Steel subcategory is an additional reason for differences between RA and SA for the period before 2008. In order to avoid double counting between Energy and Industrial Processes categories (2C Metal production), part of the solid fuels reported in the Energy balance are not accounted in the Sectoral approach (details regarding exact fuel allocation are given in Annex III). This is the reason why the difference between RA and SA for solid fuels was minimized immediately after the closure of the largest I&S plant in Bulgaria in 2008.

For liquid fuels (diesel fuel and gasoline) there is an additional reason for differences associated with the blending of biofuels. While in the SA the CO_2 emissions from the biofuels component are accounted under biomass, in the RA all liquid fuel consumption is accounted as fossil. Similarly, the use of alternative fuels, which is accounted in the SA, is not accounted in the RA.

3.3.1.4 Quantification of differences

For 2017 the difference due to statistical differences and distribution losses for gaseous fuels is equal to 1800 TJ, which is 1.6% of the total consumption of gaseous fuels. In terms of emissions, this is equivalent to 102.0 Gg CO_2. For liquid fuels, in 2017 the refinery losses are 6.6% of the refinery intake, which is equal to 19095 TJ or 1399.7 Gg CO_2. The use of alternative fuels, which are accounted in the sectoral approach, is equal to 1350 TJ or 103.1 Gg CO_2.

If all those quantified differences are accounted, the remaining difference between the reference and the sectoral approaches for 2017 is equal to 1.3% in terms of energy consumption and 3.7% in terms of emissions.

3.3.2 INTERNATIONAL BUNKER FUELS

The International Bunkers represent the fuels and the emissions resulting from international air and marine transport of passengers and cargo. These GHG emissions are also subject to the inventory and they have to be reported. However, they are not included in the total sum of the emissions of the country. The Energy balance provides a split between domestic and international fuel consumption.

Table 18 GHG Emissions from International bunker fuels

Year	Total [Gg CO_2e]	Aviation [Gg CO_2e]	Navigation [Gg CO_2e]
1988	2 071.36	1 112.46	958.90
1990	903.84	719.35	184.48
1995	1 774.90	912.48	862.41
2000	444.54	241.85	202.69
2005	917.38	569.01	348.37
2010	813.93	505.41	308.52
2011	751.14	511.61	239.53
2012	694.93	493.01	201.93
2013	766.33	480.60	285.72
2014	769.22	511.61	257.61
2015	806.69	533.31	273.38
2016	886.79	641.84	244.95
2017	894.64	718.43	252.80

3.3.3 FEEDSTOCKS AND NON-ENERGY USE OF FUELS

Non-energy use of fuels is reported for the following fuels:

- Anthracite
- Coke Oven Coke
- Other bituminous coal
- Lubricants
- Bitumen
- Naphtha
- Paraffin waxes
- White spirit
- Residual Fuel Oil
- Other Oil Products
- Petroleum Coke
- Natural Gas as Feedstock

The amounts of fuels used for non-energy purposes are available in the energy balance by activity category and type of fuel. These amounts were used in the calculations for the reference approach, applying a value of 1 for the fraction of carbon stored.

There are some fluctuations in reported consumption for some of the fuels during the examined time series. These fluctuations are due to changes in industrial production, e.g. differences in production volume, decommissioning of installations or shift from one fuel type to another. In addition, the Energy balance incorporates certain discrepancies concerning the quantities of fuels reported as non-energy use, as some industrial plants fail to report their non-energy use of fuels properly.

In order to improve reporting consistency, additional data was collected from several chemical plants regarding the annual production of ammonia, soda ash and calcium carbide. The amounts of energy and non-energy use of natural gas, anthracite, other bituminous coal and coke oven coke were reallocated according to the quantities of fuels considered as emission sources in the Industrial Processes sector.

The non-energy use of fuels is on average 8.0% of the total apparent energy consumption during the period 1988-2017 and 5.6% for 2017. The apparent consumption is calculated according to Equation 6.2 in Vol. 2, Ch. 6 of the 2006 IPCC Guidelines.

Table 19 Non-energy use of fuels compared to total apparent energy consumption

Year	Non-energy use, PJ	Apparent energy consumption incl. non-energy use, PJ	%
1988	93.53	1106.11	8.5%
1990	92.88	987.09	9.4%
1995	81.92	761.86	10.8%
2000	59.74	563.50	10.6%
2005	47.62	608.25	7.8%
2010	25.48	545.16	4.7%
2011	32.85	601.99	5.5%
2012	28.37	495.50	5.7%
2013	28.37	495.50	5.7%
2014	31.82	526.89	6.0%
2015	37.44	560.53	6.7%
2016	33.17	525.39	6.3%
2017	31.22	554.19	5.6%

The most significant fuels used as feedstock are bitumen, anthracite and natural gas. The use of naphtha has been discontinued since 2010.

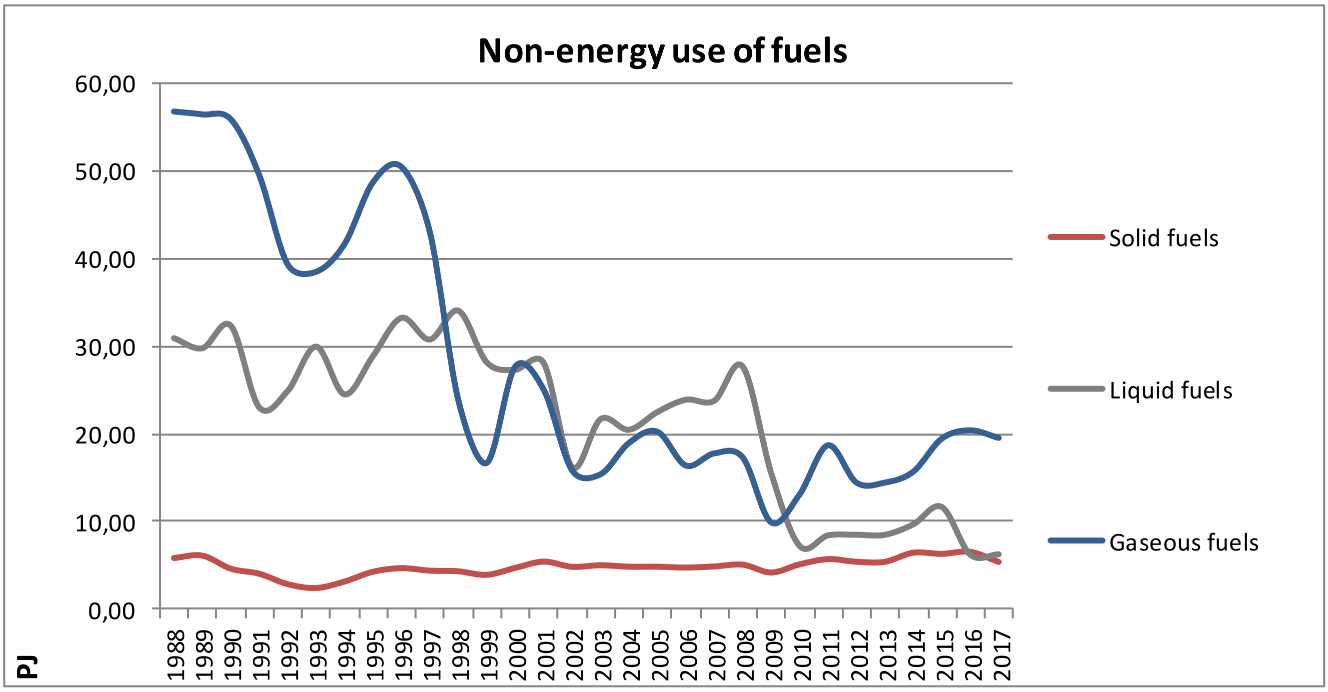

Figure 21 Non-energy use of fuels

The amounts of fuels used for non-energy purposes are available in the energy balance by activity category and type of fuel. These amounts were used in the calculations for the reference approach, As per ERT recommendation FCCC/ARR/2016/BGR E.6 in this case there is no need to use fractions of carbon stored for the non-energy use of fuels.

In general, most of the non-energy use of fuels is attributed to the industrial sector (lubricants, paraffin wax), chemical and petrochemical industry (anthracite, natural gas, naphtha, white spirit and other petroleum products) and construction (bitumen). All sources of emissions due to non-energy use of fuels (natural gas) are reported under category 2B Chemical Industry. The quantities of waste oils, which are used with energy recovery in the non-metallic minerals and other industrial plants, are reported as other fuels under category 1.A.2.g Other industries.

Table 20 Apparent consumption of non-energy fuels

PJ	Solid fuels	Liquid fuels	Gaseous fuels
1988	5.76	30.96	56.80
1990	4.58	32.38	55.91
1995	4.25	28.93	48.74
2000	4.67	27.35	27.72
2005	4.80	22.54	20.28
2010	5.07	7.27	13.14
2011	5.64	8.47	18.74
2012	5.35	8.54	14.49
2013	5.35	8.54	14.49
2014	6.35	9.73	15.74
2015	6.22	11.71	19.50
2016	6.45	6.28	20.45
2017	5.33	6.31	19.58

3.3.4 CO_2 CAPTURE FROM FLUE GASES AND SUBSEQUENT CO_2 STORAGE

CO_2 capture from flue gases and CO_2 storage is not occurring in Bulgaria.

3.3.5 COUNTRY-SPECIFIC ISSUES

Due to country specificities regarding national statistics, two independent sources of information were used for various periods. The Eurostat energy balances prepared by the National Statistics Institute were the most relevant source of information and they were used for estimating the emissions for the years 1990-2017. However, since the National statistics have not issued official balances in the Eurostat format for the years before 1990, the IEA Energy balances were used for the years 1988 and 1989. It is worth mentioning that for 1988 and 1989 the fuel allocation by category is different and significant quantities are allocated to sector 'Other'.

3.3.6 KEY CATEGORIES

The methodology and results of key category analyses are presented in Annex I. Table 21 presents the key source categories of 1 A Fuel Combustion Activities.

Table 21 Key subcategories in sector 1.A. Fuel combustion

Category	Classification	Gas	Key Category Assessment*
1.A.1 - Energy Industries	Gaseous fuels	CO_2	LA, TA

Category	Classification	Gas	Key Category Assessment*
1.A.1 - Energy Industries	Liquid fuels	CO_2	LA, TA
1.A.1 - Energy Industries	Solid fuels	CO_2	LA, TA
1.A.2 - Manufacturing Industries and Construction	Gaseous fuels	CO_2	LA, TA
1.A.2 - Manufacturing Industries and Construction	Liquid fuels	CO_2	LA, TA
1.A.2 - Manufacturing Industries and Construction	Solid fuels	CO_2	LA, TA
1.A.3.b - Road Transportation	Liquid fuels	CO_2	LA, TA
1.A.3.b - Road Transportation	Gaseous fuels	CO_2	LA, TA
1.A.3.e - Other Transportation	Gaseous fuels	CO_2	LA, TA
1.A.4 - Other Sectors	Gaseous fuels	CO_2	LA, TA
1.A.4 - Other Sectors	Liquid fuels	CO_2	LA, TA
1.A.4 - Other Sectors	Solid fuels	CO_2	LA, TA
1.A.5 – Other Stationary	Fossil fuels	CO_2	LA, TA

*LA = Level Assessment w/o LULUCF; TA = Trend Assessment w/o LULUCF

3.3.7 COMPLETENESS

All occurring sources of emissions from 1.A Fuel combustion are estimated for solid, liquid, gaseous fuels, biomass and other fuels (industrial waste). All emissions from CO_2, CH_4 and N_2O have been accounted.

3.3.8 METHODOLOGICAL ISSUES

3.3.8.1 Choice of Method

Tier 1 Methodology

Equation 2.1 from Vol. 2, Chapter 2 of the 2006 IPCC Guidelines is used to estimate the CO_2, CH_4 and N_2O emissions from stationary fuel combustion in CRF subcategories 1.A.1, 1.A.2., 1.A.4 and 1.A.5. The formula used in the calculations is the following:

$$\textit{Emissions}_{GHG} = \textit{Fuel Consumption} \bullet \textit{Emission Factor}_{GHG}$$

where:

$\textit{Emissions}_{GHG}$ = emissions of a given GHG by type of fuel (kg GHG)

Fuel Consumption = amount of fuel combusted (TJ)

$\textit{Emission Factor}_{GHG}$ = default emission factor of a given GHG by type of fuel (t gas/TJ).

Tier 2 Methodology

The same equation is used for the CO_2 emission calculations using the Tier 2 approach in CRF subcategories 1.A.1, 1.A.2., 1.A.4 and 1.A.5, with the difference that the emission factor takes into account country-specific data for carbon contents of the fuels used and carbon oxidation factors.

3.3.8.2 Choice of emission factor

3.3.8.2.1 Choice of emission factors for stationary sources

Default emission factors according to 2006 IPCC Guidelines (Vol. 2, Ch. 2, Table 2.2-2.5) are applied to all fuels for which no country-specific CO_2 emission factors are available. The 2006 IPCC default emission factors for CRF subcategories 1.A.1, 1.A.2., 1.A.4 and 1.A.5 are used for CH_4 and N_2O emissions. The country-specific carbon content of fuels was calculated based on the country-specific CO_2 emission factors using the following equation:

***C = Emission Factor* / (44/12)**

where:

C = carbon content of fuel in t/TJ

Emission Factor = emission factor for CO_2 by type of fuel (t/TJ)

Unlike the 1996 IPCC guidelines, Tier 1 default emission factors in the 2006 IPCC Guidelines reflect a fuel's full carbon content, including any non-oxidized fraction of carbon retained in the ash, particulates or soot, i.e. a complete oxidation of the carbon contained in the fuel is assumed (carbon oxidation factor equal to 1). Further, the 2006 IPCC guidelines do not provide default oxidation factors, so it is not possible to derive different emission factors (including and excluding the oxidation factor). As a result, the use of default 2006 IPCC emission factors leads to an increase in emission estimates of 0.5 to 2% depending on the fuel type, compared to default emission factors from the 1996 IPCC Guidelines.

Table 22 Default Emission factors for CO_2 for different fuels

Fuel	EF C t/TJ	EF CO2 t/TJ (excl. oxidation factor)
LIQUID FOSSIL		
Primary fuels		
Crude Oil	20.0	73.3
Orimulsion	21.0	77.0
Natural Gas Liquids	17.5	64.2
Secondary fuels/products		
Motor Gasoline	18.9	69.3
Aviation Gasoline	19.1	70.0
Jet Gasoline	19.1	70.0
Jet Kerosene	19.5	71.5
Other Kerosene	19.6	71.9
Shale Oil	20.0	73.3
Gas / Diesel Oil	20.2	74.1
Residual Fuel Oil	21.1	77.4
Liquefied Petroleum Gases	17.2	63.1
Ethane	16.8	61.6
Naphtha	20.0	73.3
Bitumen	22.0	80.7
Lubricants	20.0	73.3
Petroleum Coke*	26.6	97.5
Refinery Feedstocks	20.0	73.3
Refinery Gas	15.7	57.6
Paraffin Waxes	20.0	73.3
White Spirit and SBP	20.0	73.3
Other Petroleum Products	20.0	73.3
SOLID FOSSIL		
Primary Fuels		
Anthracite*	26.8	98.3
Coking Coal	25.8	94.6
Other Bituminous Coal*	25.8	94.6
Sub-Bituminous Coal	26.2	96.1
Lignite*	27.5	101.0
Oil Shale and Tar Sands	29.2	107.0
Secondary fuels/products		
Brown Coal Briquettes	26.6	97.5
Patent Fuel	26.6	97.5

Fuel	EF C t/TJ	EF CO2 t/TJ (excl. oxidation factor)
Coke - Gas Coke	29.2	107.0
Coal Tar	22.0	80.7
Gas Works Gas	12.1	44.4
Coke Oven Gas	12.1	44.4
Blast Furnace Gas	70.9	260.0
Oxygen Steel Furnace Gas	49.6	182.0
GASEOUS FOSSIL		
Natural Gas*	15.3	56.1
OTHER FOSSIL		
Municipal Wastes (non-biomass fraction)	25.0	91.7
Industrial Wastes	39.0	143.0
Waste Oils	20.0	73.3
Peat	28.9	106.0
SOLID BIOMASS		
Wood / Wood Waste	30.5	112.0
Sulphite lyes (Black Liquor)	26.0	95.3
Other Primary Solid Biomass	27.3	100.0
Charcoal	30.5	112.0
LIQUID BIOMASS		
Biogasoline	19.3	70.8
Biodiesels	19.3	70.8
Other Liquid Biofuels	21.7	79.6
GASEOUS BIOMASS		
Landfill Gas	14.9	54.6
Sludge Gas	14.9	54.6
Other Biogas	14.9	54.6
OTHER BIOMASS		
Municipal Wastes (biomass fraction)	27.3	100.0

The above-stated default EFs were used for the calculations, except for the following fuels, for which country-specific EFs were derived:

- Anthracite
- Other bituminous coal (Black coal)
- Lignite
- Petroleum coke
- Natural gas

The country-specific emission factors are listed in Table 24 and Table 25.

3.3.8.2.2 Country specific emission factors for CO_2 for solid fuels

Emission data reported under the European Emission Trading Scheme

A total of 173 operators have provided their verified CO_2 emission reports required under the EU ETS for the years 2007-2017. These emissions have been incorporated in the inventory to the best extent possible (see respective subchapters for more information). Furthermore, the background data for the emission calculations under the EU ETS has been used for further QA/QC checks.

Data from the verified ETS reports has been analysed in order to apply a Tier 2 methodology for the national emission calculations. Out of all operators reporting in 2017, only the 17 largest industrial plants used plant specific methodologies. That made it possible to derive country-specific EFs for the major solid fuels. There were no plants, which applied plant-specific EFs for liquid or gaseous fuels. The country-specific emission factors were derived from the verified ETS reports as a weighted average from all operators, which declared that they had used plant-specific emission factors (Tier 3 according to Commission Regulation 601/2012 on the monitoring and reporting of greenhouse gas emissions). The EFs including oxidation factor are calculated as the total sum of the verified CO_2 emissions divided by the total amount of the respective fuel as reported by the operators. For the years 2007 to 2017 the respective annual emission factors were applied, whereas for the years 1988 to 2006 an EF calculated as a weighted average was applied. A subset of all operators reported plant-specific oxidation factors, based on which country-specific EFs excluding oxidation factor were calculated, by using the country-specific EFs including oxidation factor.

The following country-specific carbon contents were calculated:

Table 23 Country-specific carbon content for solid fuels [t/TJ]

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke
1988-2006	28.1856	29.5664	26.7573	25.7857
2007	27.4792	29.3911	27.3114	26.1149
2008	28.8427	29.8238	26.9270	25.9131
2009	28.6586	29.5021	26.7776	25.3961
2010	27.9950	29.5215	26.3476	25.6574
2011	27.7125	29.3377	26.5553	25.1971
2012	27.2728	29.3820	26.8637	25.5126
2013	27.2555	29.3129	26.5746	25.6736
2014	27.4779	29.3766	26.1637	25.8451
2015	27.5376	29.3360	25.9361	25.7868
2016	29.3428	29.4636	26.0945	25.9060
2017	**29.5507**	**29.2726**	**25.4187**	**25.7673**

The following emission factors excluding oxidation factor were calculated:

Table 24 Country-specific EFs excl. oxidation factor for CO_2 for solid fuels [t/TJ]

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke
1988-2006	103.3470	108.4102	98.1099	94.5477
2007	100.7572	107.7673	100.1419	95.7545
2008	105.7566	109.3540	98.7324	95.0147
2009	105.0817	108.1742	98.1845	93.1192
2010	102.6484	108.2456	96.6078	94.0772
2011	101.6126	107.5715	97.3695	92.3894
2012	100.0003	107.7340	98.5004	93.5463
2013	99.9368	107.4805	97.4401	94.1364
2014	100.7522	107.7140	95.9336	94.7654
2015	100.9712	107.5652	95.0989	94.5517
2016	107.5904	108.0331	95.6798	94.9888
2017	**108.3525**	**107.3327**	**93.2018**	**94.4801**

The following country-specific emission factors including oxidation factor were used for the calculations of the emissions for all years and subcategories in CRF 1.A.

Table 25 Country-specific EFs incl. oxidation factor for CO_2 for solid fuels [t/TJ]

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke
1988-2006	98.4802	105.8747	95.6910	94.5161
2007	97.5236	104.9506	98.3294	95.7225

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke
2008	100.7763	106.8890	96.2981	94.9830
2009	99.6547	105.5404	95.1683	93.0881
2010	97.3953	105.8315	93.4475	94.0458
2011	96.6057	105.1891	95.0759	92.3586
2012	96.3049	105.3618	96.4435	93.5150
2013	95.8515	104.8037	95.3831	94.1049
2014	96.6008	104.6660	94.1733	94.7434
2015	98.2139	104.3856	93.4664	94.5258
2016	104.9487	104.5859	93.8423	94.9704
2017	**105.5266**	**104.0991**	**90.1683**	**94.4578**

The national emission estimates were prepared using country-specific emission factors, including oxidation factor for anthracite, lignite, other bituminous coke and petroleum coke. For all other solid fuels, default emission factors were used and an oxidation factor of 1 was applied.

For the purposes of annual reports under Regulation 601/2012 on the monitoring and reporting of greenhouse gas emissions, plant operators should use either plant-specific emission factors, the country-specific emission factors excluding oxidation factor (Table 24) or the default emission factors (Table 22). Plant operators should apply either a plant-specific oxidation factor or an oxidation factor of 1, since the IPCC Guidelines do not provide default oxidation factors. Although the calculated weighted-average country-specific oxidation factors for solid fuels are representative on a national level, they cannot be applied on a plant level due to significant technological differences among various installations.

3.3.8.2.3 Country specific emission factors for CO_2 for gaseous fuels

As CO_2 emissions from natural gas are a key category in several subcategories and following previous ARR (CC/ERT/ARR/2010/37, §82) recommendations, an improved calculation for a country-specific emission factor for natural gas was executed. To this end, additional data from relevant companies was collected:

- Bulgargaz EAD, the sole public supplier of natural gas for the territory of the Republic of Bulgaria for the period 2007-2017
- Petroceltic Bulgaria EOOD and Oil and Gas Exploration and Production AD - the companies licensed for oil and gas extraction for the period 2004-2017 and 1999-2017 respectively

The companies provided the following parameters of the natural gas they supplied or extracted over the above-stated periods:

- the percentages of methane, ethane, propane, i-butane, n-butane, i-pentane, n-pentane, neo-pentane, i-hexane, N_2 and CO_2 as molar percentage;
- density, NCV/GCV and quantities supplied or extracted at a temperature of 20°C (293.15 K) and an absolute pressure of 101.325 kPa (760 mm Hg)

Using stoichiometric calculations and the above data it was possible to calculate a country specific emission factor for natural gas for each year and also as a weighted average for the period 2007-2010.

The calculation showed that the average country-specific emission factor for natural gas is about 1.6% lower than the default emission factor, which was previously used.

Table 26 Country-specific carbon contents and EFs for CO_2 for gaseous fuels [t/TJ]

Natural gas	Carbon content	EF excl. oxidation factor
1988-2006	15.0557	55.2044
2007	15.0501	55.1839
2008	15.0479	55.1758
2009	15.0647	55.2371
2010	15.0658	55.2413
2011	15.0717	55.2628
2012	15.0542	55.1987
2013	15.0999	55.3662
2014	15.1186	55.4349
2015	15.1711	55.6275
2016	15.1734	55.6359
2017	**15.1317**	**55.4829**

As there is no country-specific oxidation factor for natural gas, the default value of 1 was used for the emission estimates.

Since all gas companies report and account the quantities of natural gas at a temperature of 20°C (293.15 K) and an absolute pressure of 101.325 kPa, all calculations were performed considering those conditions. However, since 2012, the National Statistics has started to report to Eurostat the used quantities of natural gas in cubic meters and at a temperature of 15°C. In order to convert the reported values a conversion factor of 1.017 is used (i.e. $Q_{15} = Q_{20} / 1.017$ and $NCV_{15} = NCV_{20} * 1.017$).

For CH_4 emission estimates the default emission factors referenced in IPCC 2006 guidelines, Vol. II, Ch. 2, Table 2-2, Table 2-3, Table 2-4, Table 2-5 are applied.

Table 27 Emission factors for CH_4 for different fuels [kg/TJ]

Fuel	Energy Industries	Manufacturing Industries and Construction	Commercial / Institutional	Residential and Agriculture / Forestry / Fishing
LIQUID FOSSIL				
Primary fuels				
Crude Oil	3	3	10	10
Orimulsion	3	3	10	10
Natural Gas Liquids	3	3	10	10
Secondary fuels/products				
Motor Gasoline	3	3	10	10
Aviation Gasoline	3	3	10	10
Jet Gasoline	3	3	10	10
Jet Kerosene	3	3	10	10
Other Kerosene	3	3	10	10
Shale Oil	3	3	10	10
Gas / Diesel Oil	3	3	10	10
Residual Fuel Oil	3	3	10	10
Liquefied Petroleum Gases	1	1	5	5
Ethane	1	1	5	5
Naphtha	3	3	10	10
Bitumen	3	3	10	10
Lubricants	3	3	10	10
Petroleum Coke	3	3	10	10

Fuel	Energy Industries	Manufacturing Industries and Construction	Commercial / Institutional	Residential and Agriculture / Forestry / Fishing
Refinery Feedstocks	3	3	10	10
Refinery Gas	1	1	5	5
Paraffin Waxes	3	3	10	10
White Spirit and SBP	3	3	10	10
Other Petroleum Products	3	3	10	10
SOLID FOSSIL				
Primary Fuels				
Anthracite	1	10	10	300
Coking Coal	1	10	10	300
Other Bituminous Coal	1	10	10	300
Sub-Bituminous Coal	1	10	10	300
Lignite	1	10	10	300
Oil Shale and Tar Sands	1	10	10	300
Secondary fuels/products				
Brown Coal Briquettes	1	10	10	300
Patent Fuel	1	10	10	300
Coke - Gas Coke	1	10	10	300
Coal Tar	1	1	5	5
Gas Works Gas	1	10	10	300
Coke Oven Gas	1	1	5	5
Blast Furnace Gas	1	1	5	5
Oxygen Steel Furnace Gas	1	1	5	5
GASEOUS FOSSIL				
Natural Gas	1	1	5	5
OTHER FOSSIL				
Municipal Wastes (non-biomass fraction)	30	30	300	300
Industrial Wastes	30	30	300	300
Waste Oils	30	30	300	300
Peat	1	2	10	300
SOLID BIOMASS				
Wood / Wood Waste	30	30	300	300
Sulphite lyes (Black Liquor)	3	3	3	3
Other Primary Solid Biomass	30	30	300	300
Charcoal	200	200	200	200
LIQUID BIOMASS				
Biogasoline	3	3	10	10
Biodiesels	3	3	10	10
Other Liquid Biofuels	3	3	10	10
GASEOUS BIOMASS				
Landfill Gas	1	1	5	5
Sludge Gas	1	1	5	5
Other Biogas	1	1	5	5
OTHER BIOMASS				
Municipal Wastes (biomass fraction)	30	30	300	300

For N_2O the default emission factors referenced in the IPCC 2006 Guidelines, Vol. II, Ch. 2, Table 2-2, Table 2-3, Table 2-4, Table 2-5 are applied.

Table 28 Emission factors for N_2O for different fuels [kg/TJ]

Fuel	Energy Industries	Manufacturing Industries and Construction	Commercial / Institutional	Residential and Agriculture / Forestry / Fishing
LIQUID FOSSIL				
Primary fuels				
Crude Oil	0.6	0.6	0.6	0.6
Orimulsion	0.6	0.6	0.6	0.6
Natural Gas Liquids	0.6	0.6	0.6	0.6
Secondary fuels/products				
Motor Gasoline	0.6	0.6	0.6	0.6
Aviation Gasoline	0.6	0.6	0.6	0.6
Jet Gasoline	0.6	0.6	0.6	0.6
Jet Kerosene	0.6	0.6	0.6	0.6
Other Kerosene	0.6	0.6	0.6	0.6
Shale Oil	0.6	0.6	0.6	0.6
Gas / Diesel Oil	0.6	0.6	0.6	0.6
Residual Fuel Oil	0.6	0.6	0.6	0.6
Liquefied Petroleum Gases	0.1	0.1	0.1	0.1
Ethane	0.1	0.1	0.1	0.1
Naphtha	0.6	0.6	0.6	0.6
Bitumen	0.6	0.6	0.6	0.6
Lubricants	0.6	0.6	0.6	0.6
Petroleum Coke	0.6	0.6	0.6	0.6
Refinery Feedstocks	0.6	0.6	0.6	0.6
Refinery Gas	0.1	0.1	0.1	0.1
Paraffin Waxes	0.6	0.6	0.6	0.6
White Spirit and SBP	0.6	0.6	0.6	0.6
Other Petroleum Products	0.6	0.6	0.6	0.6
SOLID FOSSIL				
Primary Fuels				
Anthracite	1.5	1.5	1.5	1.5
Coking Coal	1.5	1.5	1.5	1.5
Other Bituminous Coal	1.5	1.5	1.5	1.5
Sub-Bituminous Coal	1.5	1.5	1.5	1.5
Lignite	1.5	1.5	1.5	1.5
Oil Shale and Tar Sands	1.5	1.5	1.5	1.5
Secondary fuels/products				
Brown Coal Briquettes	1.5	1.5	1.5	1.5
Patent Fuel	1.5	1.5	1.5	1.5
Coke - Gas Coke	1.5	1.5	1.5	1.5
Coal Tar	0.1	0.1	0.1	0.1
Gas Works Gas	1.5	1.5	1.5	1.5
Coke Oven Gas	0.1	0.1	0.1	0.1
Blast Furnace Gas	0.1	0.1	0.1	0.1
Oxygen Steel Furnace Gas	0.1	0.1	0.1	0.1
GASEOUS FOSSIL				
Natural Gas	0.1	0.1	0.1	0.1
OTHER FOSSIL				
Municipal Wastes (non-biomass fraction)	4	4	4	4
Industrial Wastes	4	4	4	4
Waste Oils	4	4	4	4
Peat	1.5	1.5	1.4	1.4
SOLID BIOMASS				
Wood / Wood Waste	4	4	4	4

Fuel	Energy Industries	Manufacturing Industries and Construction	Commercial / Institutional	Residential and Agriculture / Forestry / Fishing
Sulphite lyes (Black Liquor)	2	2	2	2
Other Primary Solid Biomass	4	4	4	4
Charcoal	4	4	1	1
LIQUID BIOMASS				
Biogasoline	0.6	0.6	0.6	0.6
Biodiesels	0.6	0.6	0.6	0.6
Other Liquid Biofuels	0.6	0.6	0.6	0.6
GASEOUS BIOMASS				
Landfill Gas	0.1	0.1	0.1	0.1
Sludge Gas	0.1	0.1	0.1	0.1
Other Biogas	0.1	0.1	0.1	0.1
OTHER BIOMASS				
Municipal Wastes (biomass fraction)	4	4	4	4

3.3.8.2.4 Choice of emission factors for mobile sources

The emission factors for mobile sources are presented in Chapter 3.3.12.3.5.

3.3.8.3 Choice of activity data for stationary sources

The activity data required for the calculation of emissions from stationary combustion is based on the National Energy Balances, which provide information about indigenous production, imports, exports and inland consumption, by subcategory, of all types of fuels.

The balances provide the consumption of fuels in natural units (mass or volume units – thousands of tons/Gg for solid and liquid fuels, cubic meters for gaseous fuels) and the net calorific values for each fuel per subcategory.

Following the recommendations, the energy balances prepared by the National Statistics Institute in the Eurostat format were used for estimating the emissions for the years 1990-2017. As the National statistics have not prepared balances in the Eurostat format for the years before 1990, the IEA Energy balances were used for the years 1988 and 1989.

Additionally, it was established that the use of alternative fuels (industrial waste) is not reported in the energy balances for the entire time series. As a result, the reports provided by plants operating according to Bulgarian waste legislation and ETS reports were used in order to calculate the GHG emissions from waste incineration in cement and other plants.

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. 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.

The correspondence between the energy balance categories and CRF categories can be reviewed in detail in Annex III.

The national energy balance is provided by NSI. The energy balance also presents the net calorific values (NCVs) used for converting mass or volume units of the fuel quantities into energy units [TJ].

3.3.8.3.1 Choice of NCV

The corresponding Net Calorific Values (NCVs) for each category from the Energy balances were used in order to convert the fuel consumption reported in natural units to energy units. For solid fuels there is more than one NCV provided in the Energy balance. Details about the correspondence between each type of NCV and each category are presented in Annex III.

For the reference approach for solid fuels the weighted average NCV from the NCVs of production, imports and exports was calculated. The calculated NCVs used for the reference approach can be found in Annex IV.

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

For gaseous fuels the amount in TJ as reported by the energy balances was used directly. Since the reported values are Gross Calorific Values, all numbers were multiplied by 90% in order to calculate the NCV. (IEA Energy Statistics Manual, p. 183, Table A3.12)

Table 29 Selected Net Calorific Values for 2017

Fuel	Public electricity and heat production [TJ/Gg]	Industry [TJ/Gg]
Liquid fuels		
Crude oil	42.538	
Gasoline	42.654	
Jet Kerosene	43.000	
Gas/Diesel Oil	41.986	
Residual Fuel Oil	40.000	
LPG	46.000	
Naphtha	43.961	
Bitumen	37.700	
Lubricants	42.300	
Petroleum Coke	31.400	
Refinery Feedstocks	40.901	
Refinery Gas	45.238	
White Spirit SBP	44.000	
Paraffin Wax	30.000	
Other Petroleum Products	40.447	
Solid fuels		
Anthracite	21.375	29.498
Coking Coal	-	-
Other Bituminous Coal	20.515	24.000
Lignite and Sub-bituminous Coal	6.872	9.856
BKB & Patent Fuel	12.370	15.074
Coke Oven / Gas Coke	-	28.500
Gaseous fuels		
Natural Gas, 20°C [TJ/1000 m3]	0.034287	
Natural Gas, 15°C [TJ/1000 m3]	0.034870	

For all NCVs please consult Annex IV.

3.3.8.4 Biomass

A wide range of biomass sources can be used to produce bioenergy in a variety of forms. Solid biofuels include the following:

- wood and wood waste combusted directly for energy purposes and biomass used for charcoal production

- black liquor - concentrated residue from the pulp and paper industry
- other primary solid biomass - plant residues not included in the above-stated black liquor and wood and wood waste categories
- charcoal - a product from destructive distillation and pyrolysis of wood and other vegetal material
- Liquid biofuels as biogasoline, biodiesel and other bioliquids are mainly used for transportation. This is further explained in the transport sector section.

Landfill, sludge and other biogas is generated by the anaerobic fermentation of biomass and solid wastes in landfills, from sludge and animal slurries and other sources, respectively. In addition to biogas, a solid biomass fraction is present in municipal waste. All these types of biomass are combusted to produce heat and/or power. However, CO_2 emissions released from these processes are reported as an information item, as the released CO_2 is considered naturally absorbed. Yet, this is not applicable for the methane and N_2O emissions that are reported and accounted in the total inventory emissions.

In Bulgaria all types of biomass – solid, liquid and gaseous – are used as an energy source. Biomass is primarily used for the production of heat in the transformation sector (autoproducer heat and CHP; main activity producer heat plants), industry, residential, commercial and public services sector, agriculture and other sectors.

Over the course of the examined time series, solid biomass has primarily been combusted for the following activities:

- Energy industries (main activity producer heat plants, own use in electricity, CHP and heat plants)
- Manufacturing Industries and construction (iron and steel, chemical and petrochemical, non-ferrous metals, non-metallic minerals, transport equipment, machinery, mining and quarrying, food and tobacco, paper, pulp and print, wood and wood products, construction, textile and leather and non-specified (industry); autoproducer CHP plants and autoproducer heat plants
- Other sectors (residential, commercial/institutional, agriculture/forestry/fishing, non-specified other)
- Regarding liquid and gaseous types, only limited amounts of biodiesel, biogasoline and sludge gas has been utilized. Liquid biofuels have been consumed in road transport sector, while gaseous fuels have been consumed in agriculture, commercial and public services and electricity and heat plants. Data for liquid biofuels is reported for 2006-2017 and for gaseous biofuels is reported for 2008-2017.

For the estimate of the CH_4 and N_2O emissions the EFs from 2006 IPCC Guidelines, Vol. 2, Ch. 2, Table 2.2-2.5 were applied.

3.3.8.5 Other fossil fuels

There is a specific case to develop a separate calculation model for alternative fuels used in the industry. Due to the fact that all cement plants participate in the ETS, their verified reports were used in order to calculate the country-specific EFs for the following fuels:

- SRF/RDF
- Waste oils
- Tyres
- Filters
- Biomass

Data from the reports of all industrial plants, submitted according to Bulgarian waste legislation, was used in order to calculate the emissions based on specific waste type.

According to this model the emissions from biomass fraction and non-biogenic fraction are accounted separately, as CO_2 emissions from biomass fraction must not be included in the national totals.

3.3.8.6 Uncertainties in CRF 1.A

STATIONARY COMBUSTION

3.3.8.6.1 Uncertainty of AD

Solid fuels

About 95% of solid fuels consumption is derived from national lignite production, whereas less than 5% of solid fuels (anthracite and bituminous coal) are imported, predominantly from Russia and Ukraine. Except for electricity production, solid fuels are used in the chemical industry, as well as in the non-metallic minerals and iron and steel industry. The Eurostat format energy balances, which are prepared by NSI, are based on bottom-up and top-down approach.

For the early years of the time series, the allocation between 'Transformation sector', 'Energy sector' and 'Total Final Consumption' and among the subcategories isn't always consistent; in general, consumption tends to be allocated to 'Other' categories (1.A.2.g and 1.A.5). Varying coal properties (ash, moisture, sulphur, and calorific value) – even from the same mines – are another reason for uncertainties. Ultimately, coal is quantified on a mass basis and therefore associated conversion factors may cause uncertainties. Broadly speaking, solid fuels utilized in the ETS participating plants have a considerably lower uncertainty compared to solid fuels which are used small combustion plants.

Based on the above background information, the uncertainties are estimated as following:

- For CRF categories 1.A.1 and 1.A.2: 1%
- For CRF category 1.A.4 and 1.A.5: 2%

Natural gas

According to the Energy Act, the supply, transmission and storage of natural gas are licensed to Bulgargaz and Bulgartransgaz. The gas transmission network consists of gas pipelines with high-pressure branches, compressor stations, gas pressure-reduction stations and gas measuring stations. The gas transmission network for natural gas transit is not connected to the national gas transmission network. Furthermore, underground gas storage and a related compressor stations exist. Losses are mainly due to leakages, maintenance, old pipes, and varying pressure. Whereas the uncertainty of natural gas supplied to the industry can be assessed as low, the uncertainty for natural gas consumed by households is higher due to the large number of licensed providers and network complexity. Another reason for uncertainty is related to GCV and the conversion factor m^3 to TJ.

Based on the above background information, the uncertainties are estimated to be:

- For CRF categories 1.A.1 and 1.A.2: 1%
- For CRF category 1.A.4 and 1.A.5: 5%

Liquid fuels

Five main importers and distributors of petrol oil are operating more than 3000 petrol stations In Bulgaria. Crude oil is more or less exclusively imported from Russia, Ukraine and other former

Russian republics. Liquid fuels are either refined in the LUKOIL Neftochim refinery in Burgas or imported. Due to recent regulations the amounts of gasoline and diesel fuel, sold at petrol stations, have been monitored in real-time since January 2011, which leads to low uncertainty. Nevertheless, before 2011, there were occasional reports for small distributors not declaring the liquid fuels they have sold in order to avoid taxes. For some of the years, the allocation of various liquid fuels to the subcategories is not clear. Therefore, a higher uncertainty is estimated for small combustion plants and engines.

Based on the above background information, the uncertainties are estimated as following:

- For CRF categories 1.A.1 and 1.A.2: 3%
- For CRF category 1.A.4 and 1.A.5: 5%

3.3.8.6.2 Uncertainty for EF

Since for some of the fuels the default EFs from the 2006 IPCC GL were used, the data on default uncertainties presented in "Table A1-1 Uncertainties due to emission factors and activity data" (1996 IPCC GL, p. D 1.4) is applicable (referenced by the 2006 IPCC GL). For the energy sector the uncertainty for emission factor and activity data is 7%.

For the country-specific EFs for solid fuels, the ETS verified reports were used, which involves much lower uncertainty. Nevertheless, the conditions in which solid fuels are combusted are very different. Therefore, higher uncertainty can especially be caused by oxidation factors for solid fuels in households.

Based on the above background information, the uncertainties are estimated as follows:

- For solid fuels in CRF categories 1.A.1 and 1.A.2: 2%
- For solid fuels in CRF category 1.A.4 and 1.A.5: 5%
- For liquid fuels: 7%
- For gaseous fuels: 2%

Quantitative uncertainty estimates are provided in Annex II.

3.3.8.7 Source-specific QA/QC and verification

For the calculation of the emissions from CRF category 1A, an Excel based spreadsheet model was developed, which was linked directly to the Eurostat format energy balances provided by the NSI.

Wherever possible, automated data validation was implemented within the model, yet a number of manual checks were performed, as well.

Following recommendation FCCC/ARR/2011/BGR, §65 the possibility of obtaining a correlation between the carbon content and the NCV of each fuel, reported by selected facilities which have used higher tier methods under the EU ETS, was investigated. To this end, recent scientific literature was consulted (Fott, 1999; Mazumdar, 2000; Mesroghli et al., 2009). Due to the fact that the number of samples is relatively low and coal in Bulgaria is locally produced and imported in a varying proportion, it was established that there is a very limited correlation between the NCV and the CO_2 emission factors for all types of coal (Anthracite, Other Bituminous Coal, Sub-Bituminous Coal, Lignite). This is mostly due to the fact that the NCV is also dependent on other parameters like hydrogen, oxygen and sulphur contents, also ash and water contents.

3.3.8.7.1 Activity data checks

Trend analysis was performed regarding activity data for all subcategories and individual fuels. In order to provide an explanation for variations, the most notable data peaks/drops were discussed with

NSI. Since the methodologies used by the National statistics have changed several times over the years, there are several sectors with significant differences in fuel consumption over various time periods. These differences are a result of reallocation of the consumption in different subcategories. An attempt to compare the reallocated quantities was made. To be specific, if a significant decrease in the consumption is noticed in a subcategory, it is considered if an equal drop is noticeable in another subcategory in which case the consumption was reallocated in the following years.

Some changes in the activity data were necessary, because NCVs are not provided for some of the years for some fuels (most notably solid fuels for 1990-91 and 1998) by the NSI. All changes on the activity data were discussed with and approved by the data provider.

For some subcategories the activity data regarding the energy consumption and the data for the production were checked for correlation.

Activity data peaks/drops were discussed with industrial process experts in order to identify sectoral restructuring (closing or opening of plants) or technological changes within specific plants, which result in fuel mix or energy consumption changes.

3.3.8.7.2 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 the proper unit conversions 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 coloured 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 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.

Currently the data from the calculation models is transferred manually to the CRF reporter import templates. In order to ensure that there are no differences due to technical errors, additional comparisons are made between the data in the calculation models and the CRF tables generated by the CRF Reporter software.

3.3.8.8 Source-specific recalculations, including changes made in response to the review process

Following a recommendation of a previous ARR (CC/ERT/ARR/2010/37, §72), a change in the calculation model was introduced. Up until the year 2003, the National statistics provides only aggregated information regarding the consumption of anthracite coal and other bituminous coal – they are reported as other bituminous coal. Notably, EF for anthracite coal is about 2% higher than EF for other bituminous coal. Thus, in order to avoid underestimation of the emissions it was decided to use the EF for anthracite coal to calculate the emissions from other bituminous coal.

Following another ARR recommendation (CC/ERT/ARR/2010/37, §66), the calculation models were improved, so they could be directly linked to the activity data.

Up to the 2011 submission, the country-specific emission factors were calculated as a weighted average from the available ETS reports and applied to all the years in the time series, which was leading to an annual recalculation of the entire time series. From the 2012 submission on, the country specific emission factors are calculated as a weighted average from all reports for 2007, 2008, 2009 and 2010 and applied for the period 1988-2006, whereas for the years after 2007 the respective annual EF is used. The differences in country-specific emission factors can be found in Table 23.

Following the ERT recommendations from the 2016 review cycle, several methodological changes were adopted, leading to recalculations of the inventory. The consumption of anthracite and other bituminous coal in the National Energy Balance was aggregated for the period 1988-2003. The quantities were disaggregated based on the shares of the consumption for the period 2004-2014 and the NCVs were recalculated, which led to recalculations in all subcategories. Additionally, a new methodology for allocation of energy and non-energy use of coke oven coke in the non-ferrous sector was adopted, resulting in reallocation of a significant part of previously reported emissions to subcategory 2C.

3.3.8.9 Source-specific planned improvements, including those in response to the review process

We are currently applying a Tier 1 method for the estimation of emissions from category 1.B.1.a. Coal mining and handling. In order to implement a Tier 2/3 approach, the IPCC guidelines propose to examine measurement data from a number of underground coal mines and to measure the in-situ gas content of coal samples. Currently, no such data is available for Bulgaria. At present, about 2% of the annual coal production in Bulgaria is derived from underground mines. Moreover, mostly lignite coal is produced in Bulgaria, which has lower EF than higher coal ranks, such as bituminous. Currently, the use of global average emission factors does not lead to underestimation of the emissions from this category. The financial costs related to the required laboratory measurements necessary to derive a country-specific emission factor were estimated to be very high. Depending on the available financial resources we plan to set the timeframe for implementing a Tier 2 approach.

3.3.9 EMISSION TREND

The fuel consumption in 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

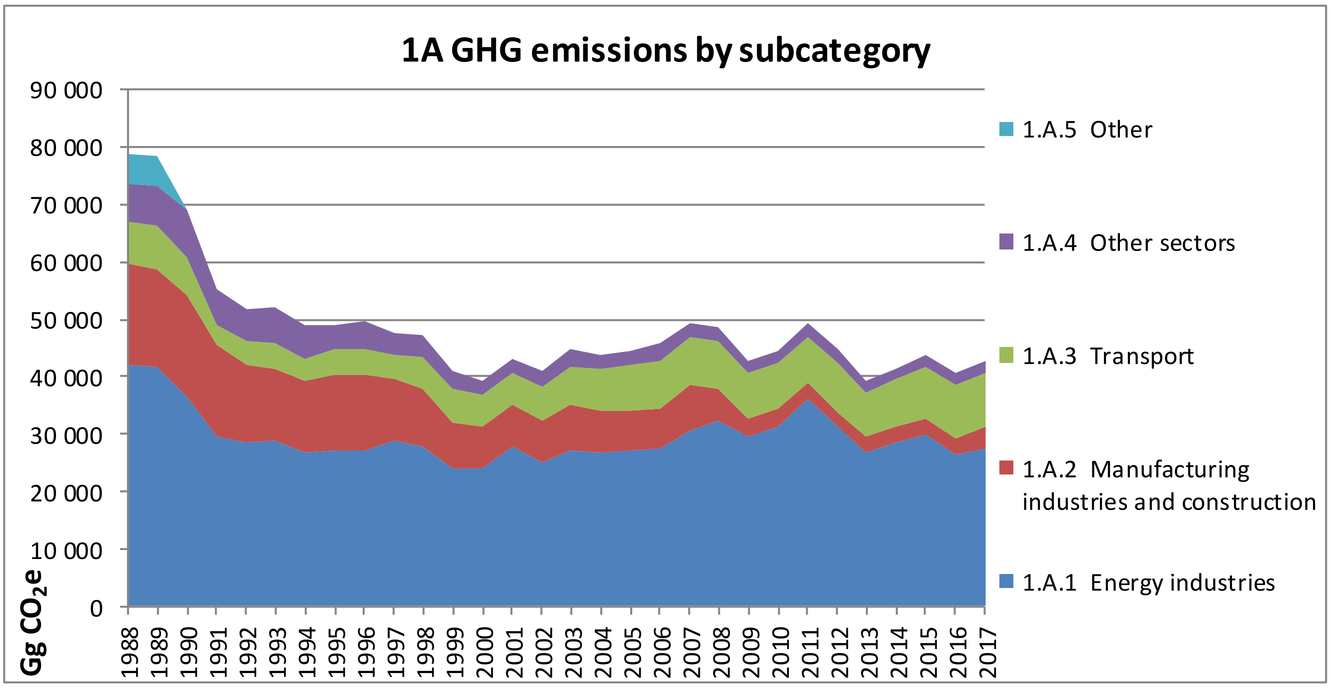

Figure 22 Total GHG emissions from Fuel combustion by subcategory

Energy Industries are the main source of GHG emissions from fuel combustion with 64.7% of the sector emissions for 2017. Transport is the second most important source with 22.1% of the sector emissions, followed by Manufacturing industries and construction with 8.4%.

The general trend shows a sharp drop in country emissions after 1990-1991 due to Bulgaria's transition from planned to market economy. The decrease of the GHG emissions continued until 1999, followed by a slow increase after 2000, when the national economy started to grow. In 2008-2009, due to the economic crisis, the emissions decreased again, approaching the 2000 levels. In 2010 and 2011 there was an increasing trend of the emissions, which was mostly due to the increase in fossil fuel energy production. In 2012 and 2013 there was a drop in country emissions, mostly due to decrease of fossil fuels used for electricity generation and an increase in renewable energy sources. The drop was partially compensated in 2014 and 2015 due to the increase of electricity exports and fuel consumption in Transport sector. In 2017 there is an increase of the emissions from fuel combustion of 5.3% compared to 2016 which is due to the decrease of electricity production and exports.

Manufacturing industry and construction is the sector, which changed drastically – compared to 1988 the emissions decreased by 79.4% in 2017. The significant decrease of the emissions after 2008 is mostly due to the restructuring of the Iron and steel industry in Bulgaria. The closure of Bulgaria's biggest I&S plant, which was the only plant in the country operating coke ovens and blast furnaces, decreased significantly the emissions from solid fuels and the emissions from the industry subcategory in general, even though since 2015 the emissions from gaseous fuels started to increase. In 2017 there was a significant increase in the consumption of liquid and solid fuels in the chemical industry.

The trend for solid fuels was reversed in 2011 mostly due to the opening of a new coal power plant and the general increase of electricity production from lignite coal in the country. However, the reduced electricity exports and the increased renewable energy production (solar, wind and biomass) in 2012 and 2013 have led to a significant decrease of solid fuels usage and emissions, which was only partially compensated in the following years.

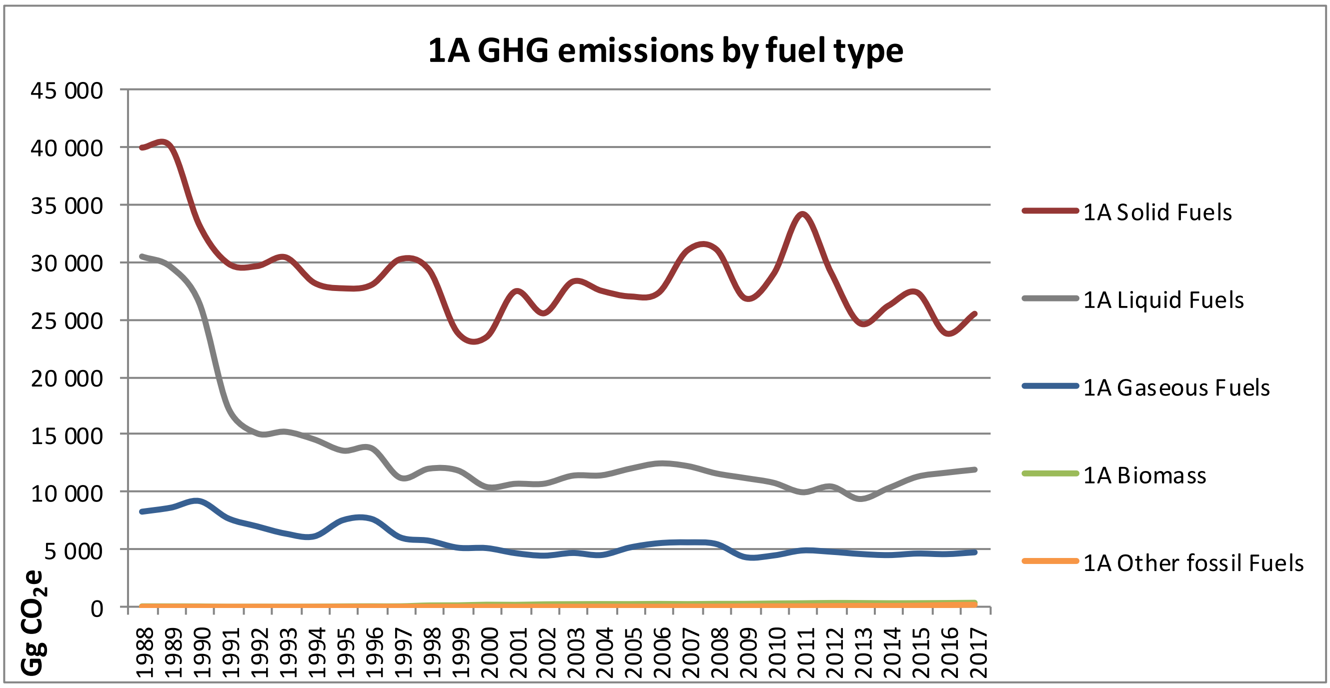

Figure 23 Total GHG emissions from Fuel combustion by fuel type

In 2017, 59.9% of the emissions from fuel combustion were from solid fuels, 28.0% were from liquid fuels, and 11.1% were from gaseous fuels.

The general trend shows a decrease in the share of solid fuels, mostly due to the energy industries reduced exports, increase in liquid and gaseous fuels due to the increase of transport and industry sectors, including of the on-going gasification of industrial plants, residential sector and transport.

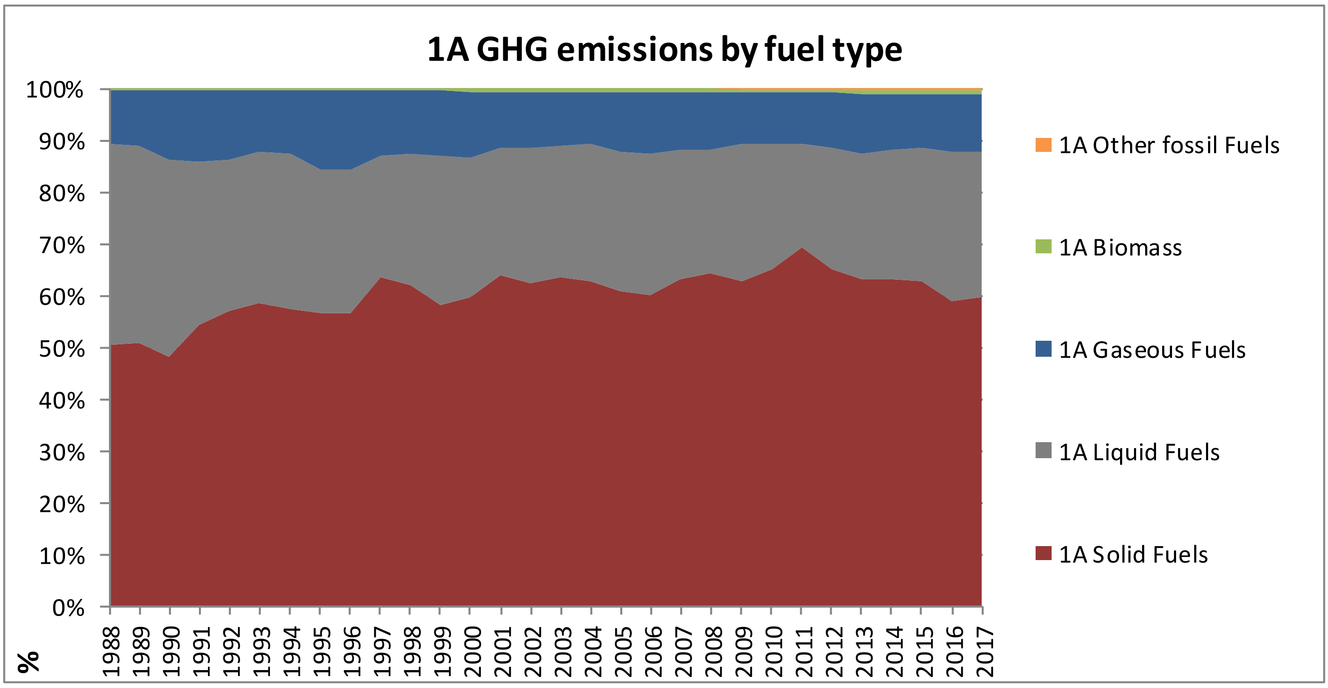

Figure 24 Total GHG emissions from Fuel combustion by fuel type

Table 30 CO_2 emissions in 1.A. Fuel Combustion

CO_2 (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	77 901.99	30 098.27	39 467.62	8 336.10	889.3920	NO
1990	68 148.36	26 010.68	32 856.19	9 281.48	808.7520	NO
1995	48 467.91	13 385.59	27 494.56	7 587.76	945.9520	NO
2000	38 766.90	10 272.75	23 388.99	5 105.16	2 580.2560	NO
2005	43 904.39	11 860.45	26 878.52	5 162.62	3 262.2153	2.8073
2010	43 977.95	10 679.34	28 827.99	4 445.63	4 283.1154	25.0006
2011	48 748.53	9 859.39	33 972.88	4 889.51	4 544.8210	26.7375
2012	44 105.69	10 360.56	28 930.94	4 774.46	5 114.8498	39.7388
2013	38 502.82	9 283.15	24 589.36	4 578.78	5 303.7763	51.5288
2014	40 867.88	10 221.22	26 123.38	4 475.36	5 053.4693	47.9238
2015	43 136.12	11 201.85	27 254.76	4 614.34	5 412.0705	65.1663
2016	39 947.72	11 554.64	23 729.49	4 561.65	5 733.2814	101.9390
2017	42 077.75	11 822.29	25 414.03	4 721.65	5 818.3931	119.7840
Decrease 1988-2017	46.0%	60.7%	35.6%	43.4%	-554.2%	-
Decrease 1990-2017	38.3%	54.5%	22.7%	49.1%	-619.4%	-
Decrease 2016-2017	-5.3%	-2.3%	-7.1%	-3.5%	-1.5%	-17.5%

Table 31 CH_4 emissions in 1.A. Fuel Combustion

CH_4 (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	18.4707	3.8981	12.0393	0.1510	2.3823	NO
1990	15.6118	3.8865	9.3878	0.1712	2.1663	NO
1995	11.5475	2.4911	6.7223	0.1408	2.1933	NO
2000	11.6212	1.6642	3.3690	0.0967	6.4913	NO
2005	12.9049	1.4695	3.4212	0.1463	7.8668	0.0010
2010	13.4687	1.1405	2.7783	0.2247	9.3150	0.0103
2011	14.4939	1.0293	3.4149	0.2380	9.8024	0.0092
2012	15.0134	1.0096	3.2582	0.2483	10.4833	0.0140
2013	14.0487	0.8738	2.7207	0.2616	10.1756	0.0169
2014	12.9599	0.9421	2.0056	0.2865	9.7093	0.0165
2015	13.0626	0.9650	2.0552	0.2902	9.7291	0.0230
2016	13.5437	0.9077	2.2399	0.2690	10.0869	0.0401
2017	14.2848	0.8376	2.3960	0.2684	10.7332	0.0496
Decrease 1988-2017	22.7%	78.5%	80.1%	-77.7%	-350.5%	-
Decrease 1990-2017	8.5%	78.4%	74.5%	-56.8%	-395.5%	-
Decrease 2016-2017	-5.5%	7.7%	-7.0%	0.2%	-6.4%	-23.6%

Table 32 N_2O emissions in 1.A. Fuel Combustion

N_2O (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	1.7567	1.1362	0.5737	0.0151	0.0318	NO
1990	1.6885	1.1663	0.4765	0.0168	0.0289	NO

N_2O (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1995	1.0615	0.6171	0.3968	0.0137	0.0338	NO
2000	0.9611	0.5236	0.3361	0.0092	0.0922	NO
2005	1.0696	0.5523	0.3909	0.0097	0.1165	0.0001
2010	0.9990	0.4152	0.4218	0.0092	0.1515	0.0014
2011	1.0881	0.4203	0.4955	0.0098	0.1612	0.0012
2012	1.0352	0.4247	0.4201	0.0096	0.1790	0.0019
2013	0.9446	0.3894	0.3592	0.0093	0.1844	0.0023
2014	0.9840	0.4143	0.3821	0.0092	0.1762	0.0022
2015	1.0458	0.4494	0.3965	0.0093	0.1875	0.0031
2016	0.9940	0.4390	0.3449	0.0092	0.1955	0.0054
2017	1.0311	0.4441	0.3709	0.0095	0.1999	0.0066
Decrease 1988-2017	41.3%	60.9%	35.3%	37.0%	-529.4%	-
Decrease 1990-2017	38.9%	61.9%	22.2%	43.5%	-592.1%	-
Decrease 2016-2017	-3.7%	-1.2%	-7.6%	-3.3%	-2.3%	-23.6%

Table 33 GHG emissions in 1.A. Fuel Combustion

GHG (Gg)	TJ	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	953 191.74	78 887.25	30 534.29	39 939.55	8 344.38	69.0232	NO
1990	855 388.27	69 041.82	26 455.40	33 232.88	9 290.77	62.7649	NO
1995	602 106.97	49 072.91	13 631.77	27 780.87	7 595.37	64.9009	NO
2000	489 196.28	39 343.85	10 470.41	23 573.36	5 110.34	189.7433	NO
2005	551 294.18	44 545.74	12 061.78	27 080.54	5 169.16	231.3895	2.8728
2010	545 120.59	44 612.38	10 831.57	29 023.14	4 453.98	278.0271	25.6658
2011	595 157.90	49 435.12	10 010.38	34 205.91	4 898.39	293.1084	27.3353
2012	555 093.91	44 789.52	10 512.35	29 137.57	4 783.54	315.4251	40.6428
2013	498 508.51	39 135.54	9 421.05	24 764.42	4 588.10	309.3506	52.6232
2014	521 886.43	41 485.11	10 368.24	26 287.39	4 485.26	295.2337	48.9889
2015	552 260.03	43 774.35	11 359.90	27 424.31	4 624.38	299.0993	66.6581
2016	526 145.72	40 582.51	11 708.17	23 888.25	4 571.12	310.4366	104.5375
2017	550 840.40	42 742.13	11 975.57	25 584.47	4 731.19	327.9048	122.9959
Decrease 1988-2017	42.2%	45.8%	60.8%	35.9%	43.3%	-375.1%	-
Decrease 1990-2017	35.6%	38.1%	54.7%	23.0%	49.1%	-422.4%	-
Decrease 2016-2017	-4.7%	-5.3%	-2.3%	-7.1%	-3.5%	-5.6%	-17.7%

3.3.10 ENERGY INDUSTRIES (CRF 1.A.1)

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

- Conventional electricity, CHP and heat plants (public and autoproducers),
- Petroleum refining plants,
- Solid fuel transformation plants,
- Oil and gas extraction and coal mining,

- Own consumption of the energy sector.

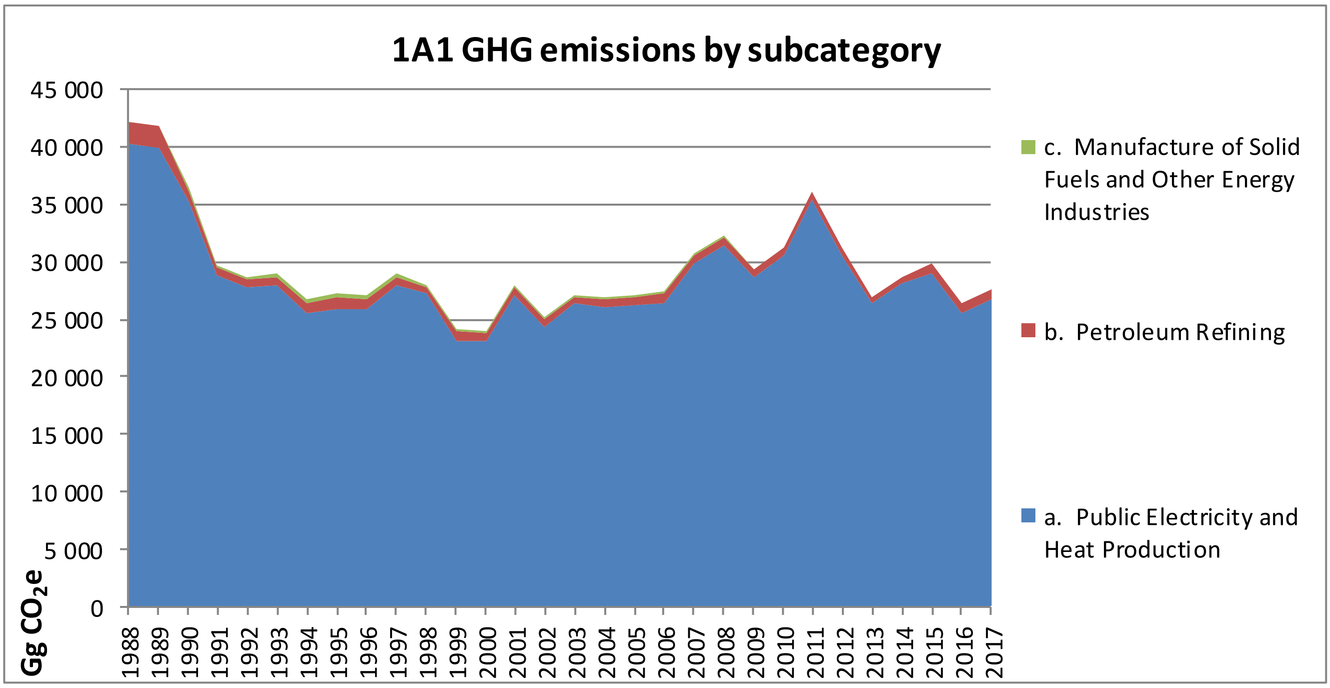

Figure 25 Total GHG emissions from 1.A.1 Energy industries by subcategory

For 2017 the general trend in CRF category 1.A.1 is a decrease in the emissions of 34.4% compared to base year and an increase of 4.9% compared to last year.

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

Category 1.A.1.a Public Electricity and Heat Production covers emissions from fuel combustion in public power and heat plants.

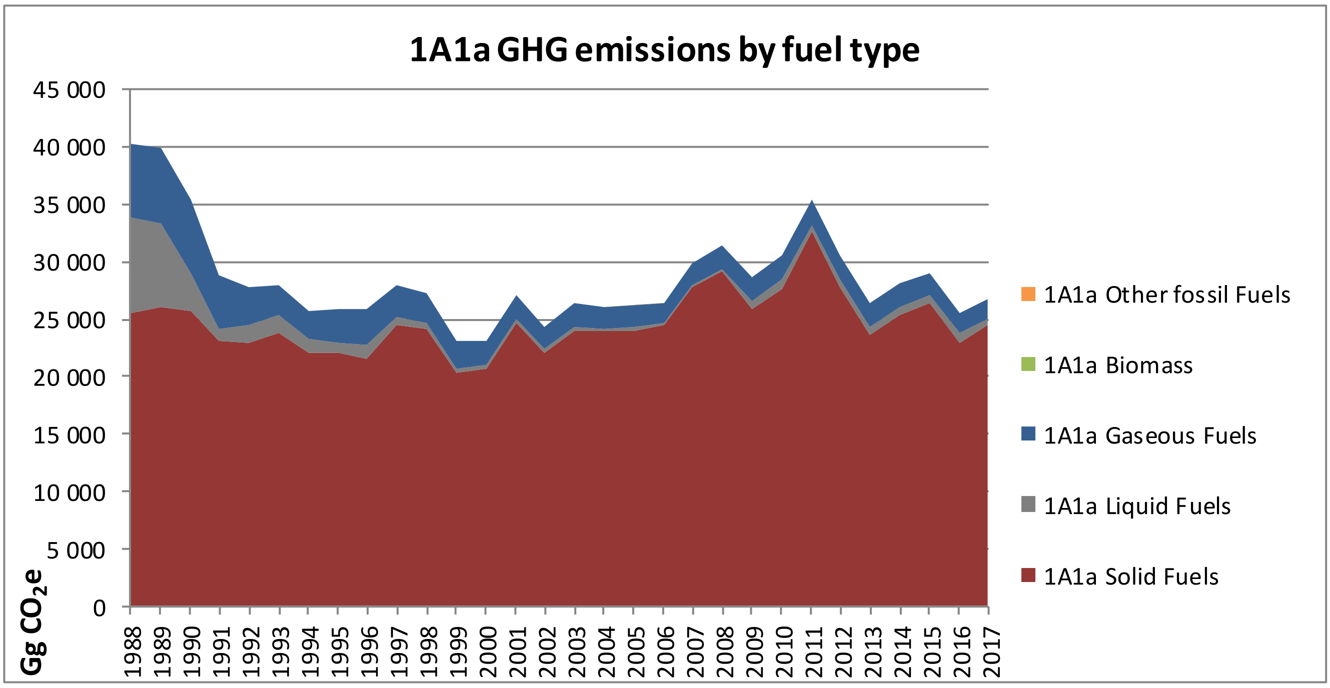

Figure 26 GHG emissions from 1.A.1.a Public Electricity and Heat Production

The share of CRF category 1.A.1.a from the total GHG emissions is 43.7% for the year 2017. The share of this subcategory from CRF category 1.A Fuel combustion is 62.7% for the year 2017. The decrease of the emissions from this subcategory is due to the decrease of electricity and heat production from combustible fuels caused by the reduction of electricity exports.

The consumption of liquid fuels in this subcategory results in a rather peculiar case study. Due to the relatively large share of petroleum coke used in main activity producers of electricity, CHP and heat plants (in 2017 used petroleum coke was 145 Gg out of 167 Gg of total liquid fuels), the resulting implied emission factor for this subcategory seems higher than what is expected for liquid fuels. The country-specific CO_2 EF for petroleum coke varies in the range of 92-95 t/TJ, which is significantly higher than the average EF of liquid fuels (usually around 74-77 t/TJ).

Table 34 CO_2 emissions in 1.A.1.a. Public Electricity and Heat Production

CO_2 (Gg)	CRF 1.A.1.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	40 166.76	8 241.55	25 416.61	6 508.60	NO	NO
1990	35 178.69	3 245.34	25 637.89	6 295.45	NO	NO
1995	25 832.78	901.28	21 960.64	2 970.85	0.1120	NO
2000	23 067.50	291.18	20 611.84	2 164.48	NO	NO
2005	26 174.65	335.05	23 885.03	1 954.57	NO	NO
2010	30 479.81	839.68	27 482.65	2 157.47	9.0720	NO
2011	35 265.22	423.28	32 557.09	2 284.85	30.4640	NO
2012	30 482.23	625.97	27 634.52	2 221.74	17.6960	NO
2013	26 226.64	668.32	23 449.64	2 108.69	19.0036	NO
2014	27 990.64	742.67	25 233.10	2 014.87	80.5434	NO
2015	28 834.16	663.76	26 313.81	1 856.60	84.4060	NO
2016	25 423.31	837.12	22 762.15	1 824.04	244.6836	NO
2017	26 677.87	498.46	24 314.03	1 865.38	175.8910	NO
Decrease 1988-2017	33.6%	94.0%	4.3%	71.3%	-	-
Decrease 1990-2017	24.2%	84.6%	5.2%	70.4%	-	-
Decrease 2016-2017	-4.9%	40.5%	-6.8%	-2.3%	28.1%	-

Table 35 CH_4 emissions in CRF 1.A.1.a. Public Electricity and Heat Production

CH_4 (Gg)	CRF 1.A.1.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.6820	0.3194	0.2446	0.1179	NO	NO
1990	0.4901	0.1259	0.2501	0.1140	NO	NO
1995	0.3013	0.0350	0.2125	0.0538	0.0000	NO
2000	0.2491	0.0113	0.1985	0.0392	NO	NO
2005	0.2794	0.0121	0.2319	0.0354	NO	NO
2010	0.3365	0.0278	0.2671	0.0391	0.0024	NO
2011	0.3792	0.0141	0.3156	0.0413	0.0082	NO
2012	0.3318	0.0200	0.2668	0.0402	0.0047	NO
2013	0.2917	0.0212	0.2277	0.0381	0.0047	NO
2014	0.3233	0.0236	0.2455	0.0363	0.0179	NO
2015	0.3260	0.0214	0.2545	0.0334	0.0168	NO
2016	0.3283	0.0269	0.2198	0.0328	0.0488	NO
2017	0.3166	0.0163	0.2354	0.0336	0.0312	NO
Decrease	53.6%	94.9%	3.8%	71.5%	-	-

CH_4 (Gg)	CRF 1.A.1.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988-2017						
Decrease 1990-2017	35.4%	87.0%	5.9%	70.5%	-	-
Decrease 2016-2017	3.6%	39.2%	-7.1%	-2.5%	36.0%	-

Table 36 N_2O emissions in 1.A.1.a. Public Electricity and Heat Production

N_2O (Gg)	CRF 1.A.1.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.4426	0.0639	0.3669	0.0118	NO	NO
1990	0.4118	0.0252	0.3752	0.0114	NO	NO
1995	0.3311	0.0070	0.3187	0.0054	0.0000	NO
2000	0.3040	0.0023	0.2978	0.0039	NO	NO
2005	0.3538	0.0024	0.3479	0.0035	NO	NO
2010	0.4104	0.0055	0.4007	0.0039	0.0003	NO
2011	0.4815	0.0028	0.4735	0.0041	0.0011	NO
2012	0.4087	0.0039	0.4002	0.0040	0.0006	NO
2013	0.3502	0.0042	0.3416	0.0038	0.0006	NO
2014	0.3790	0.0047	0.3683	0.0036	0.0024	NO
2015	0.3916	0.0043	0.3818	0.0033	0.0022	NO
2016	0.3449	0.0054	0.3297	0.0033	0.0065	NO
2017	0.3639	0.0033	0.3531	0.0034	0.0041	NO
Decrease 1988-2017	17.8%	94.9%	3.8%	71.5%	-	-
Decrease 1990-2017	11.6%	87.0%	5.9%	70.5%	-	-
Decrease 2016-2017	-5.5%	39.2%	-7.1%	-2.5%	36.2%	-

Table 37 GHG emissions in 1.A.1.a. Public Electricity and Heat Production

GHG (Gg)	TJ	CRF 1.A.1.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	469 001.13	40 315.71	8 268.58	25 532.07	6 515.06	NO	NO
1990	406 137.77	35 313.65	3 255.99	25 755.96	6 301.70	NO	NO
1995	277 954.32	25 938.98	904.24	22 060.93	2 973.80	0.0019	NO
2000	241 526.54	23 164.32	292.13	20 705.56	2 166.63	NO	NO
2005	271 362.80	26 287.08	336.08	23 994.50	1 956.51	NO	NO
2010	315 983.41	30 610.53	842.02	27 608.74	2 159.61	0.1573	NO
2011	362 152.24	35 418.18	424.46	32 706.07	2 287.11	0.5282	NO
2012	314 348.18	30 612.33	627.64	27 760.44	2 223.94	0.3068	NO
2013	273 486.45	26 338.29	670.09	23 557.11	2 110.78	0.3063	NO
2014	290 806.57	28 111.65	744.66	25 348.98	2 016.86	1.1566	NO
2015	296 000.38	28 959.02	665.57	26 433.94	1 858.43	1.0800	NO
2016	264 378.22	25 534.29	839.40	22 865.91	1 825.83	3.1491	NO
2017	276 636.17	26 794.22	499.84	24 425.15	1 867.22	2.0103	NO
Decrease 1988-2017	41.0%	33.5%	94.0%	4.3%	71.3%	-	-
Decrease 1990-2017	31.9%	24.1%	84.6%	5.2%	70.4%	-	-

GHG (Gg)	TJ	CRF 1.A.1.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
Decrease 2016-2017	-4.6%	-4.9%	40.5%	-6.8%	-2.3%	36.2%	-

3.3.10.2 Petroleum refining (CRF 1.A.1.b)

Category 1.A.1.b Petroleum refining covers emissions from fuel combustion in petroleum refineries, excluding the emissions from hydrogen production, which are reported as fugitive emissions.

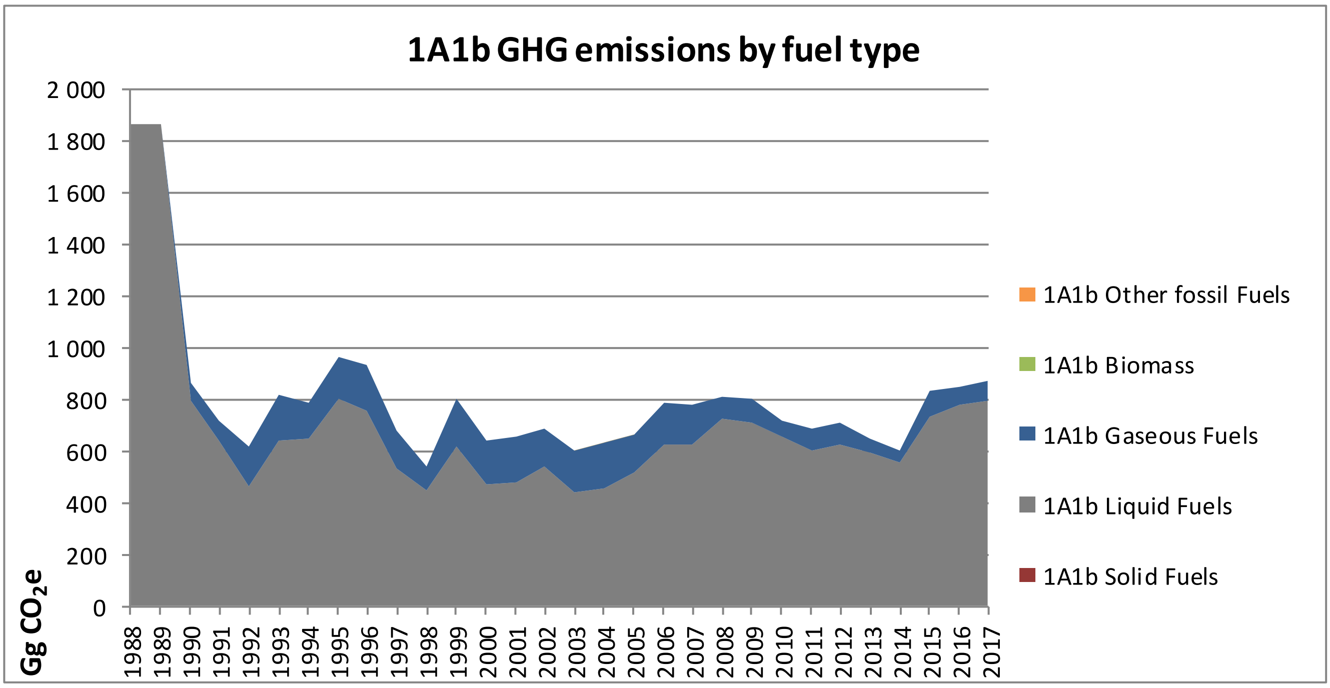

Figure 27 GHG emissions from CRF 1.A.1.b Petroleum refining

For the year 2017 the share of this subcategory from sector 1A Fuel Combustion is 2.0%, which is equivalent to 1.4% out of the total GHG emissions. Since 2015 there is a significant increase in the consumption of natural gas in this subcategory, which is reported as transformation activity in the energy balance. The increase is due to the recent opening of a new complex to process heavy residues at the biggest Bulgarian oil refinery, consisting of a main unit for hydrocracking of vacuum residue and a number of auxiliary units.

Table 38 CO_2 emissions in CRF 1.A.1.b Petroleum refining

CO_2 (Gg)	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	1 857.60	1 857.60	NO	NO	NO	NO
1990	861.38	792.72	NO	68.66	NO	NO
1995	964.41	800.35	NO	164.06	NO	NO
2000	642.16	469.01	NO	173.15	NO	NO
2005	661.60	517.07	NO	144.53	NO	NO
2010	716.93	657.07	NO	59.86	NO	NO
2011	684.45	598.75	NO	85.70	NO	NO
2012	706.79	624.67	NO	82.12	NO	NO
2013	648.63	590.72	NO	57.90	NO	NO
2014	604.76	553.42	NO	51.34	NO	NO
2015	829.49	732.41	NO	97.08	NO	NO

CO_2 (Gg)	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2016	848.53	778.83	NO	69.70	NO	NO
2017	872.87	795.80	NO	77.06	NO	NO
Decrease 1988-2017	53.0%	57.2%	-	-	-	-
Decrease 1990-2017	-1.3%	-0.4%	-	-12.2%	-	-
Decrease 2016-2017	-2.9%	-2.2%	-	-10.6%	-	-

Table 39 CH_4 emissions in CRF 1.A.1.b Petroleum refining

CH_4 (Gg)	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0720	0.0720	NO	NO	NO	NO
1990	0.0223	0.0211	NO	0.0012	NO	NO
1995	0.0256	0.0226	NO	0.0030	NO	NO
2000	0.0164	0.0133	NO	0.0031	NO	NO
2005	0.0174	0.0148	NO	0.0026	NO	NO
2010	0.0152	0.0141	NO	0.0011	NO	NO
2011	0.0140	0.0124	NO	0.0016	NO	NO
2012	0.0145	0.0130	NO	0.0015	NO	NO
2013	0.0130	0.0119	NO	0.0010	NO	NO
2014	0.0117	0.0108	NO	0.0009	NO	NO
2015	0.0162	0.0145	NO	0.0017	NO	NO
2016	0.0165	0.0152	NO	0.0013	NO	NO
2017	0.0171	0.0157	NO	0.0014	NO	NO
Decrease 1988-2017	76.2%	78.1%	-	-	-	-
Decrease 1990-2017	23.2%	25.3%	-	-11.7%	-	-
Decrease 2016-2017	-3.8%	-3.2%	-	-10.9%	-	-

Table 40 N_2O emissions in CRF 1.A.1.b Petroleum refining

N_2O (Gg)	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0144	0.0144	NO	NO	NO	NO
1990	0.0035	0.0034	NO	0.0001	NO	NO
1995	0.0041	0.0038	NO	0.0003	NO	NO
2000	0.0026	0.0023	NO	0.0003	NO	NO
2005	0.0027	0.0025	NO	0.0003	NO	NO
2010	0.0020	0.0019	NO	0.0001	NO	NO
2011	0.0017	0.0016	NO	0.0002	NO	NO
2012	0.0018	0.0017	NO	0.0001	NO	NO
2013	0.0016	0.0015	NO	0.0001	NO	NO
2014	0.0014	0.0013	NO	0.0001	NO	NO
2015	0.0019	0.0018	NO	0.0002	NO	NO
2016	0.0020	0.0018	NO	0.0001	NO	NO
2017	0.0021	0.0019	NO	0.0001	NO	NO
Decrease 1988-2017	85.7%	86.7%	-	-	-	-

N_2O (Gg)	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
Decrease 1990-2017	42.0%	43.9%	-	-11.7%	-	-
Decrease 2016-2017	-5.0%	-4.6%	-	-10.9%	-	-

Table 41 GHG emissions in CRF 1.A.1.b Petroleum refining

GHG (Gg)	TJ	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	24 000.00	1 863.69	1 863.69	NO	NO	NO	NO
1990	13 493.80	863.00	794.27	NO	68.73	NO	NO
1995	15 051.80	966.28	802.06	NO	164.22	NO	NO
2000	10 206.50	643.34	470.02	NO	173.32	NO	NO
2005	10 679.95	662.85	518.18	NO	144.67	NO	NO
2010	12 061.03	717.90	657.98	NO	59.92	NO	NO
2011	11 623.22	685.32	599.53	NO	85.78	NO	NO
2012	11 922.62	707.70	625.50	NO	82.20	NO	NO
2013	10 957.69	649.43	591.47	NO	57.96	NO	NO
2014	10 286.56	605.46	554.07	NO	51.39	NO	NO
2015	14 089.36	830.48	733.30	NO	97.17	NO	NO
2016	14 416.58	849.52	779.75	NO	69.77	NO	NO
2017	14 807.18	873.91	796.77	NO	77.14	NO	NO
Decrease 1988-2017	38.3%	53.1%	57.2%	-	-	-	-
Decrease 1990-2017	-9.7%	-1.3%	-0.3%	-	-12.2%	-	-
Decrease 2016-2017	-2.7%	-2.9%	-2.2%	-	-10.6%	-	-

3.3.10.2.1 Source-specific recalculations, including changes made in response to the review process

Following recommendations FCCC/ARR/2016/BGR E.8 and FCCC/ARR/2016/BGR E.9 were introduced several changes in the 2019 submission. As petroleum coke is combusted in order to restore the catalyst's activity and not for energy purposes, all GHG emissions from petroleum coke, which were previously reported under CRF subcategory 1.A.1.b were reallocated under CRF subcategory 1.B.2.a.4. Similarly, the GHG emissions from hydrogen production, which were previously reported under CRF subcategory 1.A.1.b were reallocated under CRF subcategory 1.B.2.c.2.i.

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

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).

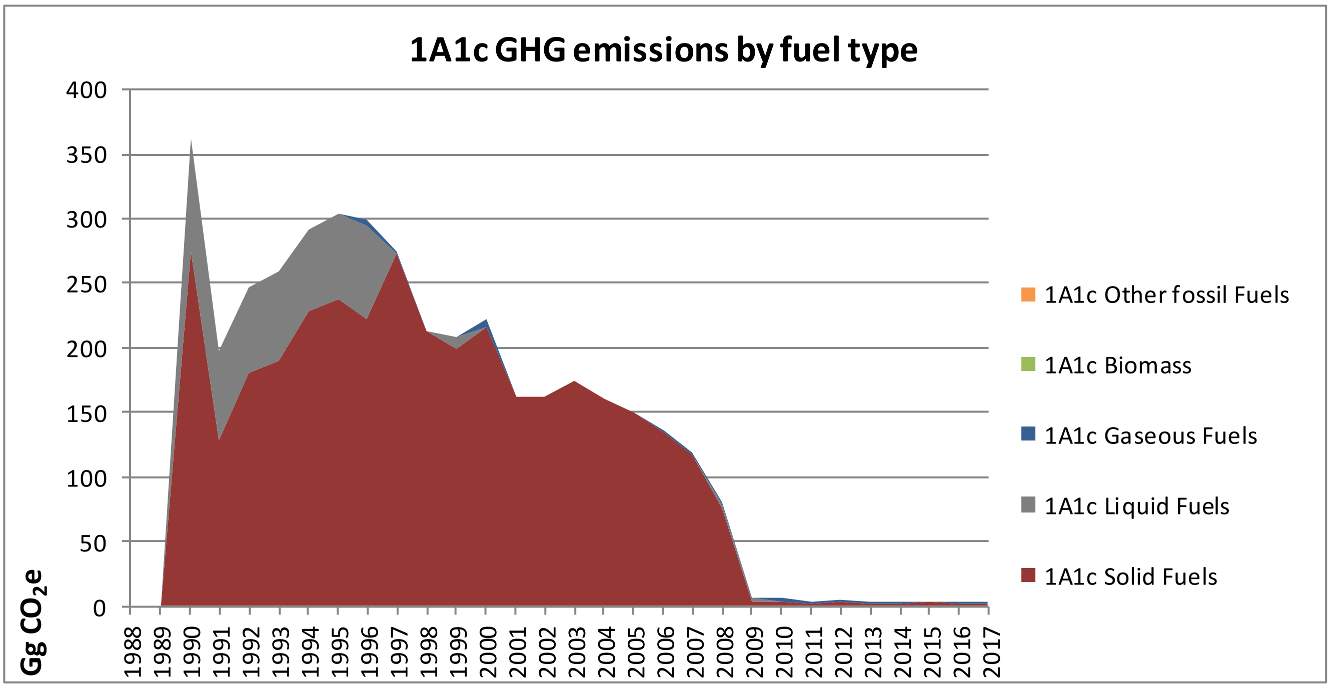

Figure 28 GHG emissions from 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

This sector has shrunk drastically due to the closure of the only I&S plant in Bulgaria, which was operating coke ovens. The category is currently responsible for 0.01% of the emissions from fuel combustion. The closure resulted also in a change in the fuel mix used in this category – from mostly coke oven gas used in coke ovens in the past years, it has now shifted to small quantities of natural gas.

Table 42 CO_2 emissions in CRF 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

CO_2 (Gg)	CRF 1.A.1.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	362.22	87.76	274.45	NO	NO	NO
1995	303.77	65.82	237.95	NO	NO	NO
2000	221.32	NO	216.06	5.27	NO	NO
2005	149.79	NO	149.79	NO	0.1120	NO
2010	6.11	NO	3.97	2.14	NO	NO
2011	3.35	NO	2.01	1.34	NO	NO
2012	5.26	NO	3.17	2.09	NO	NO
2013	3.93	NO	1.98	1.94	NO	NO
2014	4.07	NO	2.62	1.45	NO	NO
2015	3.93	NO	2.73	1.20	NO	NO
2016	3.70	NO	1.85	1.85	NO	NO
2017	3.85	0.59	1.95	1.31	NO	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	98.9%	99.3%	99.3%	-	-	-
Decrease 2016-2017	-4.0%	-	-5.7%	29.5%	-	-

Table 43 CH_4 emissions in CRF 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

CH_4 (Gg)	CRF 1.A.1.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	0.0094	0.0036	0.0058	NO	NO	NO
1995	0.0077	0.0027	0.0050	NO	NO	NO
2000	0.0045	NO	0.0045	0.0001	NO	NO
2005	0.0033	NO	0.0033	NO	0.0000	NO
2010	0.0001	NO	0.0000	0.0000	NO	NO
2011	0.0000	NO	0.0000	0.0000	NO	NO
2012	0.0001	NO	0.0000	0.0000	NO	NO
2013	0.0001	NO	0.0000	0.0000	NO	NO
2014	0.0001	NO	0.0000	0.0000	NO	NO
2015	0.0000	NO	0.0000	0.0000	NO	NO
2016	0.0001	NO	0.0000	0.0000	NO	NO
2017	0.0001	0.0000	0.0000	0.0000	NO	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	99.4%	99.6%	99.7%	-	-	-
Decrease 2016-2017	-12.6%	-	-5.7%	29.3%	-	-

Table 44 N_2O emissions in CRF 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

N_2O (Gg)	CRF 1.A.1.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	0.0017	0.0007	0.0010	NO	NO	NO
1995	0.0014	0.0005	0.0009	NO	NO	NO
2000	0.0009	NO	0.0009	0.0000	NO	NO
2005	0.0004	NO	0.0004	NO	0.0000	NO
2010	0.0001	NO	0.0001	0.0000	NO	NO
2011	0.0000	NO	0.0000	0.0000	NO	NO
2012	0.0001	NO	0.0000	0.0000	NO	NO
2013	0.0000	NO	0.0000	0.0000	NO	NO
2014	0.0000	NO	0.0000	0.0000	NO	NO
2015	0.0000	NO	0.0000	0.0000	NO	NO
2016	0.0000	NO	0.0000	0.0000	NO	NO
2017	0.0000	0.0000	0.0000	0.0000	NO	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	98.0%	99.6%	97.0%	-	-	-
Decrease 2016-2017	-10.0%	-	-5.7%	29.3%	-	-

Table 45 GHG emissions in 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

GHG (Gg)	TJ	CRF 1.A.1.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO	NO
1990	6 985.19	362.95	88.06	274.89	NO	NO	NO

GHG (Gg)	TJ	CRF 1.A.1.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1995	5 928.39	304.38	66.05	238.34	NO	NO	NO
2000	4 549.15	221.70	NO	216.43	5.27	NO	NO
2005	3 269.80	150.00	NO	150.00	NO	0.0019	NO
2010	78.26	6.13	NO	3.99	2.14	NO	NO
2011	44.36	3.36	NO	2.02	1.34	NO	NO
2012	69.77	5.28	NO	3.19	2.09	NO	NO
2013	55.45	3.94	NO	1.99	1.95	NO	NO
2014	51.97	4.08	NO	2.63	1.45	NO	NO
2015	48.65	3.95	NO	2.74	1.20	NO	NO
2016	51.75	3.71	NO	1.86	1.85	NO	NO
2017	51.78	3.86	0.59	1.96	1.31	NO	NO
Decrease 1988-2017	-	-	-	-	-	-	-
Decrease 1990-2017	99.3%	98.9%	99.3%	99.3%	-	-	-
Decrease 2016-2017	-0.1%	-4.0%	-	-5.7%	29.5%	-	-

3.3.11 MANUFACTURING INDUSTRIES AND CONSTRUCTION (1.A.2)

Sub-sector Manufacturing Industries and Construction includes the following groups:

- Iron and steel (CRF 1.A.2.a);
- Non-ferrous metals (CRF 1.A.2.b);
- Chemicals (CRF 1.A.2.c);
- Pulp, paper and print (CRF 1.A.2.d);
- Food processing, beverages and tobacco (CRF 1.A.2.e);
- Non-metallic minerals (CRF 1.A.2.f);
- Other (CRF 1.A.2.g).

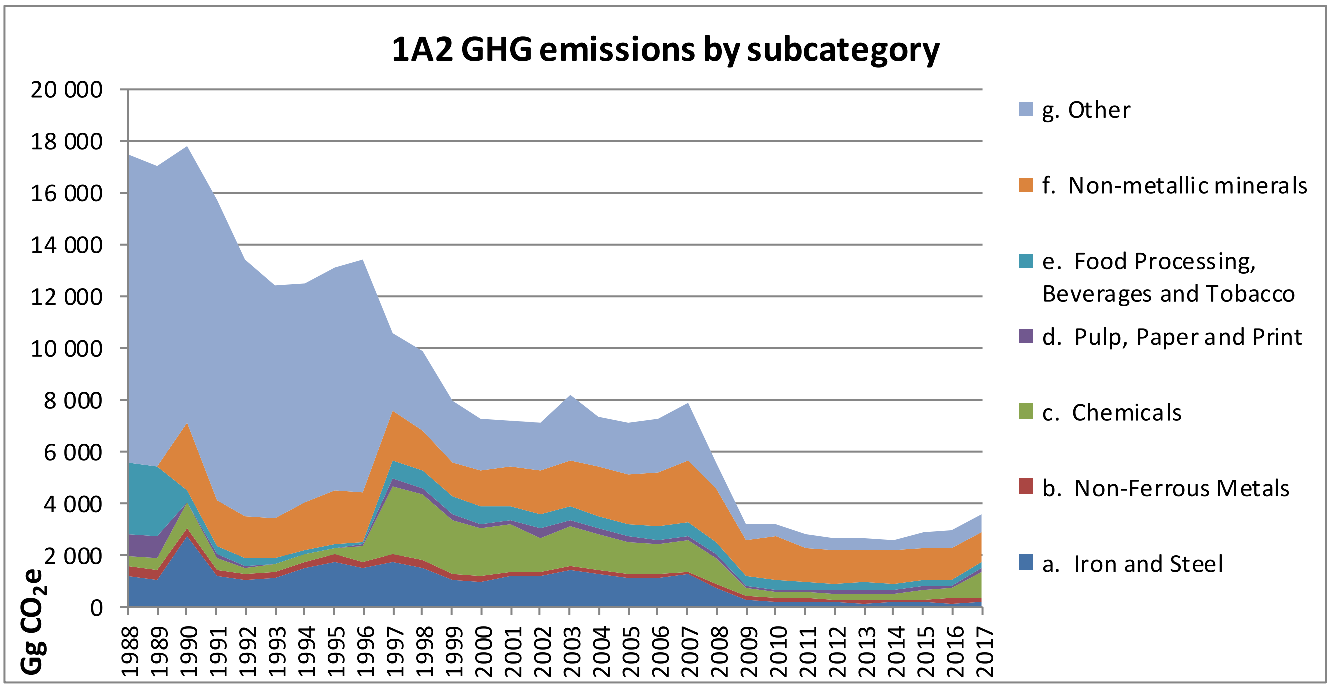

Figure 29 Total GHG emissions from 1.A.2 Manufacturing Industries and Construction by subcategory

Following the restructuring of the industry sector of the country, the general trend in CRF category 1.A.2 shows an emission decrease of 79.4% compared to base year and a notable increase of 23.9% compared to last year. Almost all subcategories within the industry sector are decreasing steadily until 2009, maintaining the same level afterwards, with the exception of the chemical industry, which is steadily increasing since 2015.

3.3.11.1 Iron and Steel (CRF 1.A.2.a.)

Category 1.A.2.a. Iron and Steel covers emissions from fuel combustion in Iron and steel industry.

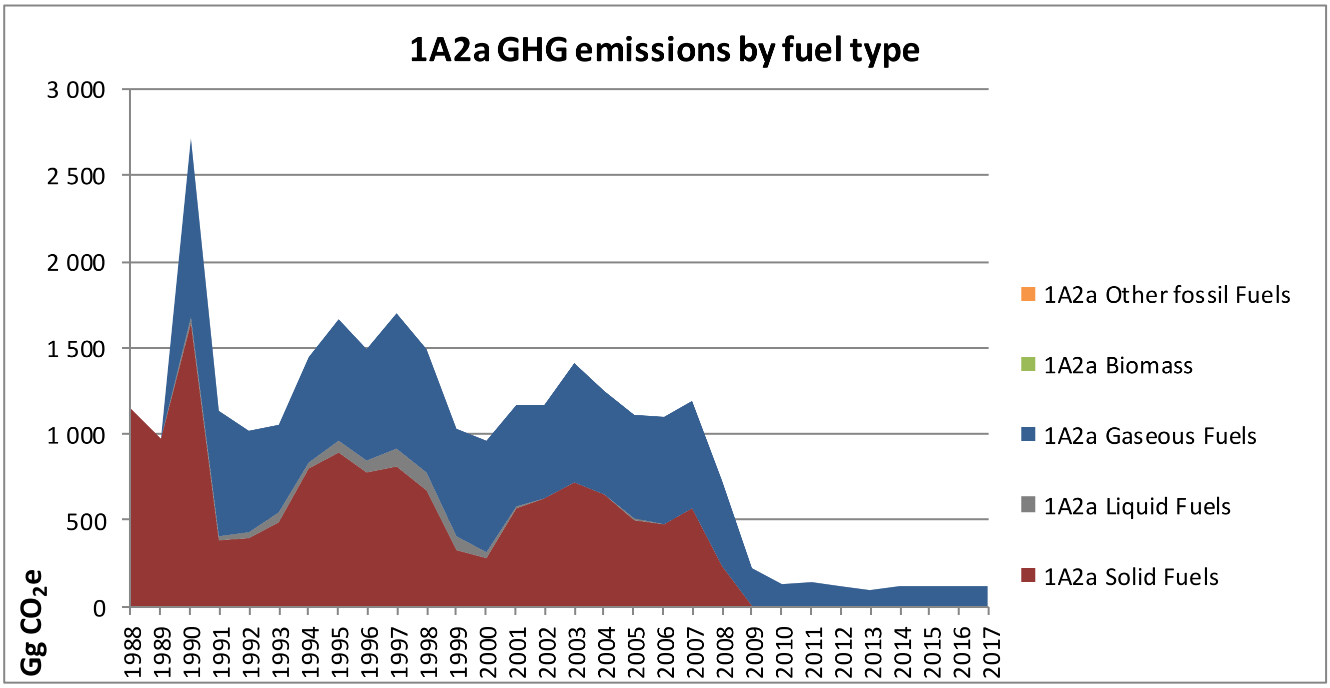

Figure 30 GHG emissions from 1.A.2.a. Iron and Steel

For the year 2017 the share of this subcategory from sector 1A Fuel Combustion is 0.3%, which is equivalent to 0.2% out of the total GHG emissions. The drastic decrease in the emissions since 2009 in this subcategory is due to the closure of the biggest iron and steel plant in Bulgaria at the end of 2008.

Table 46 CO_2 emissions in CRF 1.A.2.a. Iron and Steel

CO_2 (Gg)	CRF 1.A.2.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	1 141.10	NO	1 141.10	NO	NO	NO
1990	2 705.22	37.34	1 630.87	1 037.00	NO	NO
1995	1 656.97	71.55	881.59	703.82	0.3360	NO
2000	959.19	37.19	279.04	642.96	0.3360	NO
2005	1 103.07	6.24	496.80	600.03	0.5600	NO
2010	130.95	NO	NO	130.95	0.2240	NO
2011	146.08	NO	NO	146.08	0.2240	NO
2012	116.25	NO	NO	116.25	NO	NO
2013	99.01	NO	NO	99.01	0.1120	NO
2014	117.39	NO	NO	117.39	NO	NO
2015	115.80	NO	NO	115.80	NO	NO

CO_2 (Gg)	CRF 1.A.2.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2016	113.61	NO	NO	113.61	0.2240	NO
2017	118.61	0.79	0.24	117.58	0.1718	NO
Decrease 1988-2017	89.6%	-	100.0%	-	-	-
Decrease 1990-2017	95.6%	97.9%	100.0%	88.7%	-	-
Decrease 2016-2017	-4.4%	-	-	-3.5%	23.3%	-

Table 47 CH_4 emissions in CRF 1.A.2.a. Iron and Steel

CH_4 (Gg)	CRF 1.A.2.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0758	NO	0.0758	NO	NO	NO
1990	0.1680	0.0015	0.1477	0.0188	NO	NO
1995	0.0919	0.0028	0.0762	0.0127	0.0001	NO
2000	0.0332	0.0014	0.0200	0.0116	0.0001	NO
2005	0.0553	0.0003	0.0440	0.0109	0.0002	NO
2010	0.0024	NO	NO	0.0024	0.0001	NO
2011	0.0027	NO	NO	0.0026	0.0001	NO
2012	0.0021	NO	NO	0.0021	NO	NO
2013	0.0018	NO	NO	0.0018	0.0000	NO
2014	0.0021	NO	NO	0.0021	NO	NO
2015	0.0021	NO	NO	0.0021	NO	NO
2016	0.0021	NO	NO	0.0020	0.0001	NO
2017	0.0022	0.0000	0.0000	0.0021	0.0000	NO
Decrease 1988-2017	97.1%	-	100.0%	-	-	-
Decrease 1990-2017	98.7%	98.8%	100.0%	88.7%	-	-
Decrease 2016-2017	-4.9%	-	-	-3.8%	23.3%	-

Table 48 N_2O emissions in CRF 1.A.2.a. Iron and Steel

N_2O (Gg)	CRF 1.A.2.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0109	NO	0.0109	NO	NO	NO
1990	0.0242	0.0003	0.0221	0.0019	NO	NO
1995	0.0132	0.0006	0.0113	0.0013	0.0000	NO
2000	0.0043	0.0003	0.0029	0.0012	0.0000	NO
2005	0.0077	0.0001	0.0065	0.0011	0.0000	NO
2010	0.0002	NO	NO	0.0002	0.0000	NO
2011	0.0003	NO	NO	0.0003	0.0000	NO
2012	0.0002	NO	NO	0.0002	NO	NO
2013	0.0002	NO	NO	0.0002	0.0000	NO
2014	0.0002	NO	NO	0.0002	NO	NO
2015	0.0002	NO	NO	0.0002	NO	NO
2016	0.0002	NO	NO	0.0002	0.0000	NO
2017	0.0002	0.0000	0.0000	0.0002	0.0000	NO
Decrease 1988-2017	97.9%	-	100.0%	-	-	-
Decrease 1990-2017	99.1%	99.1%	100.0%	88.7%	-	-

N_2O (Gg)	CRF 1.A.2.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
Decrease 2016-2017	-5.6%	-	-	-3.8%	23.3%	-

Table 49 GHG emissions in CRF 1.A.2.a. Iron and Steel

GHG (Gg)	TJ	CRF 1.A.2.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	16 396.80	1 146.24	NO	1 146.24	NO	NO	NO
1990	35 474.30	2 716.64	37.47	1 641.14	1 038.03	NO	NO
1995	23 228.68	1 663.19	71.79	886.87	704.52	0.0058	NO
2000	16 535.12	961.32	37.31	280.40	643.60	0.0058	NO
2005	16 753.11	1 106.74	6.26	499.85	600.63	0.0097	NO
2010	2 372.60	131.09	NO	NO	131.08	0.0039	NO
2011	2 645.30	146.22	NO	NO	146.22	0.0039	NO
2012	2 106.00	116.36	NO	NO	116.36	NO	NO
2013	1 789.30	99.11	NO	NO	99.11	0.0019	NO
2014	2 117.70	117.51	NO	NO	117.51	NO	NO
2015	2 081.70	115.91	NO	NO	115.91	NO	NO
2016	2 044.10	113.73	NO	NO	113.73	0.0039	NO
2017	2 134.99	118.73	0.79	0.25	117.70	0.0030	NO
Decrease 1988-2017	87.0%	89.6%	-	100.0%	-	-	-
Decrease 1990-2017	94.0%	95.6%	97.9%	100.0%	88.7%	-	-
Decrease 2016-2017	-4.4%	-4.4%	-	-	-3.5%	23.3%	-

3.3.11.1.1 Source-specific recalculations, including changes made in response to the review process

In 2012 after a discussion regarding the non-energy use of Coke Oven Coke in the iron and steel industry, the National Statistics Institute initiated talks with the plant operators in order to clarify the situation, which led to the revision of the national energy balances. The quantities of Coke Oven Coke, which were previously reported under energy use are now accounted as non-energy use.

In addition, following the recommendation of the Technical review of GHG inventories under the EU Effort Sharing Decision (ESD) in 2012, we revised the methodology concerning Iron & Steel sector in order to remove the double counting with the IP sector. The quantities of coke oven gas reported under blast furnaces; blast furnace gas reported under blast furnaces, autoproducers and Iron and Steel; coke oven coke in blast furnaces were disregarded from the Energy sector.

3.3.11.2 Non-Ferrous Metals (CRF 1.A.2.b.)

Category 1.A.2.b Non-Ferrous Metals enfolds emissions from fuel combustion in non-ferrous metal industry.

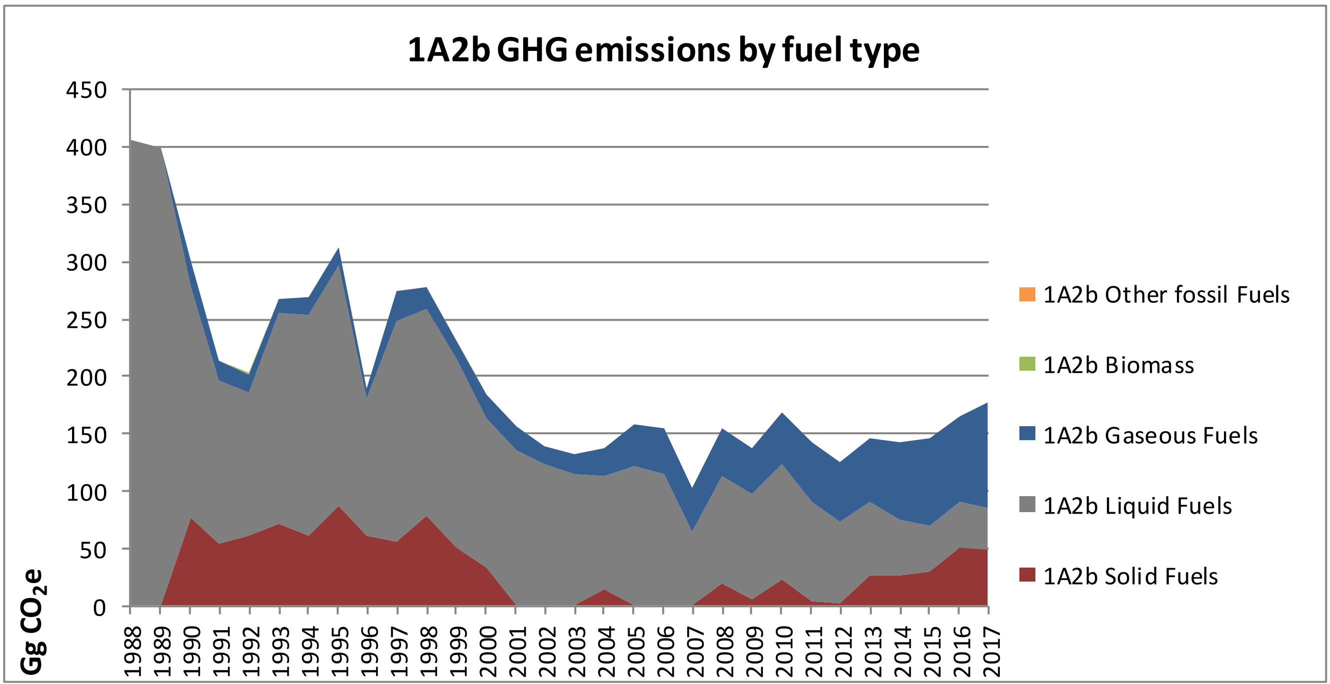

Figure 31 GHG emissions from CRF 1.A.2.b. Non-Ferrous Metals

The share of this subcategory from sector 1.A is 0.4% for the year 2017, which is equivalent to 0.3% of the total GHG emissions.

Table 50 CO_2 emissions in CRF 1.A.2.b. Non-Ferrous Metals

CO_2 (Gg)	CRF 1.A.2.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	404.06	404.06	NO	NO	NO	NO
1990	299.16	199.30	76.46	23.40	NO	NO
1995	310.99	208.43	86.86	15.70	1.9040	NO
2000	183.95	129.65	33.58	20.72	0.2240	NO
2005	157.96	121.15	NO	36.82	NO	NO
2010	167.92	101.63	22.20	44.10	0.1120	NO
2011	142.40	86.15	3.43	52.82	NO	NO
2012	124.92	70.67	2.73	51.52	NO	NO
2013	145.51	64.44	26.41	54.66	NO	NO
2014	141.66	48.99	26.31	66.36	NO	NO
2015	145.85	39.67	30.28	75.90	NO	NO
2016	164.50	39.67	49.72	75.11	NO	NO
2017	176.23	36.45	48.60	91.18	NO	NO
Decrease 1988-2017	56.4%	91.0%	-	-	-	-
Decrease 1990-2017	41.1%	81.7%	36.4%	-289.7%	-	-
Decrease 2016-2017	-7.1%	8.1%	2.3%	-21.4%	-	-

Table 51 CH_4 emissions in CRF 1.A.2.b. Non-Ferrous Metals

CH_4 (Gg)	CRF 1.A.2.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0158	0.0158	NO	NO	NO	NO
1990	0.0155	0.0079	0.0072	0.0004	NO	NO
1995	0.0172	0.0082	0.0082	0.0003	0.0005	NO

CH_4 (Gg)	CRF 1.A.2.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2000	0.0085	0.0049	0.0031	0.0004	0.0001	NO
2005	0.0052	0.0045	NO	0.0007	NO	NO
2010	0.0066	0.0037	0.0021	0.0008	0.0000	NO
2011	0.0044	0.0031	0.0003	0.0010	NO	NO
2012	0.0037	0.0025	0.0003	0.0009	NO	NO
2013	0.0058	0.0023	0.0025	0.0010	NO	NO
2014	0.0054	0.0017	0.0025	0.0012	NO	NO
2015	0.0055	0.0013	0.0028	0.0014	NO	NO
2016	0.0073	0.0013	0.0046	0.0014	NO	NO
2017	0.0074	0.0012	0.0045	0.0016	NO	NO
Decrease 1988-2017	53.3%	92.4%	-	-	-	-
Decrease 1990-2017	52.5%	84.8%	37.1%	-287.7%	-	-
Decrease 2016-2017	-0.7%	10.4%	2.3%	-21.7%	-	-

Table 52 N_2O emissions in CRF 1.A.2.b. Non-Ferrous Metals

N_2O (Gg)	CRF 1.A.2.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0032	0.0032	NO	NO	NO	NO
1990	0.0027	0.0016	0.0011	0.0000	NO	NO
1995	0.0030	0.0016	0.0012	0.0000	0.0001	NO
2000	0.0015	0.0010	0.0005	0.0000	0.0000	NO
2005	0.0010	0.0009	NO	0.0001	NO	NO
2010	0.0011	0.0007	0.0003	0.0001	0.0000	NO
2011	0.0008	0.0006	0.0000	0.0001	NO	NO
2012	0.0006	0.0005	0.0000	0.0001	NO	NO
2013	0.0009	0.0004	0.0004	0.0001	NO	NO
2014	0.0008	0.0003	0.0004	0.0001	NO	NO
2015	0.0008	0.0003	0.0004	0.0001	NO	NO
2016	0.0011	0.0003	0.0007	0.0001	NO	NO
2017	0.0011	0.0002	0.0007	0.0002	NO	NO
Decrease 1988-2017	66.1%	92.9%	-	-	-	-
Decrease 1990-2017	60.4%	85.7%	37.1%	-287.7%	-	-
Decrease 2016-2017	1.3%	11.1%	2.3%	-21.7%	-	-

Table 53 GHG emissions in CRF 1.A.2.b. Non-Ferrous Metals

GHG (Gg)	TJ	CRF 1.A.2.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	5 267.60	405.39	405.39	NO	NO	NO	NO
1990	3 774.83	300.35	199.96	76.97	23.42	NO	NO
1995	3 876.91	312.30	209.12	87.43	15.72	0.0330	NO
2000	2 383.18	184.60	130.06	33.80	20.74	0.0039	NO
2005	2 251.40	158.38	121.53	NO	36.85	NO	NO
2010	2 347.07	168.43	101.94	22.34	44.14	0.0019	NO

GHG (Gg)	TJ	CRF 1.A.2.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2011	2 128.19	142.74	86.41	3.46	52.87	NO	NO
2012	1 899.14	125.20	70.88	2.75	51.57	NO	NO
2013	2 092.11	145.92	64.63	26.58	54.72	NO	NO
2014	2 103.23	142.04	49.13	26.49	66.42	NO	NO
2015	2 185.40	146.23	39.78	30.48	75.97	NO	NO
2016	2 352.66	165.00	39.78	50.04	75.18	NO	NO
2017	2 590.59	176.74	36.55	48.92	91.28	NO	NO
Decrease 1988-2017	50.8%	56.4%	91.0%	-	-	-	-
Decrease 1990-2017	31.4%	41.2%	81.7%	36.4%	-289.7%	-	-
Decrease 2016-2017	-10.1%	-7.1%	8.1%	2.3%	-21.4%	-	-

3.3.11.2.1 Source-specific recalculations, including changes made in response to the review process

Since the National Energy Balances do not report any non-energy use of coke oven coke for the period before 2007, a methodology for allocation of energy and non-energy use of coke oven coke in the non-ferrous sector was adopted, resulting in reallocation of a significant part of previously reported emissions to subcategory 2C. In order to avoid double counting with the IP sector, the calculated quantities of coke oven coke used for the production of lead and zinc are subtracted from the total quantities reported in the National Energy Balance, with the remainder considered to be energy use.

3.3.11.3 Chemicals (CRF 1.A.2.c.)

Category 1.A.2.c Chemicals enfolds emissions from fuel combustion in chemical and petrochemical industries.

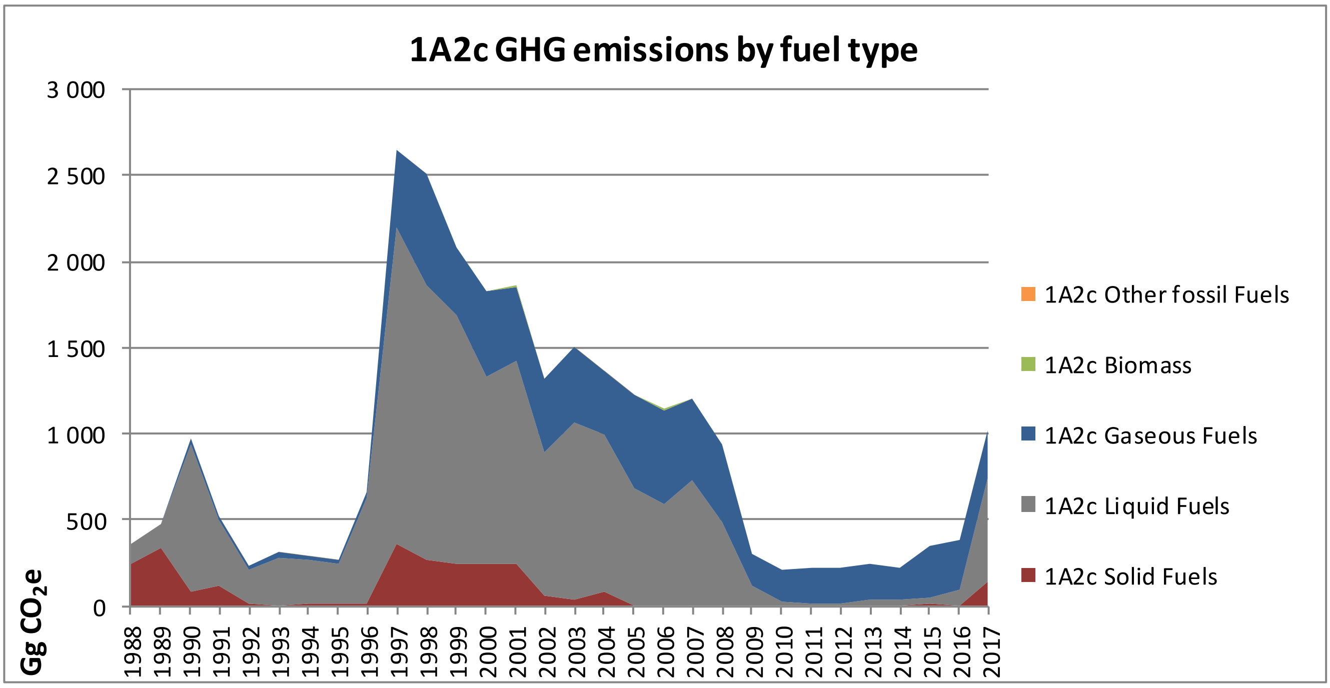

Figure 32 GHG emissions from CRF 1.A.2.c. Chemicals

The share of this subcategory from sector 1.A is 2.4% for the year 2017, which is equivalent to 1.7% out of the total GHG emissions.

The trend analysis shows some significant variability in the fuel consumption in this category – after 1997 there is an increase in the liquid fuels and a decrease in the gaseous fuels. Additional checks revealed two separate factors contributing to this trend – after 1997 the National Statistics changed the methodologies for fuel allocation: fuels consumed by autoproducer electricity, CHP and heat plants were reallocated from transformation sector to the respective industry sector. The second factor, responsible for the decrease in gaseous fuel consumption is the long-term crisis in the fertilizer production industry in Bulgaria, which has caused the gradual closure of two of the plants around 2001. The increase in the recent years is due to the use of petroleum coke and solid fuels.

Table 54 CO_2 emissions in CRF 1.A.2.c. Chemicals

CO_2 (Gg)	CRF 1.A.2.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	356.63	116.80	239.84	NO	NO	NO
1990	967.34	856.74	80.38	30.23	NO	NO
1995	267.43	238.35	11.57	17.51	0.2240	NO
2000	1 822.56	1 091.49	239.06	492.01	7.9520	NO
2005	1 222.61	685.21	2.21	535.19	189.3920	NO
2010	215.68	24.16	NO	191.52	0.2240	NO
2011	223.74	17.97	NO	205.77	0.1120	NO
2012	225.87	12.46	NO	213.41	0.2240	NO
2013	248.48	38.48	NO	210.00	3.9200	NO
2014	221.08	35.38	2.36	183.33	31.8080	NO
2015	345.67	40.63	12.30	292.74	50.7360	NO
2016	380.63	92.71	0.48	287.44	3.6960	NO
2017	1 012.76	594.78	143.16	274.81	64.1869	NO
Decrease 1988-2017	-184.0%	-409.2%	40.3%	-	-	-
Decrease 1990-2017	-4.7%	30.6%	-78.1%	-809.2%	-	-
Decrease 2016-2017	-166.1%	-541.6%	-29586.3%	4.4%	-1636.7%	-

Table 55 CH_4 emissions in CRF 1.A.2.c. Chemicals

CH_4 (Gg)	CRF 1.A.2.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0271	0.0047	0.0224	NO	NO	NO
1990	0.0302	0.0221	0.0075	0.0005	NO	NO
1995	0.0098	0.0083	0.0012	0.0003	0.0001	NO
2000	0.0678	0.0321	0.0246	0.0089	0.0021	NO
2005	0.0817	0.0211	0.0002	0.0097	0.0507	NO
2010	0.0043	0.0008	NO	0.0035	0.0001	NO
2011	0.0043	0.0005	NO	0.0037	0.0000	NO
2012	0.0044	0.0005	NO	0.0039	0.0001	NO
2013	0.0058	0.0009	NO	0.0038	0.0011	NO
2014	0.0129	0.0008	0.0002	0.0033	0.0085	NO
2015	0.0210	0.0009	0.0012	0.0053	0.0136	NO
2016	0.0080	0.0018	0.0000	0.0052	0.0010	NO
2017	0.0556	0.0176	0.0158	0.0050	0.0172	NO
Decrease	-104.7%	-271.8%	29.3%	-	-	-

CH_4 (Gg)	CRF 1.A.2.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988-2017						
Decrease 1990-2017	-84.0%	20.6%	-110.8%	-804.6%	-	-
Decrease 2016-2017	-593.2%	-869.0%	-35048.7%	4.1%	-1636.7%	-

Table 56 N_2O emissions in CRF 1.A.2.c. Chemicals

N_2O (Gg)	CRF 1.A.2.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0043	0.0009	0.0034	NO	NO	NO
1990	0.0047	0.0035	0.0011	0.0001	NO	NO
1995	0.0018	0.0016	0.0002	0.0000	0.0000	NO
2000	0.0104	0.0056	0.0037	0.0009	0.0003	NO
2005	0.0115	0.0037	0.0000	0.0010	0.0068	NO
2010	0.0005	0.0001	NO	0.0003	0.0000	NO
2011	0.0005	0.0001	NO	0.0004	0.0000	NO
2012	0.0005	0.0001	NO	0.0004	0.0000	NO
2013	0.0007	0.0001	NO	0.0004	0.0001	NO
2014	0.0016	0.0001	0.0000	0.0003	0.0011	NO
2015	0.0027	0.0001	0.0002	0.0005	0.0018	NO
2016	0.0009	0.0002	0.0000	0.0005	0.0001	NO
2017	0.0085	0.0033	0.0024	0.0005	0.0023	NO
Decrease 1988-2017	-97.6%	-254.0%	29.3%	-	-	-
Decrease 1990-2017	-81.3%	4.7%	-110.8%	-804.6%	-	-
Decrease 2016-2017	-874.4%	-1434.9%	-35048.7%	4.1%	-1636.7%	-

Table 57 GHG emissions in CRF 1.A.2.c. Chemicals

GHG (Gg)	TJ	CRF 1.A.2.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	3 817.68	358.60	117.20	241.40	NO	NO	NO
1990	14 774.60	969.50	858.34	80.90	30.26	NO	NO
1995	3 763.00	268.21	239.02	11.66	17.53	0.0039	NO
2000	27 881.74	1 827.36	1 093.95	240.78	492.50	0.1379	NO
2005	21 813.74	1 228.07	686.84	2.22	535.72	3.2839	NO
2010	3 821.21	215.93	24.22	NO	191.71	0.0039	NO
2011	3 996.80	223.98	18.01	NO	205.97	0.0019	NO
2012	4 032.82	226.13	12.50	NO	213.62	0.0039	NO
2013	4 442.69	248.83	38.55	NO	210.21	0.0680	NO
2014	4 187.91	221.88	35.44	2.37	183.52	0.5515	NO
2015	6 506.90	346.99	40.69	12.38	293.03	0.8797	NO
2016	6 773.86	381.09	92.82	0.49	287.72	0.0641	NO
2017	14 093.72	1 016.68	596.22	144.27	275.08	1.1130	NO
Decrease 1988-2017	-269.2%	-183.5%	-408.7%	40.2%	-	-	-
Decrease 1990-2017	4.6%	-4.9%	30.5%	-78.3%	-809.2%	-	-

GHG (Gg)	TJ	CRF 1.A.2.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
Decrease 2016-2017	-108.1%	-166.8%	-542.3%	-29621.7%	4.4%	-1636.7%	-

3.3.11.3.1 Source-specific recalculations, including changes made in response to the review process

Following the recommendation of the Technical review of GHG inventories under the EU Effort Sharing Decision (ESD) in 2012, we revised the methodology concerning Chemical sector in order to remove the double counting within the IP sector. The National Statistics Institute initiated talks with the plant operators in order to clarify the situation, but the revision of the national energy balances is still pending due to disagreements with some of the companies required to report. This mandates a correction of the National Energy Balance for the purposes of elaborating the National GHG inventory. Using a stoichiometric calculation (based on the reported production of ammonia, soda ash and calcium carbide) the actual quantities of natural gas and solid fuels as non-energy use in the chemical industry are estimated. The remaining quantities of natural gas and solid fuels, which are reported under Chemical industry, are considered to be energy use and accounted in the Energy sector.

The following fuels have been reallocated to the industrial processes sector:

- Natural gas used for ammonia production
- Anthracite used for soda ash and for calcium carbide
- Other bituminous coal used for soda ash and for calcium carbide
- Coke oven coke used for soda ash

3.3.11.4 Pulp, Paper and Print (CRF 1.A.2.d.)

Category 1.A.2.d Pulp, Paper and Print enfolds emissions from the fuel combustion in pulp, paper and print industries.

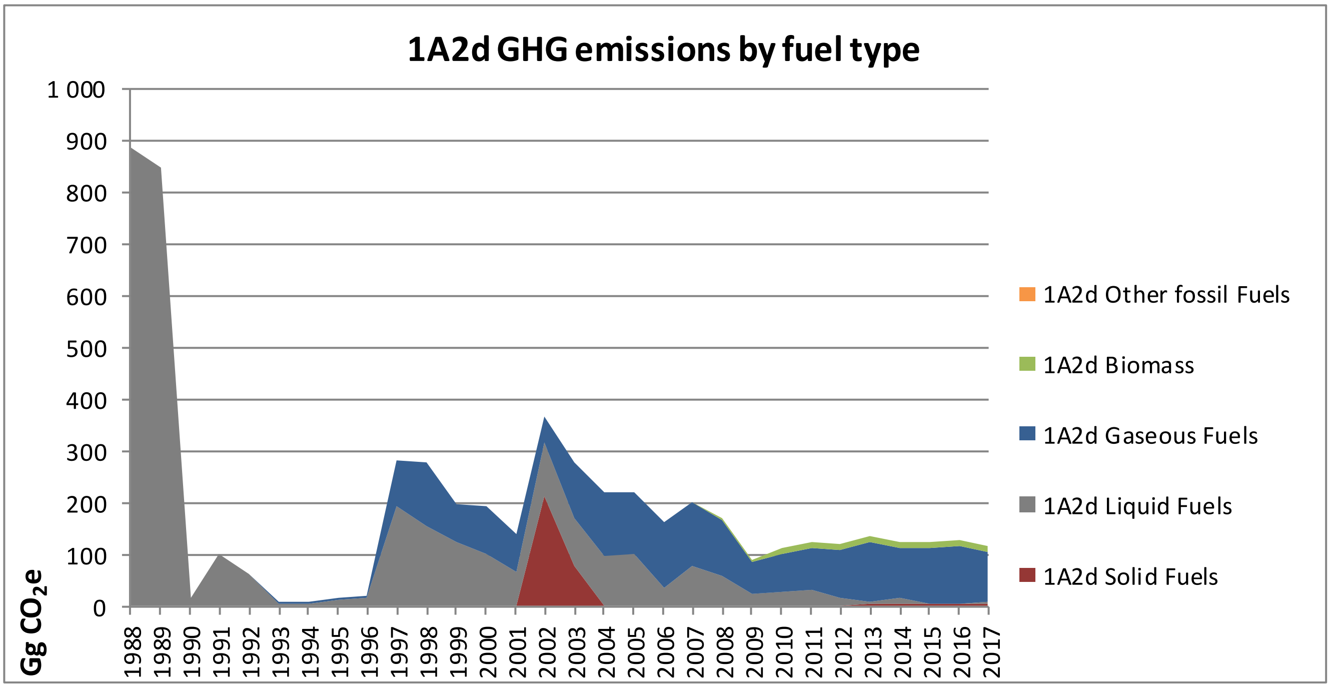

Figure 33 GHG emissions from CRF 1.A.2.d. Pulp, Paper and Print

The share of this subcategory from sector 1.A is 0.3% for 2017, which is equivalent to 0.2% of the total GHG emissions.

Table 58 CO_2 emissions in CRF 1.A.2.d. Pulp, Paper and Print

CO_2 (Gg)	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	882.36	882.36	NO	NO	NO	NO
1990	15.56	15.56	NO	NO	NO	NO
1995	15.39	12.46	NO	2.93	0.2240	NO
2000	192.07	99.11	NO	92.96	0.1120	NO
2005	221.22	102.17	NO	119.04	32.8160	NO
2010	102.69	27.86	NO	74.82	540.8480	NO
2011	112.48	30.96	NO	81.52	660.2400	NO
2012	107.78	15.48	NO	92.30	649.7120	NO
2013	122.97	6.19	3.37	113.41	772.1280	NO
2014	113.31	12.38	4.13	96.79	612.1920	NO
2015	111.17	NO	3.63	107.54	762.0480	NO
2016	117.01	NO	6.65	110.36	729.4560	NO
2017	105.62	2.67	5.84	97.11	648.3276	NO
Decrease 1988-2017	88.0%	99.7%	-	-	-	-
Decrease 1990-2017	-578.9%	82.8%	-	-	-	-
Decrease 2016-2017	9.7%	-	12.2%	12.0%	11.1%	-

Table 59 CH_4 emissions in CRF 1.A.2.d. Pulp, Paper and Print

CH_4 (Gg)	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0342	0.0342	NO	NO	NO	NO
1990	0.0006	0.0006	NO	NO	NO	NO
1995	0.0006	0.0005	NO	0.0001	0.0001	NO
2000	0.0056	0.0038	NO	0.0017	0.0000	NO
2005	0.0149	0.0040	NO	0.0022	0.0088	NO
2010	0.1473	0.0011	NO	0.0014	0.1449	NO
2011	0.1795	0.0012	NO	0.0015	0.1769	NO
2012	0.1763	0.0006	NO	0.0017	0.1740	NO
2013	0.2094	0.0002	0.0003	0.0020	0.2068	NO
2014	0.1666	0.0005	0.0004	0.0017	0.1640	NO
2015	0.2064	NO	0.0003	0.0019	0.2041	NO
2016	0.1980	NO	0.0006	0.0020	0.1954	NO
2017	0.1761	0.0001	0.0006	0.0018	0.1737	NO
Decrease 1988-2017	-414.8%	99.8%	-	-	-	-
Decrease 1990-2017	-28583.5%	86.4%	-	-	-	-
Decrease 2016-2017	11.1%	-	11.0%	11.8%	11.1%	-

Table 60 N_2O emissions in CRF 1.A.2.d. Pulp, Paper and Print

N_2O (Gg)	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0068	0.0068	NO	NO	NO	NO
1990	0.0001	0.0001	NO	NO	NO	NO
1995	0.0001	0.0001	NO	0.0000	0.0000	NO
2000	0.0009	0.0008	NO	0.0002	0.0000	NO
2005	0.0022	0.0008	NO	0.0002	0.0012	NO
2010	0.0197	0.0002	NO	0.0001	0.0193	NO
2011	0.0240	0.0002	NO	0.0001	0.0236	NO
2012	0.0235	0.0001	NO	0.0002	0.0232	NO
2013	0.0279	0.0000	0.0000	0.0002	0.0276	NO
2014	0.0222	0.0001	0.0001	0.0002	0.0219	NO
2015	0.0275	NO	0.0001	0.0002	0.0272	NO
2016	0.0263	NO	0.0001	0.0002	0.0261	NO
2017	0.0234	0.0000	0.0001	0.0002	0.0232	NO
Decrease 1988-2017	-242.5%	99.8%	-	-	-	-
Decrease 1990-2017	-18985.8%	87.7%	-	-	-	-
Decrease 2016-2017	11.1%	-	11.0%	11.8%	11.1%	-

Table 61 GHG emissions in CRF 1.A.2.d. Pulp, Paper and Print

GHG (Gg)	TJ	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	11 400.00	885.25	885.25	NO	NO	NO	NO
1990	204.60	15.61	15.61	NO	NO	NO	NO
1995	219.70	15.44	12.50	NO	2.93	0.0039	NO
2000	2 967.20	192.49	99.44	NO	93.05	0.0019	NO
2005	3 771.27	222.24	102.51	NO	119.16	0.5690	NO
2010	6 543.50	112.23	27.96	NO	74.90	9.3779	NO
2011	7 770.10	124.11	31.06	NO	81.60	11.4481	NO
2012	7 673.20	119.19	15.53	NO	92.39	11.2655	NO
2013	9 054.56	136.52	6.21	3.39	113.52	13.3881	NO
2014	7 413.95	124.09	12.42	4.16	96.89	10.6150	NO
2015	8 772.00	124.52	NO	3.66	107.64	13.2134	NO
2016	8 560.20	129.81	NO	6.70	110.47	12.6482	NO
2017	7 633.64	117.00	2.68	5.88	97.21	11.2415	NO
Decrease 1988-2017	33.0%	86.8%	99.7%	-	-	-	-
Decrease 1990-2017	-3631.0%	-649.6%	82.9%	-	-	-	-
Decrease 2016-2017	10.8%	9.9%	-	12.2%	12.0%	11.1%	-

3.3.11.5 Food Processing, Beverages and Tobacco (CRF 1.A.2.e.)

Category 1.A.2.e Food Processing, Beverages and Tobacco enfolds emissions from fuel combustion in food processing, beverages and tobacco industry.

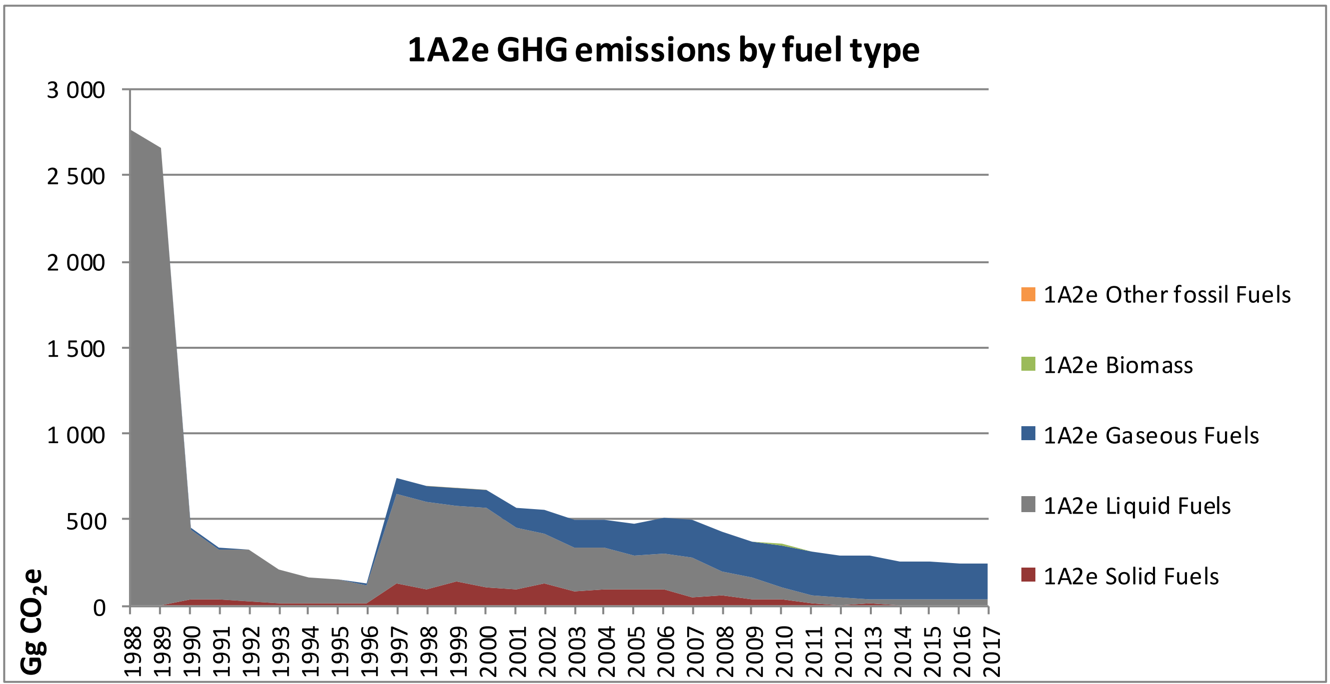

Figure 34 GHG emissions from 1.A.2.e. Food Processing, Beverages and Tobacco

The share of this subcategory from sector 1.A is 0.6% for 2017, which is equivalent to 0.4% of total GHG emissions.

Table 62 CO_2 emissions in CRF 1.A.2.e. Food Processing, Beverages and Tobacco

CO_2 (Gg)	CRF 1.A.2.e.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	2 760.71	2 760.71	NO	NO	NO	NO
1990	453.59	409.27	32.90	11.43	NO	NO
1995	154.80	140.32	11.05	3.43	1.9040	NO
2000	668.07	450.17	111.43	106.47	36.8480	NO
2005	476.91	204.94	89.93	182.04	19.4880	NO
2010	354.30	70.59	39.85	243.86	33.0400	NO
2011	318.41	51.82	8.96	257.64	24.7520	NO
2012	289.79	46.01	4.42	239.35	60.9280	NO
2013	289.28	24.50	10.35	254.43	63.0560	NO
2014	256.40	30.75	4.13	221.52	94.4160	NO
2015	259.19	33.86	7.45	217.88	129.6960	NO
2016	239.90	33.43	2.53	203.94	114.2400	NO
2017	240.19	30.05	3.16	206.98	34.6145	NO
Decrease 1988-2017	91.3%	98.9%	-	-	-	-
Decrease 1990-2017	47.0%	92.7%	90.4%	-1711.3%	-	-
Decrease 2016-2017	-0.1%	10.1%	-24.9%	-1.5%	69.7%	-

Table 63 CH_4 emissions in 1.A.2.e. Food Processing, Beverages and Tobacco

CH_4 (Gg)	CRF 1.A.2.e.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.1080	0.1080	NO	NO	NO	NO
1990	0.0198	0.0164	0.0032	0.0002	NO	NO
1995	0.0072	0.0056	0.0011	0.0001	0.0005	NO

CH_4 (Gg)	CRF 1.A.2.e.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2000	0.0408	0.0176	0.0114	0.0019	0.0099	NO
2005	0.0257	0.0079	0.0093	0.0033	0.0052	NO
2010	0.0199	0.0025	0.0042	0.0044	0.0089	NO
2011	0.0139	0.0017	0.0009	0.0047	0.0066	NO
2012	0.0227	0.0016	0.0004	0.0043	0.0163	NO
2013	0.0234	0.0008	0.0010	0.0046	0.0169	NO
2014	0.0308	0.0011	0.0004	0.0040	0.0253	NO
2015	0.0406	0.0012	0.0007	0.0039	0.0347	NO
2016	0.0356	0.0011	0.0003	0.0037	0.0306	NO
2017	0.0120	0.0009	0.0003	0.0037	0.0070	NO
Decrease 1988-2017	88.9%	99.2%	-	-	-	-
Decrease 1990-2017	39.2%	94.4%	89.4%	-1702.2%	-	-
Decrease 2016-2017	66.2%	13.4%	-25.2%	-1.8%	77.0%	-

Table 64 N_2O emissions in 1.A.2.e. Food Processing, Beverages and Tobacco

N_2O (Gg)	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0216	0.0216	NO	NO	NO	NO
1990	0.0038	0.0033	0.0005	0.0000	NO	NO
1995	0.0014	0.0011	0.0002	0.0000	0.0001	NO
2000	0.0067	0.0035	0.0017	0.0002	0.0013	NO
2005	0.0040	0.0016	0.0014	0.0003	0.0007	NO
2010	0.0027	0.0005	0.0006	0.0004	0.0012	NO
2011	0.0018	0.0003	0.0001	0.0005	0.0009	NO
2012	0.0030	0.0003	0.0001	0.0004	0.0022	NO
2013	0.0030	0.0002	0.0002	0.0005	0.0023	NO
2014	0.0040	0.0002	0.0001	0.0004	0.0034	NO
2015	0.0054	0.0002	0.0001	0.0004	0.0046	NO
2016	0.0047	0.0002	0.0000	0.0004	0.0041	NO
2017	0.0015	0.0002	0.0001	0.0004	0.0009	NO
Decrease 1988-2017	93.0%	99.2%	-	-	-	-
Decrease 1990-2017	59.7%	95.0%	89.4%	-1702.2%	-	-
Decrease 2016-2017	67.5%	15.0%	-25.2%	-1.8%	77.1%	-

Table 65 GHG emissions in 1.A.2.e. Food Processing, Beverages and Tobacco

GHG (Gg)	TJ	CRF 1.A.2.e.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	36 011.40	2 769.85	2 769.85	NO	NO	NO	NO
1990	5 984.34	455.21	410.65	33.12	11.44	NO	NO
1995	2 045.98	155.38	140.79	11.12	3.43	0.0330	NO
2000	9 289.09	671.10	451.66	112.22	106.58	0.6389	NO
2005	7 090.76	478.74	205.60	90.57	182.22	0.3379	NO
2010	6 082.06	355.62	70.79	40.15	244.10	0.5729	NO

GHG (Gg)	TJ	CRF 1.A.2.e.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2011	5 690.71	319.30	51.96	9.02	257.89	0.4292	NO
2012	5 551.54	291.24	46.15	4.45	239.59	1.0564	NO
2013	5 600.49	290.76	24.56	10.42	254.68	1.0933	NO
2014	5 304.20	258.37	30.84	4.16	221.74	1.6371	NO
2015	5 613.63	261.81	33.96	7.50	218.10	2.2488	NO
2016	5 187.53	242.19	33.51	2.55	204.15	1.9808	NO
2017	4 588.44	240.94	30.12	3.18	207.19	0.4539	NO
Decrease 1988-2017	87.3%	91.3%	98.9%	-	-	-	-
Decrease 1990-2017	23.3%	47.1%	92.7%	90.4%	-1711.3%	-	-
Decrease 2016-2017	11.5%	0.5%	10.1%	-24.9%	-1.5%	77.1%	-

3.3.11.6 Non-metallic minerals (CRF 1.A.2.f.)

Category 1.A.2.f Non-metallic minerals enfolds emissions from fuel combustion from all activities in the non-metallic minerals industry (mostly cement production industry).

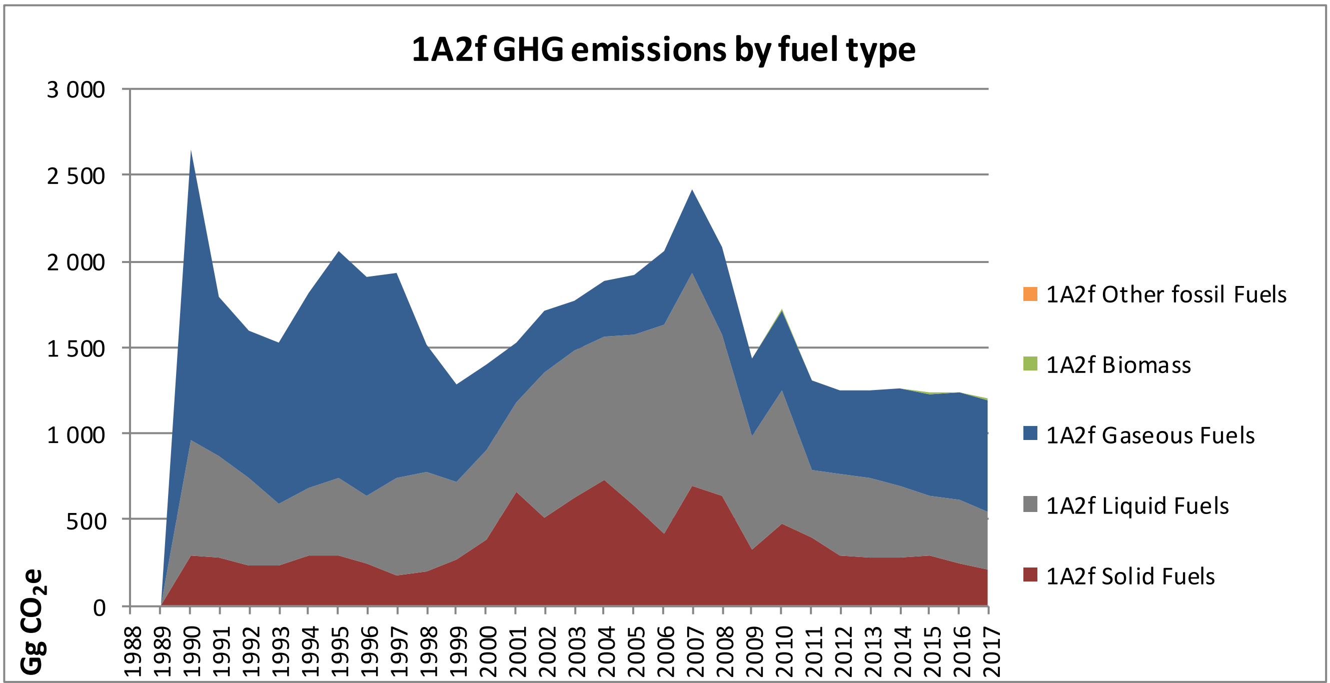

Figure 35 GHG emissions from 1.A.2.f. Non-metallic minerals

The share of this subcategory from sector 1.A is 2.8% for 2017, which is equivalent to 2.0% of total GHG emissions.

This industry experienced a notable growth until 2007, which was followed by a significant decline after 2008 as a result of the global financial crisis and the following decline in the construction sector. Additionally, the sector experienced some restructuring resulting in the closure of some of the cement plants in the country.

Table 66 CO_2 emissions in 1.A.2.f. Non-metallic minerals

CO_2 (Gg)	CRF 1.A.2.f.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	2 645.80	666.44	295.28	1 684.09	NO	NO
1995	2 050.57	445.93	292.19	1 312.45	1.5680	NO
2000	1 397.08	520.00	382.32	494.75	0.6720	NO
2005	1 917.04	987.48	577.05	352.51	1.8953	NO
2010	1 712.41	778.07	470.09	464.26	70.1155	NO
2011	1 304.59	393.31	388.05	523.23	54.6855	NO
2012	1 246.25	468.16	293.77	484.32	106.4638	NO
2013	1 244.78	470.38	272.51	501.88	108.8573	NO
2014	1 254.45	417.00	279.71	557.74	77.6949	NO
2015	1 228.79	354.02	286.60	588.16	89.3569	NO
2016	1 232.14	370.38	239.72	622.05	136.1593	NO
2017	1 194.11	338.65	209.15	646.30	156.4240	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	54.9%	49.2%	29.2%	61.6%	-	-
Decrease 2016-2017	3.1%	8.6%	12.8%	-3.9%	-14.9%	-

Table 67 CH_4 emissions in 1.A.2.f. Non-metallic minerals

CH_4 (Gg)	CRF 1.A.2.f.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	0.0857	0.0256	0.0296	0.0305	NO	NO
1995	0.0715	0.0171	0.0302	0.0238	0.0004	NO
2000	0.0659	0.0175	0.0393	0.0090	0.0002	NO
2005	0.0973	0.0316	0.0588	0.0064	0.0005	NO
2010	0.1013	0.0250	0.0492	0.0084	0.0188	NO
2011	0.0774	0.0129	0.0403	0.0095	0.0146	NO
2012	0.0827	0.0151	0.0303	0.0088	0.0285	NO
2013	0.0816	0.0150	0.0284	0.0091	0.0292	NO
2014	0.0734	0.0133	0.0292	0.0101	0.0208	NO
2015	0.0761	0.0113	0.0303	0.0106	0.0239	NO
2016	0.0844	0.0118	0.0250	0.0112	0.0365	NO
2017	0.0870	0.0108	0.0226	0.0116	0.0419	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	-1.4%	57.8%	23.7%	61.8%	-	-
Decrease 2016-2017	-3.1%	8.4%	9.3%	-4.2%	-14.9%	-

Table 68 N_2O emissions in 1.A.2.f. Non-metallic minerals

N_2O (Gg)	CRF 1.A.2.f.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	0.0126	0.0051	0.0044	0.0031	NO	NO

N_2O (Gg)	CRF 1.A.2.f.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1995	0.0104	0.0034	0.0045	0.0024	0.0001	NO
2000	0.0103	0.0035	0.0059	0.0009	0.0000	NO
2005	0.0158	0.0063	0.0088	0.0006	0.0001	NO
2010	0.0157	0.0050	0.0074	0.0008	0.0025	NO
2011	0.0115	0.0026	0.0061	0.0009	0.0020	NO
2012	0.0122	0.0030	0.0045	0.0009	0.0038	NO
2013	0.0121	0.0030	0.0043	0.0009	0.0039	NO
2014	0.0108	0.0026	0.0044	0.0010	0.0028	NO
2015	0.0111	0.0023	0.0045	0.0011	0.0032	NO
2016	0.0121	0.0024	0.0037	0.0011	0.0049	NO
2017	0.0123	0.0022	0.0034	0.0012	0.0056	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	2.2%	57.6%	23.7%	61.8%	-	-
Decrease 2016-2017	-1.9%	8.4%	9.3%	-4.2%	-14.9%	-

Table 69 GHG emissions in CRF 1.A.2.f. Non-metallic minerals

GHG (Gg)	TJ	CRF 1.A.2.f.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO	NO
1990	42 276.98	2 651.70	668.59	297.35	1 685.76	NO	NO
1995	32 659.47	2 055.45	447.37	294.29	1 313.75	0.0272	NO
2000	18 825.47	1 401.79	521.48	385.06	495.24	0.0117	NO
2005	22 851.49	1 924.19	990.15	581.15	352.86	0.0329	NO
2010	22 307.73	1 719.63	780.18	473.51	464.72	1.2158	NO
2011	18 324.48	1 309.96	394.40	390.86	523.75	0.9482	NO
2012	17 833.82	1 251.97	469.44	295.88	484.80	1.8460	NO
2013	17 916.21	1 250.41	471.65	274.49	502.38	1.8875	NO
2014	18 128.91	1 259.51	418.12	281.75	558.29	1.3472	NO
2015	18 207.86	1 233.98	354.98	288.71	588.74	1.5494	NO
2016	18 851.53	1 237.85	371.37	241.46	622.66	2.3609	NO
2017	18 943.35	1 199.95	339.57	210.73	646.94	2.7123	NO
Decrease 1988-2017	-	-	-	-	-	-	-
Decrease 1990-2017	55.2%	54.7%	49.2%	29.1%	61.6%	-	-
Decrease 2016-2017	-0.5%	3.1%	8.6%	12.7%	-3.9%	-14.9%	-

3.3.11.7 Other (CRF 1.A.2.g.)

Category 1.A.2.g Other, includes emissions from fuel combustion from all activities which could not be classified under any of the other subcategories from 1.A.2 subcategory.

Most notably these are:

- Autoproducer Electricity Plants
- Autoproducer CHP Plants

- Autoproducer Heat Plants
- Manufacturing of machinery
- Manufacturing of transport equipment
- Mining and quarrying
- Wood and wood products
- Construction
- Textile and leather
- Off-road vehicles and other machinery
- Other non-specified (Industry)

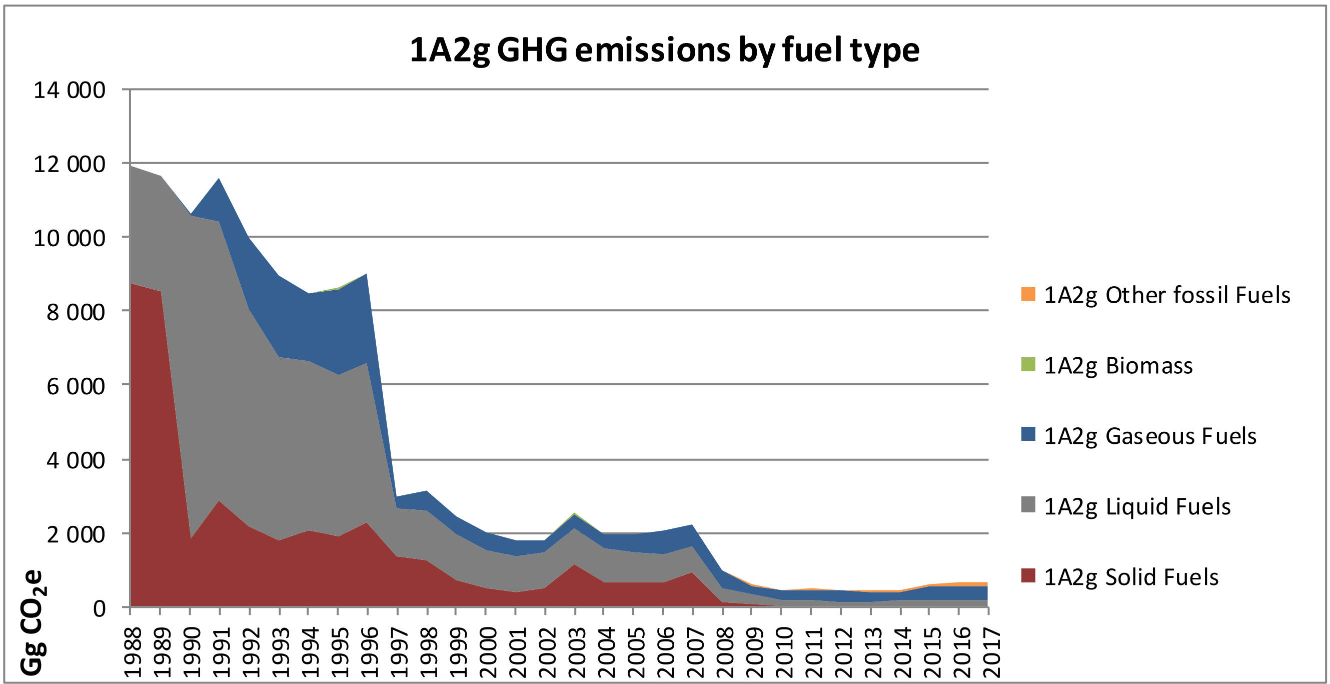

Figure 36 GHG emissions from 1.A.2.g. Other industries

The share of this subcategory from sector 1.A is 1.6% for 2017, which is equivalent to 1.1% total GHG emissions.

Up to 1997 there was a significantly higher consumption in this sector, due to the fact that the total amount of fuels used by autoproducers CHP and heat plants was reported under autoproducers instead of reporting only the quantities sold to third parties. The National statistics changed their methodologies after 1997 and reallocated fuels used for the production of electricity and heat for own use to the respective subcategories from category 1.A.2. This sector also includes the emissions from the use of alternative fuels (e.g. SRF/RDF, waste oils and tires, etc.) in cement and other industries, which started after 2004.

Table 70 CO_2 emissions in 1.A.2.g. Other industries

CO_2 (Gg)	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	11 822.59	3 155.83	8 666.75	NO	NO	NO
1990	10 579.45	8 632.34	1 858.13	88.98	NO	NO
1995	8 572.11	4 312.13	1 909.43	2 350.55	134.9600	NO
2000	1 974.35	990.09	510.62	473.64	128.1280	NO
2005	1 952.83	771.44	679.80	498.78	117.1520	2.8073
2010	444.50	167.11	12.26	240.13	163.8182	25.0006
2011	469.42	179.77	10.36	252.56	155.6198	26.7375

CO_2 (Gg)	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2012	461.41	124.04	12.67	284.96	220.0744	39.7388
2013	448.42	127.13	12.94	256.82	281.3230	51.5288
2014	440.28	139.72	9.81	242.82	335.6318	47.9238
2015	610.93	157.17	15.81	372.78	352.0846	65.1663
2016	624.18	143.72	13.24	365.28	338.2638	101.9390
2017	662.77	161.13	24.35	357.52	335.4148	119.7840
Decrease 1988-2017	94.4%	94.9%	99.7%	-	-	-
Decrease 1990-2017	93.7%	98.1%	98.7%	-301.8%	-	-
Decrease 2016-2017	-6.2%	-12.1%	-83.9%	2.1%	0.8%	-17.5%

Table 71 CH_4 emissions in 1.A.2.g. Other industries

CH_4 (Gg)	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	1.0085	0.1312	0.8774	NO	NO	NO
1990	0.5157	0.3397	0.1743	0.0016	NO	NO
1995	0.4307	0.1677	0.1843	0.0426	0.0362	NO
2000	0.1323	0.0392	0.0502	0.0086	0.0343	NO
2005	0.1419	0.0308	0.0697	0.0090	0.0314	0.0010
2010	0.0660	0.0072	0.0013	0.0043	0.0430	0.0103
2011	0.0633	0.0078	0.0011	0.0046	0.0406	0.0092
2012	0.0848	0.0054	0.0013	0.0052	0.0589	0.0140
2013	0.1033	0.0058	0.0014	0.0046	0.0746	0.0169
2014	0.1163	0.0065	0.0010	0.0044	0.0880	0.0165
2015	0.1296	0.0070	0.0017	0.0067	0.0912	0.0230
2016	0.1398	0.0058	0.0014	0.0066	0.0859	0.0401
2017	0.1466	0.0044	0.0026	0.0064	0.0835	0.0496
Decrease 1988-2017	85.5%	96.6%	99.7%	-	-	-
Decrease 1990-2017	71.6%	98.7%	98.5%	-299.8%	-	-
Decrease 2016-2017	-4.8%	24.2%	-90.9%	1.9%	2.8%	-23.6%

Table 72 N_2O emissions in 1.A.2.g. Other industries

N_2O (Gg)	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.3020	0.1704	0.1316	NO	NO	NO
1990	0.2138	0.1877	0.0260	0.0002	NO	NO
1995	0.1106	0.0740	0.0275	0.0043	0.0048	NO
2000	0.0313	0.0184	0.0075	0.0009	0.0046	NO
2005	0.0473	0.0317	0.0104	0.0009	0.0042	0.0001
2010	0.0303	0.0225	0.0002	0.0004	0.0057	0.0014
2011	0.0323	0.0250	0.0002	0.0005	0.0054	0.0012
2012	0.0267	0.0163	0.0002	0.0005	0.0079	0.0019
2013	0.0350	0.0221	0.0002	0.0005	0.0099	0.0023
2014	0.0403	0.0258	0.0002	0.0004	0.0117	0.0022

N_2O (Gg)	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2015	0.0420	0.0259	0.0003	0.0007	0.0121	0.0031
2016	0.0398	0.0221	0.0002	0.0007	0.0114	0.0054
2017	0.0195	0.0008	0.0004	0.0006	0.0111	0.0066
Decrease 1988-2017	93.5%	99.6%	99.7%	-	-	-
Decrease 1990-2017	90.9%	99.6%	98.5%	-299.8%	-	-
Decrease 2016-2017	50.9%	96.6%	-90.9%	1.9%	2.9%	-23.6%

Table 73 GHG emissions in CRF 1.A.2.g. Other industries

GHG (Gg)	TJ	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	129 467.75	11 937.80	3 209.90	8 727.91	NO	NO	NO
1990	134 955.71	10 656.06	8 696.75	1 870.23	89.07	NO	NO
1995	120 844.05	8 615.84	4 338.38	1 922.24	2 352.88	2.3401	NO
2000	28 554.65	1 986.99	996.55	514.11	474.11	2.2216	NO
2005	27 918.06	1 970.48	781.65	684.66	499.27	2.0313	2.8728
2010	8 560.83	455.17	174.00	12.35	240.37	2.7807	25.6658
2011	8 823.67	480.62	187.41	10.43	252.81	2.6243	27.3353
2012	9 383.69	471.48	129.02	12.77	285.24	3.8124	40.6428
2013	9 585.48	461.44	133.88	13.03	257.08	4.8289	52.6232
2014	9 979.99	455.20	147.57	9.88	243.06	5.6921	48.9889
2015	13 037.71	626.69	165.05	15.93	373.15	5.8989	66.6581
2016	13 283.63	639.52	150.45	13.34	365.64	5.5593	104.5375
2017	13 883.40	672.26	161.46	24.53	357.87	5.4010	122.9959
Decrease 1988-2017	89.3%	94.4%	95.0%	99.7%	-	-	-
Decrease 1990-2017	89.7%	93.7%	98.1%	98.7%	-301.8%	-	-
Decrease 2016-2017	-4.5%	-5.1%	-7.3%	-83.9%	2.1%	2.8%	-17.7%

3.3.11.7.1 Source-specific recalculations, including changes made in response to the review process

During the 2014 submission a calculation error for the CH_4 and N_2O emissions was identified. Before that, the use of alternative fuels was leading to double counting of the emissions, as they were reported both under 'Biomass' and 'Other fuels'. Since the alternative fuels contain both a biomass and a fossil fraction, the resulting emissions from the biomass fraction are currently reported under biomass, while the emissions from the fossil fraction are reported under 'Other fuels'.

3.3.12 TRANSPORT (CRF 1.A.3)

The GHG emissions in Transport (CRF 1.A.3) are estimated following the 2006 IPCC Guidelines and the recommendations of ERT set out in FCCC/ARR/2013/BGR and FCCC/ARR/2014/BGR.

3.3.12.1 Source category description

The IPCC source category for transport covers all types of mobile sources and the range of characteristics that affect the emission factors and consequently the emissions. Those are compiled according to the source in the following five categories:

Table 74 Transport sector categories

Number	Category	CO_2	CH_4	N_2O	Method
CRF 1.A.3.a	Civil aviation (domestic)	✓	✓	✓	TIER 2
CRF 1.A.3.b	Road transport	✓	✓	✓	TIER 2
CRF 1.A.3.c	Railways	✓	✓	✓	TIER 1
CRF 1.A.3.d	Navigation	✓	✓	✓	TIER 1
CRF 1.A.3.e	Other Transport	✓	✓	✓	TIER 1

For each of the main emissions from transport – carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) – the most appropriate calculation method based on the type of emission, transport category and data availability has been selected. The uncertainty of the main inputs regarding the emission type has been considered and evaluated. Furthermore, for the GHG inventory compilation, the ERT recommendations set out in FCCC/ARR/2012/BGR have been followed.

Emission trends over the years depend mostly on the amount of fuel consumed for CO_2, whereas for CH_4 and N_2O the vehicle fleet and the fuel quality parameters are more important factors. The fuel quantities used in the CRF 1.A.3 Transport for 1988 – 2017 are shown below.

Table 75 Fuels for CRF 1.A.3 Transport in TJ 1988 - 2017

CRF 1A3 Transport	a. Civil Aviation	b. Road Transportation	c. Railways	d. Navigation	e. Other Transport
	TJ				
1988	2 937	96 173	NO	NO	NO
1990	1 899	81 973	4 357	761	1 777
1995	1 280	56 070	3 066	167	40
2000	887	68 599	1 607	85	6 887
2005	561	100 129	1 227	153	9 042
2010	646	104 200	846	117	5 896
2011	904	104 123	761	127	8 528
2012	474	111 430	931	115	8 519
2013	517	100 027	630	96	7 608
2014	388	113 134	505	116	7 032
2015	560	125 871	673	137	6 141
2016	851	128 185	546	99	6 013
2017	863	129 330	563	99	7 158

The fuel consumption associated with navigation (where notation key NO assigned in the years) is elaborated in section CRF 1.A.3.d Navigation and CRF 1.A.3.c Railways.

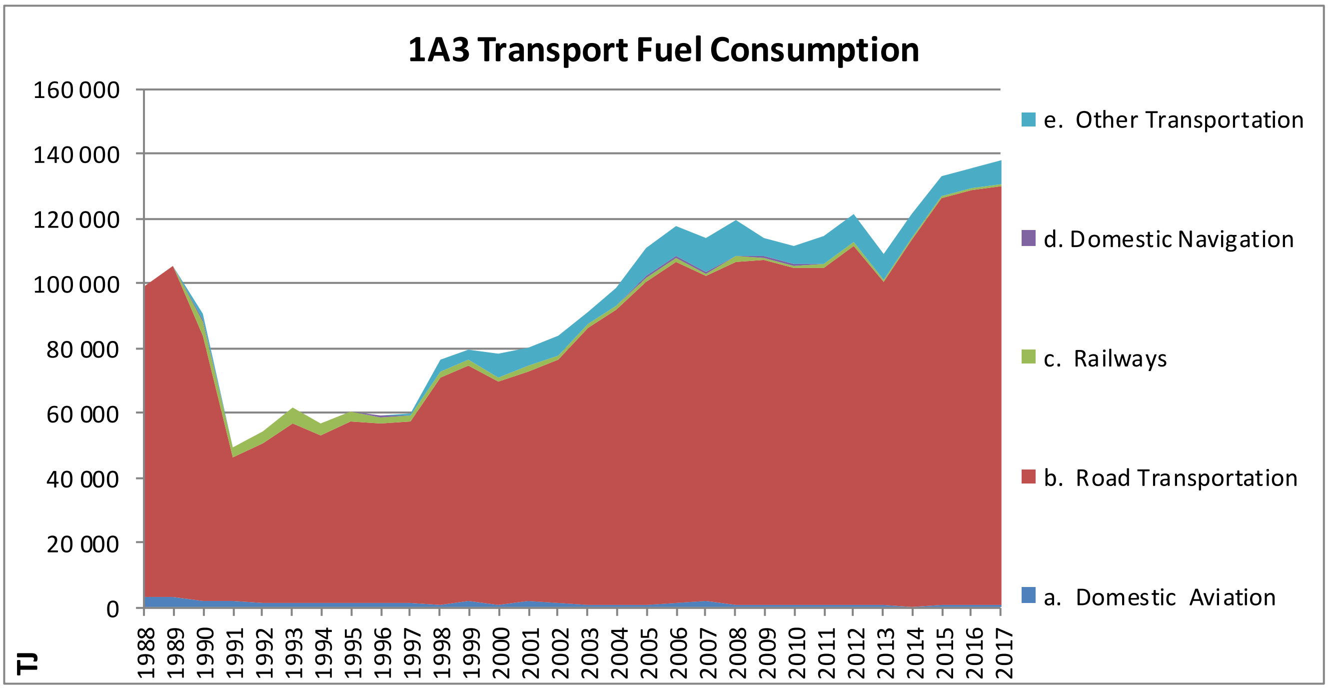

Figure 37 Fuels for CRF 1.A.3 transport for 1988 - 2017

In the period between 1988 and 1991 fuel consumption in the transport sector decreased by 48% due to the collapse of the economy. Since 1991 fuel consumption has been increasing steadily mainly due to road transport. Even though a decrease was observed in 2013, as of 2014 the use of road transport fuels has started to increase again. The share of transport categories for the last decade is as follows:

Table 76 Share of fuel consumption in 1A3 Transport fuel

CRF 1A3 Transport	a. Civil Aviation	b. Road Transportation	c. Railways	d. Navigation	e. Other Transport
1988	3.0%	97.0%	-	-	-
1990	2.1%	90.3%	4.8%	0.8%	2.0%
1995	2.1%	92.5%	5.1%	0.3%	0.1%
2000	1.1%	87.9%	2.1%	0.1%	8.8%
2005	0.5%	90.1%	1.1%	0.1%	8.1%
2010	0.6%	93.3%	0.8%	0.1%	5.3%
2011	0.8%	91.0%	0.7%	0.1%	7.5%
2012	0.4%	91.7%	0.8%	0.1%	7.0%
2013	0.5%	91.9%	0.6%	0.1%	7.0%
2014	0.3%	93.4%	0.4%	0.1%	5.8%
2015	0.4%	94.4%	0.5%	0.1%	4.6%
2016	0.6%	94.5%	0.4%	0.1%	4.4%
2017	0.6%	93.7%	0.4%	0.1%	5.2%

3.3.12.2 CRF 1.A.3.a Civil Aviation

3.3.12.2.1 Source description

The IPCC source category for civil aviation includes emissions from all civil commercial use of airplanes (international and domestic) consisting of scheduled and charter traffic for passengers and freight as well as general aviation. Emissions from aviation are derived from the combustion of jet kerosene and aviation gasoline. Aircrafts emit carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO_2), particulate matter (PM) and nitrogen oxides (NO_x). Domestic aviation is related to the transport of passengers and cargo as well as general aviation. The types of flights include both scheduled and non-scheduled. International aviation is differentiated from domestic aviation on the basis of departure and landing locations.

3.3.12.2.2 Emission trend

For 2017 there was a decrease of 70.4% in the emissions from civil aviation compared to the base year, and an increase of 1.5% compared to the year before. In 2017 the sector was responsible for 0.15% of the emissions allocated to 1.A Fuel combustion and for 0.10% of the total GHG emissions (excluding LULUCF). The main source of emissions was the use of jet kerosene with only insignificant amounts of aviation gasoline being consumed.

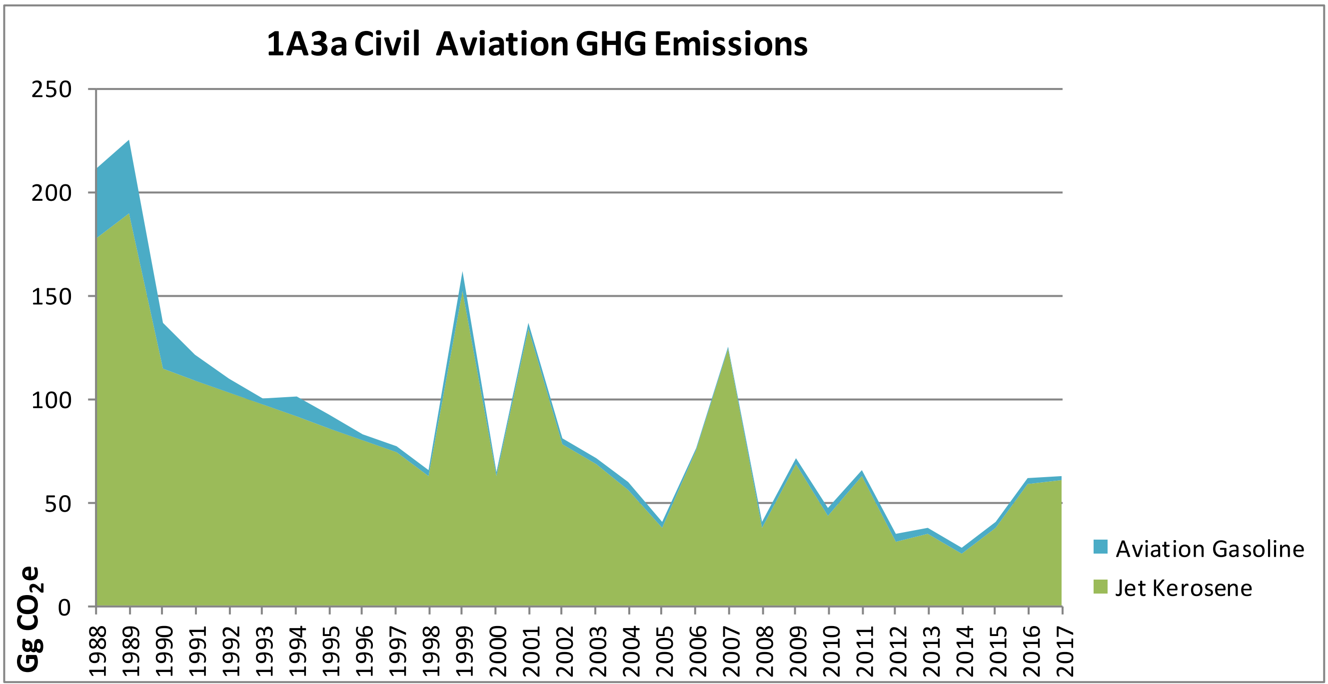

Figure 38 GHG emission in CRF 1.A.3.a Civil aviation – domestic (1988 - 2017)

Table 77 Fuel consumption and emissions from Civil aviation - all fuels

Year	TJ	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	Total GHG [Gg CO_2e]
1988	2 936.74	208.93	0.0015	0.0059	210.72
1990	1 899.00	135.10	0.0009	0.0038	136.26
1995	1 279.71	91.31	0.0006	0.0026	92.08
2000	887.19	63.62	0.0018	0.0018	64.21
2005	561.40	40.20	0.0011	0.0012	40.59
2010	646.00	46.30	0.0008	0.0014	46.75
2011	904.00	64.78	0.0012	0.0020	65.40
2012	474.00	34.01	0.0008	0.0011	34.36
2013	517.00	37.05	0.0005	0.0011	37.38
2014	388.00	27.81	0.0006	0.0008	28.07
2015	560.00	40.11	0.0006	0.0012	40.47
2016	851.10	60.95	0.0007	0.0018	61.49
2017	862.57	61.84	0.0007	0.0018	62.40

Table 78 Fuel consumption and emissions from Civil aviation - jet kerosene

Year	TJ	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	Total GHG [Gg CO_2e]
1988	2 460.43	175.92	0.0012	0.0049	177.42
1990	1 591.00	113.76	0.0008	0.0032	114.72
1995	1 191.71	85.21	0.0006	0.0024	85.93
2000	860.00	61.74	0.0018	0.0018	62.31
2005	517.44	37.16	0.0011	0.0011	37.52
2010	602.00	43.25	0.0008	0.0014	43.68
2011	860.00	61.73	0.0012	0.0019	62.33
2012	430.00	30.96	0.0008	0.0010	31.28
2013	473.00	34.00	0.0005	0.0010	34.31
2014	344.00	24.76	0.0005	0.0007	25.00
2015	516.00	37.06	0.0006	0.0011	37.40
2016	817.00	58.59	0.0007	0.0017	59.11
2017	842.41	60.44	0.0007	0.0018	60.99

Table 79 Fuel consumption and emissions from Civil aviation – aviation gasoline

Year	TJ	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	Total GHG [Gg CO_2e]
1988	476.31	33.01	0.00024	0.0010	33.30
1990	308.00	21.34	0.00015	0.0006	21.53
1995	88.00	6.10	0.00004	0.0002	6.15
2000	27.19	1.88	0.00001	0.0001	1.90
2005	43.96	3.05	0.00002	0.0001	3.07
2010	44.00	3.05	0.00002	0.0001	3.08
2011	44.00	3.05	0.00002	0.0001	3.08
2012	44.00	3.05	0.00002	0.0001	3.08
2013	44.00	3.05	0.00002	0.0001	3.08
2014	44.00	3.05	0.00002	0.0001	3.08
2015	44.00	3.05	0.00002	0.0001	3.08
2016	34.10	2.36	0.00002	0.0001	2.38
2017	20.15	1.40	0.00001	0.0000	1.41

3.3.12.2.3 Methods

Civil aviation is considered a minor contributor to Transport sector emissions as a result of the limited quantities of fuel consumed, as reported by the NSI. Nevertheless, on the basis of planned methodology improvement, the emission estimates for domestic aviation were calculated according to Tier 2 and following 2006 IPCC GL.

The Tier 2 method requires as a first step to perform a calculation based on landing and take-off (LTO) cycles per aircraft type per year, separately for domestic and international flights. Corresponding emission factors and fuel consumption factors are applied per LTO and per aircraft type and according to the following equations:

LTO Emissions = Number of LTOs • Emission Factor LTO

LTO Fuel Consumption = Number of LTOs • Fuel Consumption per LTO

As a second step the total amount of fuel consumed in all LTOs is subtracted from the total fuel reported in order to calculate the cruise fuel consumption. The appropriate cruise emission factors are the applied via the following equation:

Cruise Emissions = (Total Fuel Consumption – LTO Fuel Consumption) • Emission Factor Cruise

The final step includes the sum of LTOs and cruise emissions in order to calculate the total emissions from aviation. This is calculated via the following equation:

Total Emissions = LTO Emissions + Cruise Emissions

3.3.12.2.4 Activity data

Total fuel consumption is obtained from the Energy balance and converted into energy units using the country-specific NCV.

The LTOs per aircraft type per year were obtained from Eurocontrol for the period 1996-2017 with the note that data for 1996 and 1997 is incomplete, since Bulgaria became an Eurocontrol member on 1st June 1997. The primary data for all years consists of more than 500 airplane types classified by ICAO code. The data was matched with the information from ICAO DOC 8643 Aircraft Type Designators document, which currently consists of more than 10 000 type designators in order to identify the manufacturer, model, engine type, engine count and wake turbulence category. About 90 of the ICAO type designators, reported by Eurocontrol, were not present in the ICAO DOC 8643. For those airplanes a manual search was performed in order to identify the exact type of airplane.

As a second step, all aircraft type designators were manually matched to the appropriate aircraft types from 2006 IPCC GL, Vol.2, Ch. 3, Table 3.6.9.

Since the IPCC guidelines provide information for only about 50 different aircraft types, the following correspondence table was used for the remaining aircrafts for which it was not possible to manually match the aircrafts based on their model:

Table 80 Correspondence between aircraft characteristics and generic aircraft types

WTC	Engine number	Engine type	Generic aircraft type	ICAO
L	1	Turboprop	King Air	BE30
L	1	Jet	Dornier 328 Jet	D328
L	2	Turboprop	BEECHCRAFT King Air	BE30
L	2	Jet	Dornier 328 Jet	D328
M	1	Jet	Gulfstream IV	G550
M	2	Turboprop	ATR72-500	ATR75
M	2	Jet	Fokker 100/70/28	F100
M	3	Turboprop	Dornier 328 Jet	D328
M	3	Jet	Yak-42M	YK42
M	4	Turboprop	BAE146	B463
M	4	Jet	BAE146	B463
H	2	Jet	Average fleet (B767)	B767
H	3	Jet	Lockheed Tristar	L1011
H	4	Jet	A340-300	A343
H	6	Jet	Old Fleet747-100	B741

The outcome of the updated Tier 2 methodology results in increase of the GHG emissions from jet kerosene by an average of 1%.

3.3.12.2.5 Emission factors

The default Tier 2 emissions factors for jet kerosene from 2006 IPCC GL, Vol.2, Ch. 3, Table 3.6.9 were used.

3.3.12.2.6 Uncertainties

Since the default emission factors are used, the following default uncertainties are assumed (2006 IPCC GL):

AD: 5 %

EF CO_2: ±5 %

EF N_2O (for all fuel): -70 %/ +150 %

EF CH_4 (for all fuel): -57 % / +100 %

3.3.12.2.7 Source-specific QA/QC and verification

All activities regarding QC as described in QA/QC System have been undertaken.

The following sector specific QA/QC procedures have been carried out:

- Check of methodology, CO_2 emissions, emission factors and IEF (time series);
- Time series consistency;
- Plausibility checks of dips and jumps;
- Documentation and archiving of all information required in NIR, background documentation and archive;
- Comparison of Tier 1 and Tier 2 approach.

3.3.12.2.8 Source-specific recalculations

No recalculations have been performed for the 2017 submission.

3.3.12.2.9 Source-specific planned improvements

No improvements are planned for next submission.

3.3.12.3 CRF 1.A.3.b Road transport

3.3.12.3.1 Source description

The IPCC source category for road transport 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, and on-road motorcycles (including mopeds, scooters, and three-wheelers). Road transport emits significant amounts of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as several other pollutants.

Road transport is defined as a key category, as a result of the considerable amount of CO_2 emissions from the use of diesel, gasoline and LPG presented below.

A unique feature of the Bulgarian vehicle fleet is its age structure. In 2017 about 86% of the vehicles were above 10 years old, whereas new vehicles (1 to 5 years) were 5% of the total and 9% were aged between 6 and 10 years.

The total number of registered vehicles in Bulgaria for the period 1988 – 2017 is presented in the following table.

Table 81 Number of vehicles by type

Vehicle type	Passenger cars	LDV and HDV	Busses	Motor-cycles	Mopeds
1988	1 220 784	210 805	5 486	217 360	276 901
1990	1 317 437	227 782	7 468	225 533	281 270
1995	1 647 571	289 430	15 371	233 365	285 901
2000	1 992 748	326 204	17 290	236 327	286 047
2005	2 544 198	393 565	12 584	97 754	48 667
2010	2 602 461	368 195	20 458	70 394	54 983
2011	2 694 862	382 324	20 120	73 805	58 019
2012	2 806 814	402 648	20 040	77 972	61 840
2013	2 910 235	424 299	20 277	82 481	65 479
2014	3 013 863	449 458	20 685	88 035	68 982
2015	3 162 037	483 945	21 265	93 869	71 885
2016	3 143 634	496 038	21 302	99 806	74 690
2017	2 775 758	459 927	19 350	106 047	78 114

Road transport accounts for the largest share in total fuel consumption in the Transport subsector. In 2017 road transport was responsible for 94.6% of the consumed energy in the sector.

3.3.12.3.2 Emission trend

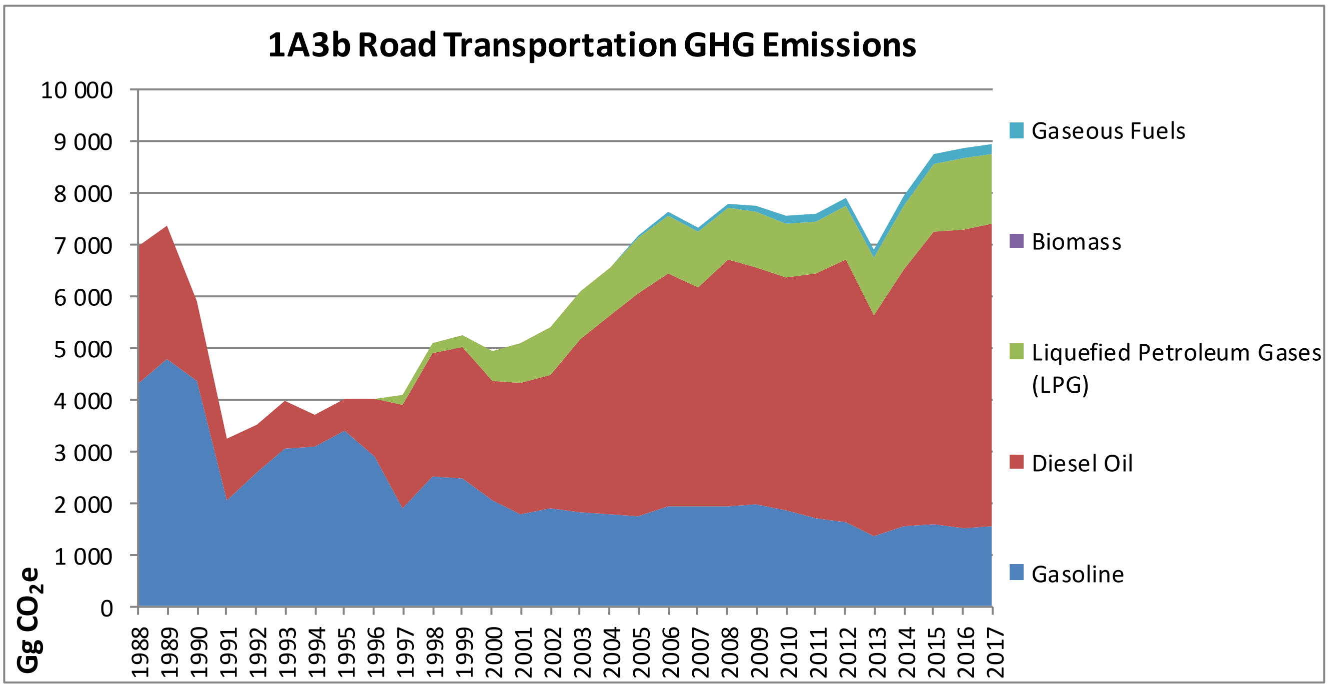

Figure 39 GHG emissions in CRF 1.A.3.b Road transport 1988 - 2017

Following a steep decline after 1989 as a result of the political and economic crisis, a distinct uptrend of GHG emissions can be observed ever since 2000. That change came as a result of the economic recovery, ushered in by the introduction of a currency board regime in 1997 and rigorous economic and political reforms. The main contributing gas is CO_2, followed by CH_4 and N_2O.The CO_2 emission trend is directly related to fuel consumption and therefore shows a decrease in the period 1990-2000.

However, in line with the reviving economy, CO_2 emissions grew steadily until 2006. Afterwards, a period of stabilization took place until 2009 when a slight drop in emissions was observed, mainly related to the economic crisis and the consequent decline in transportation. For 2013 there was again a drop in the fuel consumption (mostly for diesel fuel), which resulted in a decrease of emissions, but the drop was compensated after 2014, reaching a historical high in 2016 which was even surpassed in 2017.

Overall, the GHG emissions from road transport increased by 28.4% compared to the base year level of 6 968 Gg CO_2e and reached 8 946 Gg CO_2e in 2017.

The most significant contributor to GHG emissions were passenger cars, followed by heavy-duty vehicles, light-duty vehicles and motorcycles and mopeds. As it can be observed in the following figure, in 2017 passenger cars accounted for 63.3%, light-duty vehicles were responsible for 14.8%, and heavy duty vehicles (incl. buses) for 21.6% of total GHG CO_2e emissions; and the share of passenger cars was clearly increasing over the time series. The remaining 0.3% were shared among mopeds and motorcycles.

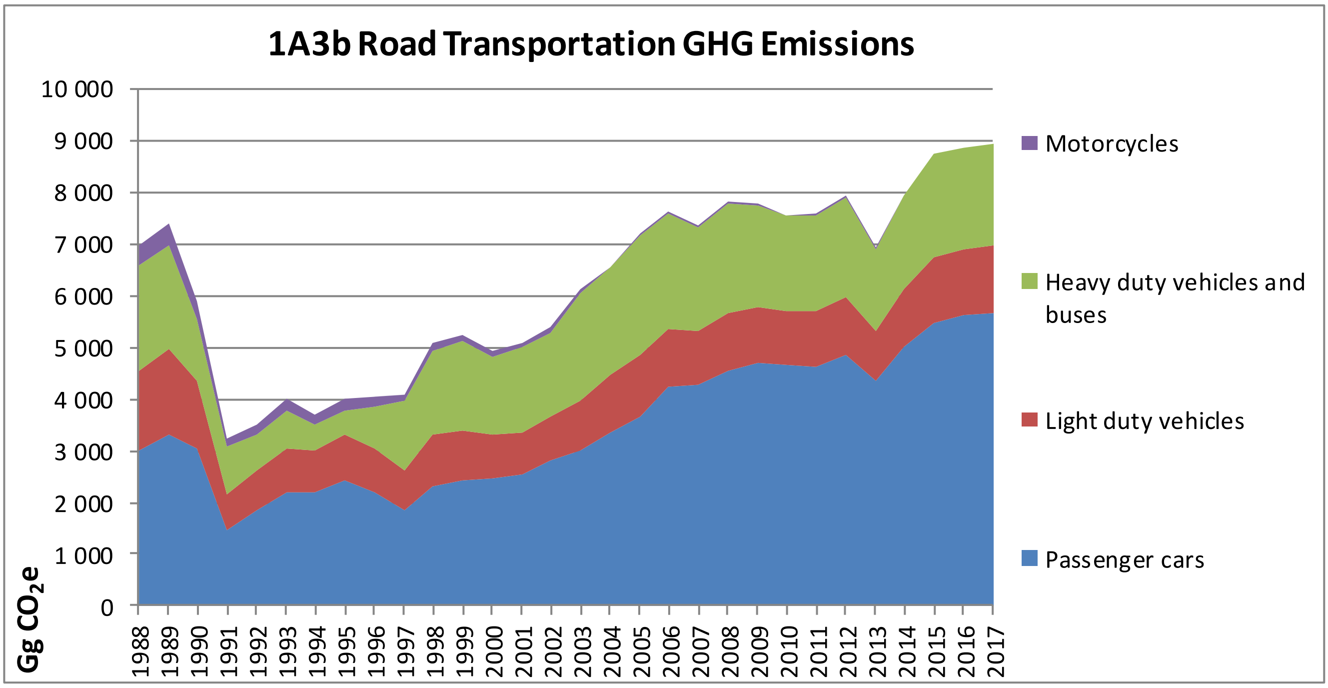

Figure 40 Emissions allocated to vehicle categories for the period 1988-2017

Whereas CO_2 emissions were closely linked to fuel consumption, CH_4 and N_2O emissions were considerably impacted by engine technology and did not follow the trend in the fuel consumption. As it can be observed in the following figure, N_2O emissions and implied emission factors tend to fluctuate for the period of the inventory following the introduction to the market of various engine technologies implementing EURO emission standards and various fuel quality standards (e.g. lead and sulphur content). However, the trend is not always downward, e.g. there was an increase in the IEF for the years up to 2003 which was closely linked to the gradual introduction of gasoline Euro 1 vehicles - a category known for its higher N_2O emissions. As the technology improves in time, there is a noticeable N_2O decrease resulting from the introduction of fuels with lower sulphur content (moving from Euro 1 to Euro 3) which is clearly observed after 2004.

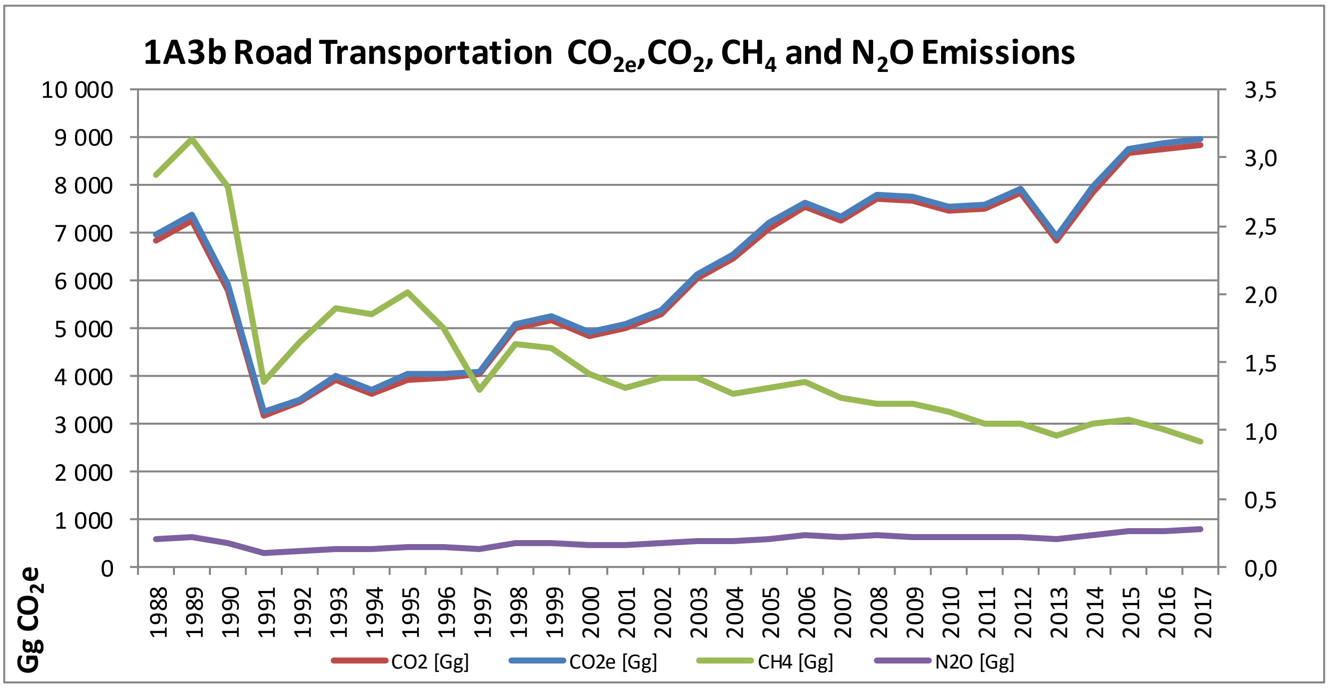

Figure 41 CO_2, CO_2e, CH_4 and N_2O emissions trends for the period 1988-2017

CH_4 emissions plummet, following Bulgarian gasoline consumption pattern, as the main source of those emissions proves to be pre-EURO gasoline passenger cars. After the crisis in the early 90s, a slight increase in the period 1992 – 1995 can be observed, followed by downward trend. Ultimately, compliance with strict Euro emission standards significantly influences CH_4 emissions and results in decreased levels of methane.

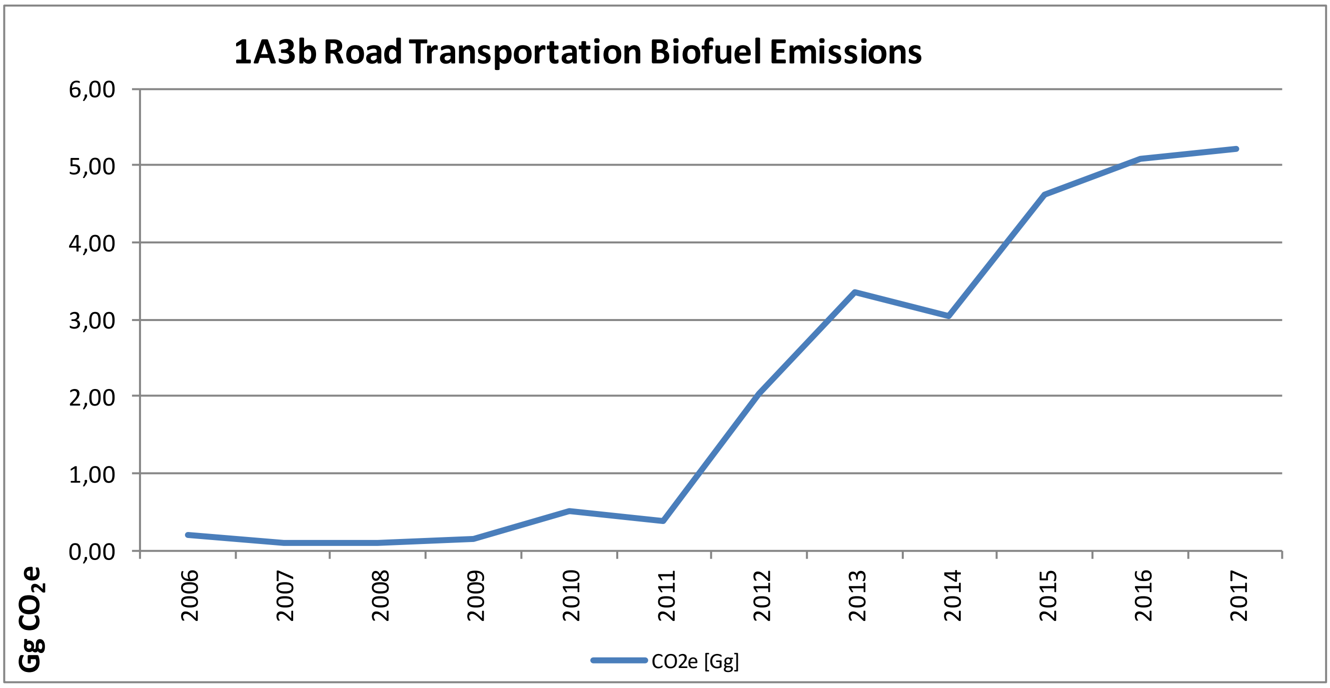

Figure 42 Emissions by biofuels from Road Transport for the period 2006-2017

Bulgarian market transport diesel and gasoline contain a small percentage of biofuels which are reported in the Energy balances as biofuels for blending. The reporting approach subtracts the amounts of biofuels for blending from the total amounts of road diesel and gasoline. A steep upward trend can be noticed due to an increase in biodiesel consumption since 2011.

3.3.12.3.3 Methods

CO_2 emissions are best calculated based on the amount and type of fuel combusted and its carbon content. The emissions of CH_4 and N_2O are more difficult to estimate accurately because emission factors depend on vehicle technology, fuel and operating characteristics.

Road transport is a key category as a source of CO_2. In view of Review Report FCCC/ARR/2010/BGR, emission calculations of road transport have been conducted with the use of the COPERT computer model version 5.1 with subsequent adjustments, corresponding to Tier 2 methodology, according to the 2006 IPCC GL. Country-specific technology-based emission factors have been derived using the COPERT model, based on various country-specific and default parameters.

A number of changes regarding new passenger cars subsectors and emission factor updates have been made in COPERT's latest version – 5.

For the 2018 submission, a complete recalculation has been performed, introducing the new COPERT version 5.1. In order to apply the new version, an updated vehicle distribution matrix has been developed.

In the COPERT model emissions are calculated through numerous input parameters like data on average daily trip distance, fuel Reid vapor pressure (RVP), monthly minimum and maximum temperatures, fuel consumption and fuel specifications, vehicle fleet categorized by sectors, subsectors and technologies, vehicle stock, annual mileage, speed, driving shares and others. Comparison of Tier 2 with Tier 1 is performed as a verification cross-check.

3.3.12.3.4 Activity data

Fuel consumption (liquid, gaseous and biofuels) is obtained from the Energy balance and converted into energy units using the country-specific NCV (as recommended by the ERT (FCCC/ARR/2013/BGR). Further, as recommended by the ERT (FCCC/ARR/2011/BGR), CO_2 emissions are calculated based on total fuels sold in the country. The total amount of fuels sold is compared to the amount of fuels calculated according to the model and the difference is used for mileage adjustment to correspond to the fuel quantities from the Energy balance, as explained under "Mileage" below.

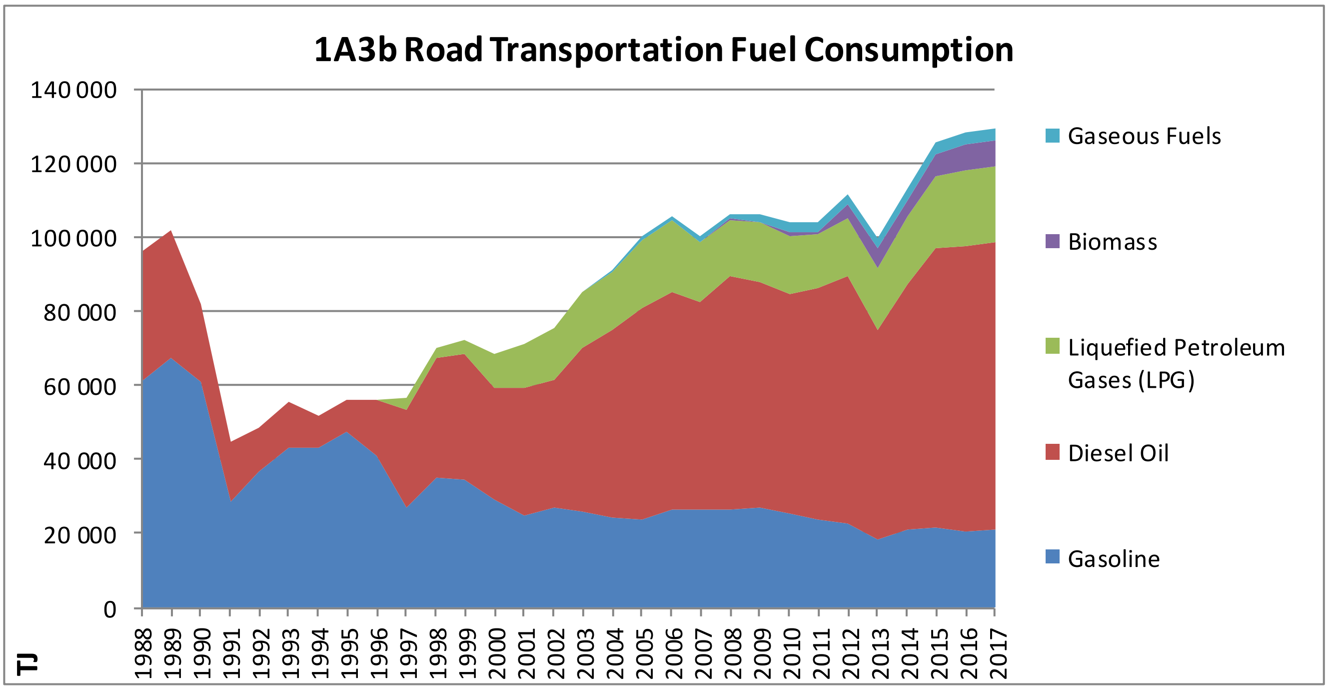

Figure 43 Fuel consumption in CRF 1.A.3.b Road transport (1988 - 2017)

Other data, necessary for implementation of the COPERT model has been provided by national institutions and companies (National Statistical Institute, National Institute of Meteorology and Hydrology, Ministry of Internal affairs, Department Traffic police, Lukoil Neftohim oil refinery, State Agency for Metrological and Technical Surveillance). However, in some cases, the completeness and quality of submitted information was not of the required detail. When directly related data was not available, surrogate data from various sources was used to complete the missing gaps and ensure the representativeness of the inputs to the COPERT model. A degree of expert judgment was required as well.

The following input data is compiled for the emission calculations with the use of COPERT 5:

Average daily trip distance

Average daily trip distance was calculated through www.bgmaps.com, one of the most popular websites for maps, routes, records and services to find individual addresses, locations and other information on the maps. An analysis of major cities' population and plausible daily journeys was performed; available data lead to an estimation of 15.1 km as average daily trip distance. Even though, the average European value of 12.4 km (Samaras et al. 2000) is slightly lower, the calculated figure seems to be more appropriate for Bulgarian conditions and driving culture. Time trip duration was estimated at 0.42 hour.

Minimum and maximum temperatures

Complete, country-specific data on monthly average minimum and maximum temperatures for the whole period of 1988 to 2017 was compiled by the National Institute of Meteorology and Hydrology.

Fuel specifications

Fuel specifications of liquid fuels were provided by Lukoil Neftohim – Burgas (as most of the liquid fuels sold on the national market are produced by Lukoil) and by the State Agency for Metrological and Technical Surveillance (SAMTS). The latter conduct quality inspections of the liquid fuels placed on the market according to national and European legislation requirements and by using accredited laboratories. As fuel sold at gas stations in the country is sampled regularly, SAMTS fuel quality data is considered representative for the fuel delivered to the final customer and utilized by the national fleet. Country specific data for diesel and gasoline for some of the fuel specifications was provided for the years 2005-2017 by Lukoil Neftohim – Burgas and SAMTS. Fuel quality data on LPG, biofuels and CNG was not obtained. Hence, literature information and regulatory technical requirements were used instead. In some cases, default values provided by COPERT were used and extrapolation of the existing numbers was applied to fill the gaps in the available data (Samaras 2000). It is important to note that since 2004 only unleaded gasoline is sold in Bulgaria (National Program to phase out lead in petrol). The percentage of leaded gasoline varies in the years before 2004, however, in 2003 the leaded gasoline share was only 2% (National Statistical Institute). An investigation of required fuel quality measurements showed that values for H:C and O:C ratios are not measured as a required fuel quality parameter in Bulgaria. Thus, country specific data on H:C and O:C values cannot be obtained at this stage (FCCC/ARR/2013/BGR). Further, as fuels sold in Bulgaria comply with European fuel quality requirements it is assumed that default COPERT values better represent the national circumstances.

Values for fuel volatility (RVP – Reid vapor pressure) are available for the period 2006-2017 (provided by Lukoil Neftohim oil refinery). For the previous periods, a summer and winter ranges are specified according to the technical requirements. Therefore, RVP data for the years 2000-2005 is estimated based on the available values and the legal requirements. RVP of 62 kPa (summer) and 67 kPa (winter) for the period 1988 -1999 is applied, based on the market average for 1996 (Samaras et al. et al. 2000) and the ratio of legal requirements to measured data, submitted in recent years.

Speed

Infrastructure and vehicle stock differ significantly in different regions. Vehicle speed varies between big and small agglomerations, being quite low in the rush hours, especially in densely populated areas. However, detailed data for speed variations is not available for the whole period. Krzywkowska et al. (2004) report approximate value of 24 km/h for mini buses in the urban region of Sofia. Additionally, a number of studies (André 2006, Samaras et al. 2002, Coronas Metropolitanas 2006) document various average speeds for several European cities. Also, private measurement of passenger cars average speed per day is considered. Ultimately, an average urban speed of 36.2 km/h was calculated via www.bgmaps.com, applying the above-stated methods for average daily trip distance calculation. That value is preferred for the inventory, considering traffic conditions in urban areas and literature research. A slightly higher value of 37 km/h is estimated for the period 1989-2000 regarding the traffic conditions in the past and the fluctuation in bus speed.

Considering public transport, buses are the most well-developed mode of transport in Sofia (MottMacDonald 2009), as that is the case for the other large cities (e.g. Plovdiv, Varna). Trams and trolleybuses occupy the second and third place, as trams are only used in the capital and are not subject to road transport category. Bus transport remains the preferred method of public and long-distance transportation as well. Average public transport speed for buses in Sofia is 19.4 km/h (Krzywkowska 2004), and for trolleybuses – 14.4 km/h (MottMacDonald 2009). These numbers vary back in the years as demonstrated by Breshkov, 2005.

Table 82 Average operational speed (km/h)

Vehicle type/ Year	2009	2006	2002	1995	1989
Trolleybus	14.4		14	14	14
Urban bus	19.4	19.65	18.1	18.1	19.5

Since bus lines are limited only to some areas, traffic jams frequently impede the free flow not only of private cars, but also of buses and trolley busses. That being said, the average speed of private cars is expected to be the highest under most circumstances, thus making the car one of the most preferred ways of city transport.

Speed values for rural and highway roads depend not only on vehicle type and purpose of the trip, but also on road quality. In Bulgaria, there are four classes of road classification: Motorway, Class I, II and III. Class III roads represent 60% of the total length and are characterized by extremely poor quality, compared to other classes. Hence, the free flow speed variation in relation to the above-stated classes is the following (AECOM 2010):

Table 83 Average free flow speed (km/h) per type of road class

Road Class	Average free flow speed (km/h)
Class I	79
Class II	70
Class III	55
Motorway (Highway)	110

In view of available data, the average speed for emission calculations was estimated at 68km/h for rural areas for all types of vehicles (except for mopeds) and 110 km/h for motorway, except for coaches. When inappropriate data was available or it was missing altogether, the legal requirement speed limit was applied instead of the above-stated figures. Finally, a comparison of road classes for the years 2010-2002 revealed a negligible change in relation to rural speed variation. Therefore, an identical value of 68 km/h was used for all years.

Driving share

In most regards, Bulgarian road network density is similar to the average density of other EU member states. Still, in terms of high speed roads and motorways the country lags far behind – 3.8 km/1000 km^2 compared to Austria - 19 km/1000 km^2 in Slovenia - 14 km/1000 km^2, and in Lithuania - 6 km/1000 km^2 (MRDPW 2010).

Due to lack of data for Bulgaria on mileage split between urban, rural and highway driving, literature survey of driving cycles (André, 2006) based on information from 80 representative European private cars in France, the UK, Germany and Greece was performed. Additionally, comparison of road statistics for Slovakia and Bulgaria shows a number of similarities related to road classes' ratio, length of network, geography and GDP trends. Taking into account the above-mentioned surveys, the driving share split for Slovakia was adopted. Where necessary, data gaps for some years and categories were filled in by extrapolating the existing values.

Vehicle fleet

Corresponding to the COPERT methodology, detailed knowledge of the structure of the vehicle fleet is required in order to accurately estimate the emissions. The main sources of data on vehicle stock and classifications are the National Statistical Institute and the Ministry of Internal affairs. However, apart from the total numbers for main vehicle categories, only partial data considering distribution into fuel, weight, technology classes and age was provided for this submission, as well. Irrespective of those data gaps, a country specific vehicle fleet matrix was developed, as described below (FCCC/ARR/2013/BGR).

Data regarding the total number of vehicle types by age is represented in 6 ranges, from 1 to more than 20-year-old vehicles. This data is available for the period 2005 – 2017. Thus, the technology split for each vehicle category is determined based on the age structure and EURO standard year of market adoption. This approach is applied to estimate the vehicle numbers by sector and technology for the period 2005-2017. Additionally, data on vehicles by brand and expert judgment was used to estimate the entire time series back to 1988, especially concerning old gasoline cars.

Additionally, a split by fuel and engine volume is conducted. National data on vehicle type per fuel type for the period 2005 – 2017 is applied in a model, in order to generate the required subsector split. There are more than 10 vehicle categories by fuel (including bi-fuel combinations) according to national data, among which hybrids as well. This is why a conservative approach is applied to apportion vehicle figures to relevant COPERT vehicle groups. The resulting allocation by vehicle category is combined with data on engine volume extracted from TRACCS EU project. Since TRACCS provide data for 2005 to 2010, data gaps for the remaining years were filled in by extrapolation and expert judgement. Finally, total numbers for the national vehicle fleet were distributed in accordance with COPERT categories following the previously generated split by fuel, engine and EURO standard.

Mopeds classification to 2-sroke and 4-stroke engines is another type of split, required by COPERT. It is assumed, based on expert judgement, that 4-stroke mopeds are very rare and applicable for the matrix only for some countries (e.g. Italy). Thus, this subsector is considered irrelevant in the current matrix.

Mileage

As only basic information on mileage per urban buses, coaches and heavy duty vehicles (>6t) was obtained from the National Statistics Institute, mileage for 2005 was estimated based on the average for 16 European countries that provided such data (Ntziachristos et al. 2008). However, the average EU15 mileage data may lead to overestimations of emissions. As recommended by Ntziachristos et al. (2008) mileage values were adjusted in order to better match the statistical fuel consumption (actual fuel sold). This was performed in relation to the fact that CO_2 emissions are calculated on the basis of fuel consumption (Ntziachristos et al., 2008) and that CO_2 emissions from road transport are indicated as a key category. The calibration procedure seeks to ensure an exact match between statistical and calculated fuel consumption. The updated COPERT 5 model performs this calibration automatically. The calibration procedure ultimately ensures that CO_2 emission estimates are prepared based on the quantities of fuel sold, according to the IPCC guidelines.

For all other required parameters (e.g. fuel injection, evaporation control, evaporation distribution, slope factor, load factor) the default values provided by the COPERT model were used.

3.3.12.3.5 Emission factors

According to the IPCC guidelines, an emission factor is defined as the average emission rate of a given GHG for a given source, relative to units of activity. Whereas, an implied emission factor (IEF) is defined as emissions divided by the relevant measure of activity:

IEF = Emissions / Activity data

IEF are not equivalent to the emissions factors for emissions calculations. IEF are akin to results providing average values for complex categories such as road transport, where the emissions are dependent on many parameters related to vehicle fleet distribution.

The emission factors used for the calculations of GHG emissions from road transport subsector are based on the algorithms of COPERT. The emission factors are internal parameters that depend both on the input data (e.g. average trip distance, driving and climatic conditions, etc.) and COPERT algorithms. However, the COPERT model uses different emission factors for each vehicle category and technology. Thus, it is only possible to provide the implied emission factors which take into account the calculated emissions of greenhouse gases per fuel and the model related to the reported fuel consumption.

The decrease in the CH_4 implied emission factor (IEF) for gasoline and diesel fuel is a result of the gradual increase in the number of vehicles that meet the standards set out in the EU directive on emissions from motor vehicles (mostly EURO 2 and EURO 3 vehicles), which slowly replaced the older technologies. It has to be noted, that the Bulgarian car fleet consists mostly of second hand vehicles, imported from Western Europe. This leads to a delay in the introduction of each new vehicle technology by 4 to 7 years, compared to other EU countries. It is also slightly more complex to model a vehicle distribution matrix, since it is influenced both by the sales of new vehicles and by the imports of second hand vehicles. Finally, there is still a very large number of very old vehicles in operation – the average vehicle age is much higher than in the other European countries.

Table 84 Implied emission factors of CO_2, N_2O and CH_4 by fuel types

Fuel type	Gasoline			Diesel		
Emissions	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Year	t/TJ	kg/TJ	kg/TJ	t/TJ	kg/TJ	kg/TJ
1988	69.30	42.82	2.20	69.30	42.82	2.20
1990	69.30	43.06	2.25	69.30	43.06	2.25
1995	69.30	40.92	2.82	69.30	40.92	2.82
2000	69.30	35.37	3.47	69.30	35.37	3.47
2005	71.58	25.04	3.75	71.58	25.04	3.75
2010	71.71	19.53	2.71	71.71	19.53	2.71
2011	71.60	18.63	2.63	71.60	18.63	2.63
2012	71.49	17.44	2.41	71.49	17.44	2.41
2013	71.49	17.44	2.41	71.49	17.44	2.41
2014	71.64	17.00	2.36	71.64	17.00	2.36
2015	71.63	16.14	2.23	71.63	16.14	2.23
2016	71.64	15.00	2.05	71.64	15.00	2.05
2017	71.73	13.82	1.81	71.73	13.82	1.81

Table 85 Implied emission factors of CO_2, N_2O and CH_4 by fuel types

Fuel type	LPG			CNG		
Emissions	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Year	t/TJ	kg/TJ		t/TJ	kg/TJ	
1988	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO
2000	63.10	19.77	1.23	NO	NO	NO
2005	57.87	18.02	2.16	56.71	49.41	0.52
2010	65.73	16.10	2.97	56.04	43.92	0.51
2011	65.73	15.67	3.03	56.03	48.86	0.49
2012	65.73	14.60	2.85	56.08	53.21	0.45
2013	65.73	14.60	2.85	56.08	53.21	0.45
2014	65.73	14.20	2.85	56.14	55.93	0.44
2015	65.73	13.64	2.77	56.20	56.61	0.42
2016	65.73	12.91	2.70	56.04	52.48	0.43
2017	65.73	12.00	2.55	56.03	49.87	0.42

A new approach was adopted as a result of the ERT recommendation (FCCC/ARR/2014/BGR) to conduct a Tier 2 estimate of CO_2 emissions from gasoline fuel, based on country-specific EFs, due to the introduction of biofuels to road transportation. Biofuels in transport are mostly consumed in the form of biodiesel blended with diesel and biogasoline (consumption started in 2013 in insignificant amounts, but increased rapidly). Thus, the consumption of biofuels cannot be linked to the decreasing trend of CO_2 IEF for gasoline. Regarding the recommendation to use a Tier 2 approach, Lukoil Neftochim was approached in order to obtain country-specific values for the carbon content of the liquid fuels produced. However, it was established that the fuel producer did not measure this fuel feature properly. On a related note, Bulgaria imports significant amounts of diesel and gasoline from neighbouring countries, which makes the estimate of a country-specific emission factor highly uncertain.

The 2006 IPCC GL do allow the CO_2 emission factors to be adjusted to take account of un-oxidized carbon or carbon emitted as a non-CO_2 gas at higher tiers (Chapter 3.2.1.2). The COPERT model, utilizing all available country-specific parameters, is considered to produce country-specific emission factors to the best possible extent, even though some of the parameters are used with their default values.

During emission estimates it was ensured that activity data regarding fuel consumption used in the COPERT model matched exactly the amounts of fuel sold reported by the National statistics. Using emission factors from the COPERT model (which is partly based on some default fuel properties according to EMEP/EEA air pollutant emission inventory guidebook) is considered to be much more relevant than the default IPCC emission factors. The EMEP/EEA emission factors are also higher than the default IPCC factors, which helps to avoid underestimating emissions from Road transport.

Additionally, the IEF of LPG for the period 2004-2006 is varying as a result of fluctuations in NCV provided by national statistics. Up to 2006 Bulgaria used the NCVs for liquid fuels provided by the producers/importers. In order to harmonize Bulgarian and EU statistics (IEA/Eurostat uses average NCVs for all liquid fuels) the preferred EU approach has been adopted since 2007. In this regard, discussions with Lukouil Neftochim revealed that NCVs had never been measured by laboratory tests, since the process was too costly. Instead, other relevant characteristics were monitored to ensure compliance with international standards. This is the key reason to use the average European NCVs for the years after 2007.

The NCV methodology adopted adjusts the annual mileage in order to have an exact match with the reported fuel consumption in natural units (Gg) and the calculated fuel consumption by the COPERT model. It is considered that the NCV difference does not influence emission estimates, but only reflects the IEF.

3.3.12.3.6 Uncertainties

The following default uncertainties are assumed (IPCC 2006 GLs, Ch. 3.2.2 Uncertainty Assessment, page 3.29 – 3.30):

			EF CO_2	EF N_2O	EF CH_4
AD	+/-5 %	Motor Gasoline	5% / -3%	244% / -70%	233% / -71%
		Gas / Diesel Oil	1% / -2%	208% / -67%	144% / -59%
		LPG	4% / -2%	200% / -68%	238% / -70%

Except for the above-mentioned uncertainty values, the inherited uncertainty of COPERT is associated with model formulation and input data. Emission factors, derived from experimental data, comprise an internal parameter of significant uncertainty. With respect to inputs, vehicle fleet information and related data on vehicle movements are the most probable source of uncertainties.

Monte Carlo simulations reveal that 16 or 17 items comprising a total 51 of internal parameters and input variables are responsible for more than 90% of the total uncertainty in countries with good and poor statistics, respectively. In our case, as a country with relatively poor transport statistics, the most probable factors, according to this research, could be hot and cold-start emission factors, technology distribution, mileage, mean trip distance. Further, coefficient of variation for the following was estimated (Kioutsioukisa et al., 2010):

Parameter	Uncertainty for countries with poor transport statistics (%)
Fuel consumption and CO_2	<10
CH_4	>20
N_2O	>20

3.3.12.3.7 Source-specific QA/QC and verification

All activities regarding QC as described in QA/QC System have been undertaken.

The following sector specific QA/QC procedures have been carried out:

- Check of methodology, CO_2 emissions, emission factors and IEF (time series)
- Time series consistency
- Plausibility checks of dips and jumps (this is due to the Energy balance)
- Documentation and archiving of all information required in NIR, background documentation and archive.

3.3.12.3.8 Source-specific recalculations

Following a recommendation from FCCC/ARR/2010/BGR §79, a recalculation of the entire time series is undertaken due to implementation of higher tier method and incorporation of the COPERT model, version 11, into the national road transport inventory.

Following a recommendation from FCCC/ARR/2010/BGR §76, the allocation of reported consumption of residual fuel oil in Road and Rail transport categories for the period 1991–1996 to Commercial and public services category is continued.

Regarding recommendation from FCCC/ARR/2011/BGR §70, a detailed review of the activity data and parameters used in the COPERT model was undertaken. It was concluded that the main cause for the decrease of the implied emission factor for gasoline is the gradual increase of EURO-standard vehicles (mostly Euro 2 and Euro 3) introduced in the country, which replaced the older Pre-ECE and ECE vehicles. As the CH_4 EF of the Pre-ECE and ECE vehicles is 5 times higher than the EURO vehicles, a significant drop in the IEF is observed. This is also why a generally stable downwards trend in the IEF is observed.

For the 2015 submission a detailed investigation of country-specific parameters used in the COPERT model concerning vehicle fleet and split was conducted. As a result, a new vehicle distribution matrix was developed which better represents relevant national circumstances compared to the vehicle distribution matrix of Slovenia, used previously.

For the 2017 submission an error was identified and corrected in the vehicle fleet matrix, which led to revised annual mileages. Additionally, the updated COPERT 4 model resulted in updated emission estimates for CH_4 and N_2O emissions.

Additionally, following a recommendation from the ERT from the 2016 review cycle, CO_2 emissions from Road transport were recalculated. For the period 1988-2003, the IPCC default EF for gasoline, diesel oil and LPG (69.3 t/TJ, 74.1 t/TJ and 63.1 t/TJ respectively) were applied, as the EFs provided by the EMEP/EEA Emission Inventory Guidebook (adopted by the COPERT model) were deemed unsuitable, due to the different fuel quality standards applicable for that period. For the period 2004-2017 the EFs derived by the COPERT model were applied, considering the fact the EMEP/EEA Emission Inventory Guidebook provides better EFs regarding fuels sold in Europe. Post 2003 the production of leaded gasoline has been discontinued, so it was assumed that the produced fuels fully comply with the European fuel quality standards and thus the COPERT EFs were considered to better represent national circumstances.

For the 2017 submission a test run of the new COPERT 5 model was conducted. It required significant efforts in order to adapt the vehicle fleet matrix and other input parameters. During that process some data input issues were encountered and certain omissions regarding emission calculations, compared to COPERT 4 model, were identified (e.g. the lack of urea and lubricants consumption).

For the 2018 submission the COPERT 5 model was re-evaluated. The resolution of pending issues in COPERT 5 led to a complete recalculation as a result of the adoption of the updated software. The vehicle distribution matrix was revised, introducing more categories and correcting some errors, which had previously led to incorrect allocation of vehicles between categories.

3.3.12.3.9 Source-specific planned improvements

We had several conversations with our refinery on the possibility to perform samples on the produced fuels in order to derive a country-specific emission factors for liquid fuels, as recommended by ERT. The refinery is not currently measuring any fuel parameters related to carbon content or H:C and O:C ratios. Additionally, the refinery was also not aware of the applicable laboratory standards, that should be used for determining the diesel and gasoline carbon content. We also considered the possibility to take fuel samples at gas stations, but we concluded that this approach would not be correct, as the fuels sold are already blended with biofuels. Additional complication provided the fact, that out refinery delivers to around 50% of the market, with the rest being covered by imports from Romania, Greece and other countries with varying annual shares. In order to calculate a representative country-specific EF, we would have to consider those annual variations, provided that we would be able to obtain the carbon content of the imported fuels. As a conclusion, we consider that the default fuel parameters, provided in the EMEP/EEA emission inventory guidebook and subsequently used by the COPERT model are much more certain and relevant nationally (considering the fact that liquid fuels are following common European standards), than a potential approach for deriving a country-specific emission factor, which is based on a limited number of laboratory measurements and some hard to obtain parameters of imported fuels.

We plan to update the calculation methodology for CO_2 emissions when country-specific CO_2 emission factors are available (if provided by the Lukoil Neftochim – the national refinery).

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

3.3.12.4.1 Source category description

GHG emissions from the Railways sector is not defined as a key source category. The main emission source is the use of gas-diesel oil.

3.3.12.4.2 Emission trend

Fuel consumption from Railway transport constitutes 0.5% of the total Transport sector and thus, as a category does not contribute significantly to the total emissions from the Transport sector in Bulgaria.

Railways related GHG emissions are quite low in Bulgaria, due to decreasing railway transport of passengers and freight and the fact that most of the locomotives in use are electricity-powered. A clear downward trend in GHG emissions has been observed in recent years:

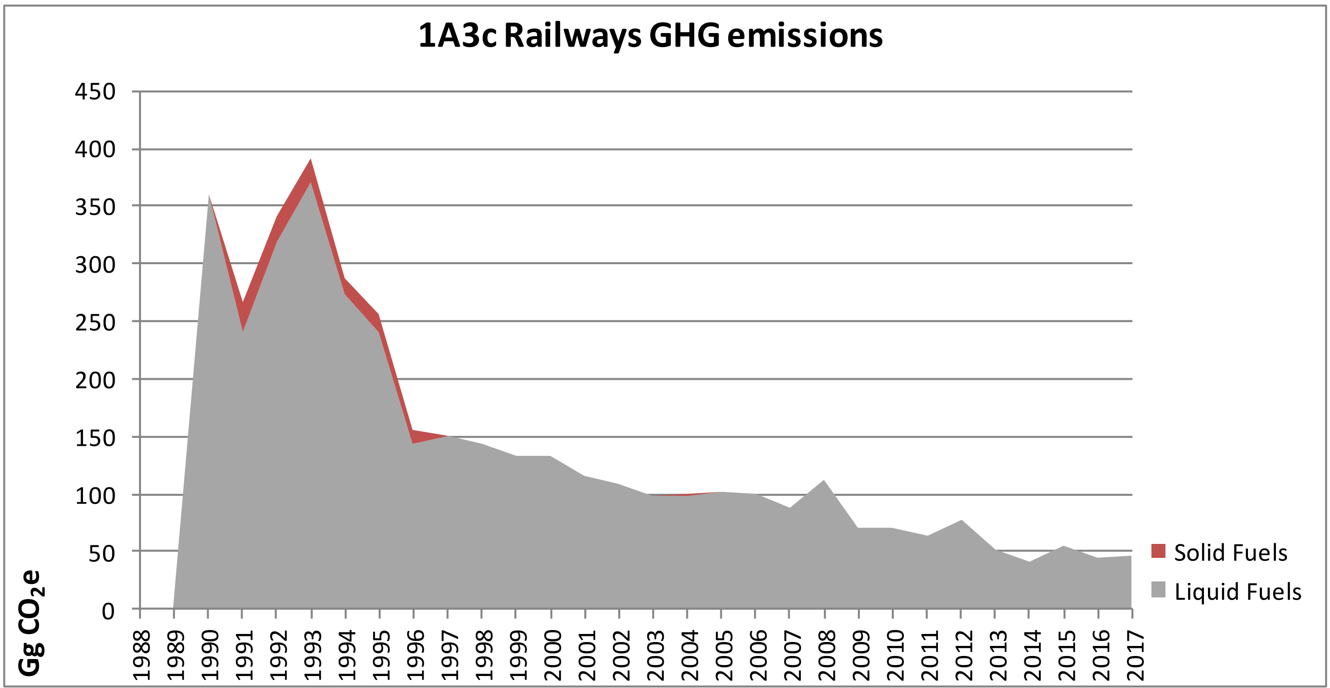

Figure 44 GHG emissions in CRF 1.A.3.c Railway transport (1988 - 2017)

As the figure above demonstrates, emissions from Railway transport in 2017 have plummeted by 87.1% since 1990. The emissions are mainly due to the consumption of liquid fuels (gas-diesel oil). Regarding the years 1988-1989, fuels consumed in the Railways category have not been reported; therefore the data entries are marked as NO. However, it has been assumed that the relevant quantities are reported under CRF 1.A.5 Other.

3.3.12.4.3 Methods

Following the recommendations of ERT set out in FCCC/ARR/2010/BGR §75 the emissions from Railway are calculated based on Revised 2006 IPCC GL and Tier 1 approach has been applied.

Equation 3.4.1 (GENERAL METHOD FOR EMISSIONS FROM LOCOMOTIVES) has been applied:

$$\textbf{Emissions} = \Sigma(\textbf{Fuel}_j \bullet \textbf{EF}_j)$$

Where:

Emissions = emissions (kg)

Fuel j = fuel type j consumed (as represented by fuel sold) in (TJ)

EF j = emission factor for fuel type j, (kg/TJ)

j = fuel type

For Tier 1, emissions are estimated using fuel-specific default emission factors, assuming that for each fuel type the total fuel is consumed by a single locomotive type.

3.3.12.4.4 Activity data

Fuel consumption (liquid and solid) is obtained from Eurostat Energy balance and converted into energy units using country-specific NCV. The energy balance provides activity data for consumption of residual fuel oil both in railways and road transport in the period 1991 – 1996. This is an improbable allocation and following the recommendations of ERT set out in FCCC/ARR/2010/BGR §76, quantities of this fuel reported under railways and road transport have been allocated to subcategory 1A4a Stationary combustion in Commercial/Institutional, as this fuel has probably been used for heating purposes.

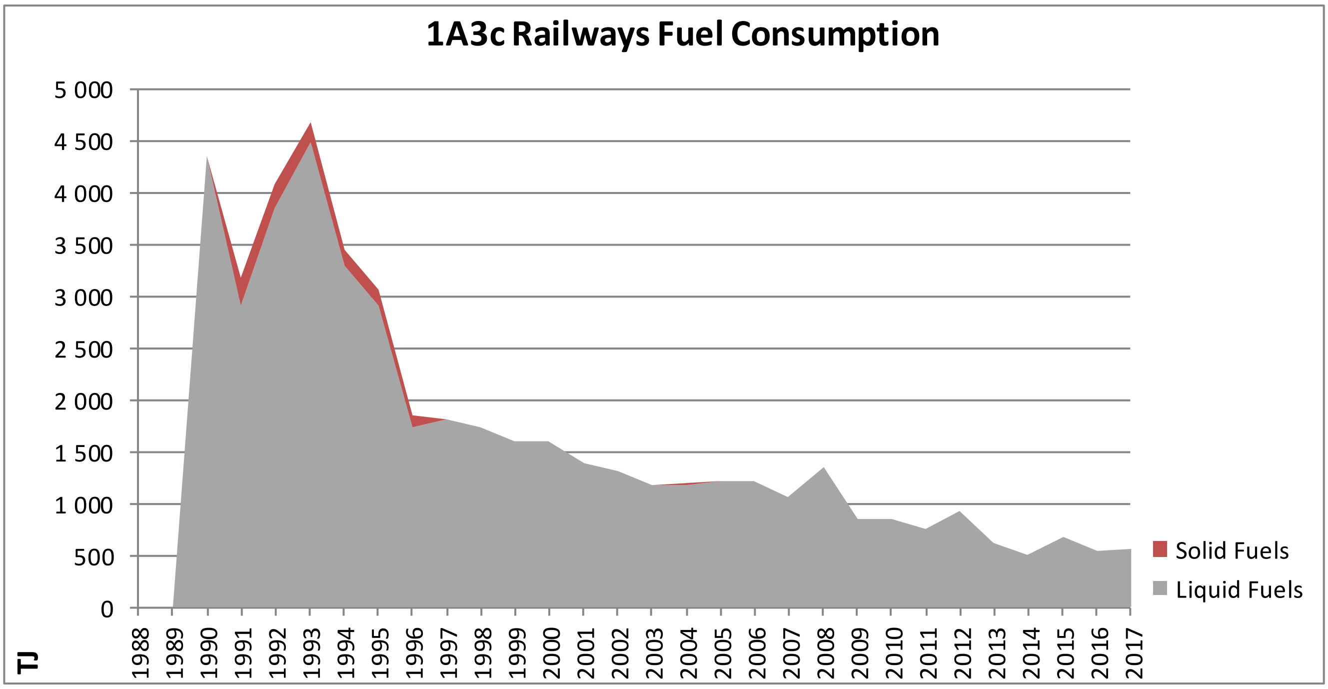

Figure 45 Fuel consumption in CRF 1.A.3.c Railway transport (1988 - 2017)

Table 86 Activity data for Gas-Diesel Oil, emissions and emission factors for subcategory 1A3c Railways

	Gas-Diesel Oil			EF* CO_2	CO_2 emission	EF* N_2O	N_2O emission	EF* CH_4	CH_4 emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	0	NO	42.6	74.10	NO	0.0286	NO	0.00415	NO
1990	103	4 357	42.3	74.10	323	0.0286	0.125	0.00415	0.018
1995	69	2 919	42.3	74.10	216	0.0286	0.083	0.00415	0.012
2000	38	1 607	42.3	74.10	119	0.0286	0.046	0.00415	0.007
2005	29	1 227	42.3	74.10	91	0.0286	0.035	0.00415	0.005
2010	20	846	42.3	74.10	63	0.0286	0.024	0.00415	0.004
2011	18	761	42.3	74.10	56	0.0286	0.022	0.00415	0.003
2012	22	931	42.3	74.10	69	0.0286	0.027	0.00415	0.004
2013	15	630	42.0	74.10	47	0.0286	0.018	0.00415	0.003
2014	12	505	42.1	74.10	37	0.0286	0.014	0.00415	0.002
2015	16	673	42.0	74.10	50	0.0286	0.019	0.00415	0.003
2016	13	546	42.0	74.10	40	0.0286	0.016	0.00415	0.002
2017	13	563	42.0	74.10	42	0.0286	0.016	0.00415	0.002

** 2006 IPCC Guidelines, Vol. 2, Ch. 3, Table 3.4.1*

3.3.12.4.5 Emission factors

The 2006 IPCC GL default GHG EFs for liquid and solid fuels have been applied.

3.3.12.4.6 Uncertainties

The following default uncertainties are assumed (2006 IPCC GL, Ch. 3.4.1.6 Uncertainty Assessment, page 3.45 – 3.46):

	EF CO_2	EF N_2O	EF CH_4
Diesel	1.5%	58%	60%
AD	+/-5 %		

3.3.12.4.7 Source-specific QA/QC and verification

All activities regarding QC as described in QA/QC System have been undertaken.

- Check of methodology, CO_2 emissions, emission factors and IEF (time series)
- Time series consistency
- Plausibility checks of dips and jumps (due to the Energy balance)
- Documentation and archiving of all information required in NIR, Background documentation and archive.

3.3.12.4.8 Source-specific recalculations

Following a recommendation made by FCCC/ARR/2013/BGR emissions from residual fuel oil in the railways subcategory are reallocated to the category commercial/institutional for the entire time series.

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

3.3.12.5.1 Source category description

GHG emissions from navigation are not defined as key source.

In Bulgaria navigation is used mostly for transportation of freights. However, the consumption patterns have been unstable since 2000, as it can be observed from the figures below.

The previous assumption regarding residual fuel oil and gas/diesel oil consumed by navigation and marine transport was that it was reported in the industry sector, since there were some discussions regarding erroneously allocated fuel quantities. In addition, in the earlier years of the time series, NSI reported in the energy balances all quantities of fuels loaded on Bulgarian ships regardless of the port the fuel was loaded on. This explains the large quantities reported for the years before 1997. More recently, it has been clarified by the NSI that vessels do not load fuels at Bulgarian ports because of the low fuel quality and higher prices.

Currently cargo is predominantly transported on international routes. Very limited amounts are transported within Bulgaria and this usually happens as part of an international route. Still, there is high uncertainty regarding the way fuel loading is accounted in this particular scenario. It is assumed that freight companies load their fuel mainly outside Bulgaria – either in Romania or on their way to other countries.

3.3.12.5.2 Emission trend

Navigation is a very minor source of emissions for Bulgaria.

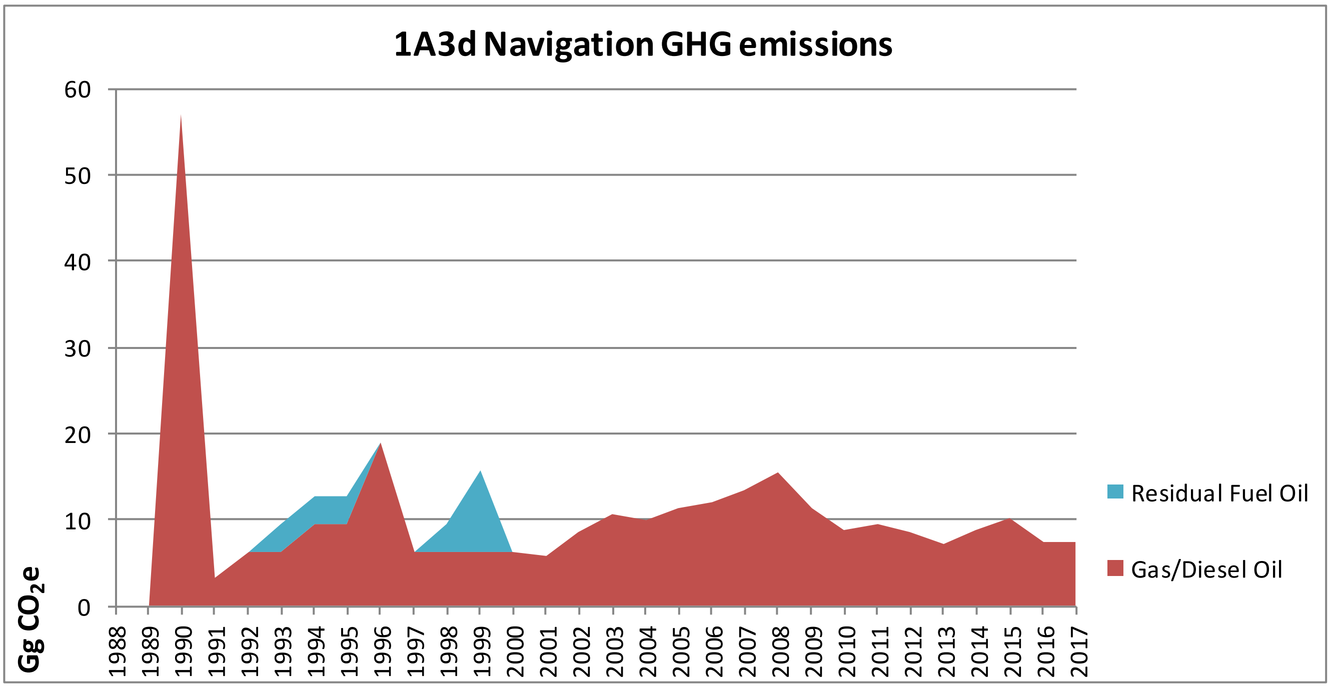

Figure 46 GHG emissions in CRF 1.A.3.d Navigation (1988 - 2017)

3.3.12.5.3 Methods

The 2006 IPCC Guidelines Tier 1 approach has been applied (Equation 3.5.1. Water-Borne Navigation Equation)

$$\textbf{\textit{Emissions}} = \Sigma(\textit{Fuel Consumed}_{ab} \bullet \textit{Emission Factor}_{ab})$$

Where:

a = fuel type (diesel, gasoline, LPG, bunker, etc.)

b = water-borne navigation type (i.e., ship or boat, and possibly engine type.) (Only at Tier 2 is the fuel used differentiated by type of vessel so b can be ignored at Tier 1)

3.3.12.5.4 Activity data

Considering the fuel consumption fluctuations described above and in order to avoid underestimating emissions from navigation, the amount of fuel consumed is calculated based on the cargo transported inland (domestic transport of goods) for the period 2001-2017. Data on transported cargo inland is obtained from the National Statistics Institute (NSI) and the Danube Commission (DC). Data on transported goods for previous years (1988 – 2000) is not available, thus the reported quantities of fuels sold are used for the present emission estimates.

Average freight distance is calculated at 205 km, based on the distance between western and eastern Bulgarian ports. Further, distance in tonne kilometres travelled goods (tkm) is derived from the average distance and weight of domestic goods transported.

Fuel economy for barge operation (kg/tkm) is estimated as average European data from Ecoinvent database is applied to calculate the tonnes of fuel consumed.

Table 87 Data on transported goods and fuel consumed for transportation

Year	Transported goods (DC)	Transported goods (NSI)	Transported goods (domestic)	Average distance	Distance	Fuel economy	Fuel consumed
Unit	1000t			km	tkm	kg diesel/tkm	t
2001	950	0	950	205	194 647 500	0.00939	1828
2002	1402	0	1402	205	287 410 000	0.00939	2699
2003	1731	0	1731	205	354 855 000	0.00939	3332
2004	1621	0	1621	205	332 202 500	0.00939	3119
2005	1741	1875	1875	205	384 375 000	0.00939	3609
2006	1001	2000	2000	205	410 000 000	0.00939	3850
2007	1130	2203	2203	205	451 615 000	0.00939	4241
2008	1392	2543	2543	205	521 315 000	0.00939	4895
2009	842	1864	1864	205	382 120 000	0.00939	3588
2010	390	1434	1434	205	293 970 000	0.00939	2760
2011	390	1563	1563	205	320 415 000	0.00939	3009
2012	0	1407	1407	205	288 435 000	0.00939	2708
2013	0	1190	1190	205	243 950 000	0.00939	2291
2014	0	1431	1431	205	293 355 000	0.00939	2755
2015	0	1695	1695	205	347 475 000	0.00939	3263
2016	0	1222	1222	205	250 510 000	0.00939	2352
2017	0	1092	1092	205	223 860 000	0.00939	2102

3.3.12.5.5 Emission factors

The 2006 IPCC Guidelines default GHG EFs for Gas-Diesel Oil and Residual Fuel Oil have been applied (assuming an oxidation factor of 1). The emission factors are provided in the following tables:

Table 88 Activity data, emissions and emission factors for subcategory 1A3d Navigation

	Gas-Diesel Oil			EF* CO_2	CO_2 emission	EF* N_2O	N_2O emission	EF* CH_4	CH_4 emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	0	NO	42.60	74.10	NO	0.002	NO	0.007	NO
1990	18	761.4	42.30	74.10	56.4	0.002	0.0015	0.007	0.0053
1995	3	126.9	42.30	74.10	9.4	0.002	0.0003	0.007	0.0009
2000	2	84.6	42.30	74.10	6.3	0.002	0.0002	0.007	0.0006
2005	4	152.7	42.30	74.10	11.3	0.002	0.0003	0.007	0.0011
2010	3	116.8	42.30	74.10	8.7	0.002	0.0002	0.007	0.0008
2011	3	127.3	42.30	74.10	9.4	0.002	0.0003	0.007	0.0009
2012	3	114.6	42.30	74.10	8.5	0.002	0.0002	0.007	0.0008
2013	2	96.3	42.03	74.10	7.1	0.002	0.0002	0.007	0.0007
2014	3	115.8	42.05	74.10	8.6	0.002	0.0002	0.007	0.0008
2015	3	137.2	42.04	74.10	10.2	0.002	0.0003	0.007	0.0010
2016	2	98.8	42.00	74.10	7.3	0.002	0.0002	0.007	0.0007
2017	2	88.3	41.99	74.10	6.5	0.002	0.0002	0.007	0.0006

Table 89 Activity data, emissions and emission factors for subcategory 1A3d Navigation

	Residual Fuel Oil			EF* CO_2	CO_2 emission	EF* N_2O	N_2O emission	EF* CH_4	CH_4 emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	0	NO	40	77.40	NO	0.002	NO	0.007	NO

	Residual Fuel Oil			EF* CO_2	CO_2 emission	EF* N_2O	N_2O emission	EF* CH_4	CH_4 emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1990	0	NO	40	77.40	NO	0.002	NO	0.007	NO
1995	1	40	40	77.40	3.1	0.002	0.0001	0.007	0.0003
2000	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2005	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2010	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2011	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2012	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2013	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2014	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2015	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2016	0	NO	40	77.40	NO	0.002	NO	0.007	NO
2017	0	NO	40	77.40	NO	0.002	NO	0.007	NO

For N_2O *and* CH_4 *the default values from table 3.5.3 IPCC 2006 GL have been used.*

3.3.12.5.6 Uncertainties

The following default uncertainties are assumed (2006 IPCC GL, Ch. 3.5.1.7 Uncertainty Assessment, page 3.54):

	EF CO_2	EF N_2O	EF CH_4
Diesel	± -1.5%	-40%/+140%	±50%
Residual Fuel Oil	± -3%		
AD	+/-50%		

3.3.12.5.7 Source-specific QA/QC and verification

All activities regarding QC as described in QA/QC System have been undertaken.

The following sector specific QA/QC procedures have been carried out:

- Check of methodology, CO_2 emissions, emission factors and IEF (time series)
- Time series consistency
- Plausibility checks of dips and jumps (at this stage not possible - this is due to the Energy balance / see trend description)
- Documentation and archiving of all information required in NIR, Background documentation and archive.

3.3.12.5.8 Source-specific planned improvements

No specific improvements for this subcategory are planned.

3.3.12.6 Other (CRF 1.A.3.e)

3.3.12.6.1 Source category description

The category (1.A.3.e) includes emissions from all remaining transport activities including pipeline transportation, related to the operation of compressor stations and maintenance of pipelines. This is a key category for 2017, mainly because of the significant volume of natural gas consumed for pipeline transport.

3.3.12.6.2 Emission trend

Some small quantities of liquid fuels are reported at the beginning of the time series, but in general natural gas remains the main source of emissions from this subcategory. Data regarding the consumption is provided in the Energy balance.

Table 90 Activity data, emissions and emission factors for gas-diesel oil

	Gas-Diesel Oil			EF CO_2	CO_2 emission	EF N_2O	N_2O emission	EF CH_4	CH_4 emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	0	NO	42.60	74.10	NO	0.03	NO	0.00	NO
1990	42	1 777	42.30	74.10	131.65	0.03	0.051	0.00	0.0074
1995	0	NO	42.30	74.10	NO	0.03	NO	0.00	NO
2000	0	NO	42.30	74.10	NO	0.03	NO	0.00	NO
2005	0	NO	42.30	74.10	NO	0.03	NO	0.00	NO
2010	0	NO	42.30	74.10	NO	0.03	NO	0.00	NO
2011	0	NO	42.30	74.10	NO	0.03	NO	0.00	NO
2012	0	NO	42.30	74.10	NO	0.03	NO	0.00	NO
2013	0	NO	42.03	74.10	NO	0.03	NO	0.00	NO
2014	0	NO	42.05	74.10	NO	0.03	NO	0.00	NO
2015	0	NO	42.04	74.10	NO	0.03	NO	0.00	NO
2016	0	NO	42.00	74.10	NO	0.03	NO	0.00	NO
2017	0	NO	41.99	74.10	NO	0.03	NO	0.00	NO

Table 91 Activity data, emissions and emission factors for residual fuel oil

	Residual fuel oil			EF CO_2	CO_2 emission	EF N_2O	N_2O emission	EF CH_4	CH_4 emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
1990	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
1995	1	40	40.00	77.40	3.1	0.002	0.0001	0.007	0.0003
2000	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2005	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2010	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2011	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2012	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2013	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2014	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2015	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2016	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2017	0	NO	40.00	77.40	NO	0.002	NO	0.007	NO

Table 92 Activity data, emissions and emission factors for natural gas

	Natural gas	EF CO_2	CO_2 emission	EF N_2O	N_2O emission	EF CH_4	CH_4 emission
	TJ	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	NO	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO

	Natural gas	EF CO_2	CO_2 emission	EF N_2O	N_2O emission	EF CH_4	CH_4 emission
	TJ	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
2000	6886.8	55.20	380.2	0.10	0.001	1.0	0.007
2005	9042.3	55.20	499.2	0.10	0.001	1.0	0.009
2010	5895.9	55.24	325.7	0.10	0.001	1.0	0.006
2011	8527.5	55.26	471.3	0.10	0.001	1.0	0.009
2012	8518.5	55.20	470.2	0.10	0.001	1.0	0.009
2013	7607.7	55.37	421.2	0.10	0.001	1.0	0.008
2014	7031.7	55.43	389.8	0.10	0.001	1.0	0.007
2015	6140.7	55.63	341.6	0.10	0.001	1.0	0.006
2016	6012.9	55.64	334.5	0.10	0.001	1.0	0.006
2017	7157.8	55.48	397.1	0.10	0.001	1.0	0.007

3.3.12.6.3 Methods

The 2006 IPCC Guidelines Tier 2 approach has been applied for gaseous fuels, Tier 1 for liquid fuels. Emissions from off-road sources have been allocated under construction and agriculture/forestry sectors, while the fuel quantities used by vehicles at airports and harbours have been reported under road transport sector.

3.3.12.6.4 Activity data

The National energy balances have been used to obtain the fuel consumption and net calorific values.

3.3.12.6.5 Emission factors

The default EFs from the 2006 IPCC Guidelines for Gas-Diesel Oil and Residual Fuel Oil has been applied. For the calculation of pipeline transport emissions, the country-specific emission factors have been used.

3.3.12.6.6 Uncertainties

Greenhouse gas emissions from other transport sources are typically much smaller than those from road transportation, but activities in this category are diverse and are thus typically associated with higher uncertainties because of the extra uncertainty in activity data.

The types of equipment and their operating conditions are typically more diverse than those for road transportation. This may give rise to a larger variation in emission factors and thus to larger uncertainties. However, the uncertainty estimate is likely to be dominated by the activity data for natural gas. Therefore, it is reasonable to assume as a default that the values for gaseous fuels apply.

The following default uncertainties are assumed based on the lower and higher values of the EFs (2006 IPCC GL, Ch. 3, Table 3.2.2 Uncertainty Assessment):

AD	+/-5 %		EF CO_2	EF N_2O	EF CH_4
		Natural gas	1% / -2%	208% / -67%	144% /-59%

3.3.12.6.7 Source specific QA/QC and verification

All activities regarding QC as described in QA/QC System have been undertaken.

The following sector specific QA/QC procedures have been carried out:

- Check of methodology, CO_2 emissions, emission factors and IEF (time series)
- Time series consistency
- Plausibility checks of dips and jumps (at this stage not possible due to the Energy balance - see trend description)
- Documentation and archiving of all information required in NIR, background documentation and archive.

There are some variations of the IEF for liquid fuels for some of the years, e.g. for 1990 the value is lower (74.10 t/TJ) than the rest of the time series (77.40 t/TJ). This is due to the fuel mix in this category - some quantities of Gas/Diesel Oil are reported as Not elsewhere specified (Transport) in the National Energy Balance, which has an EF of 74.1 t/TJ. For the period 1993-1996 and 1999 the value of the IEF (77.4 t/TJ) is higher than the rest of the time series. This is due to some quantities of Residual Fuel Oil reported as Not elsewhere specified (Transport) in the National Energy Balance, which has an EF of 77.4 t/TJ.

3.3.13 OTHER SECTORS (CRF 1.A.4)

Other sectors include the following subcategories:

- Commercial / Institutional (1.A.4.a);
- Residential (1.A.4.b);
- Agriculture / Forestry / Fisheries (1.A.4.c);

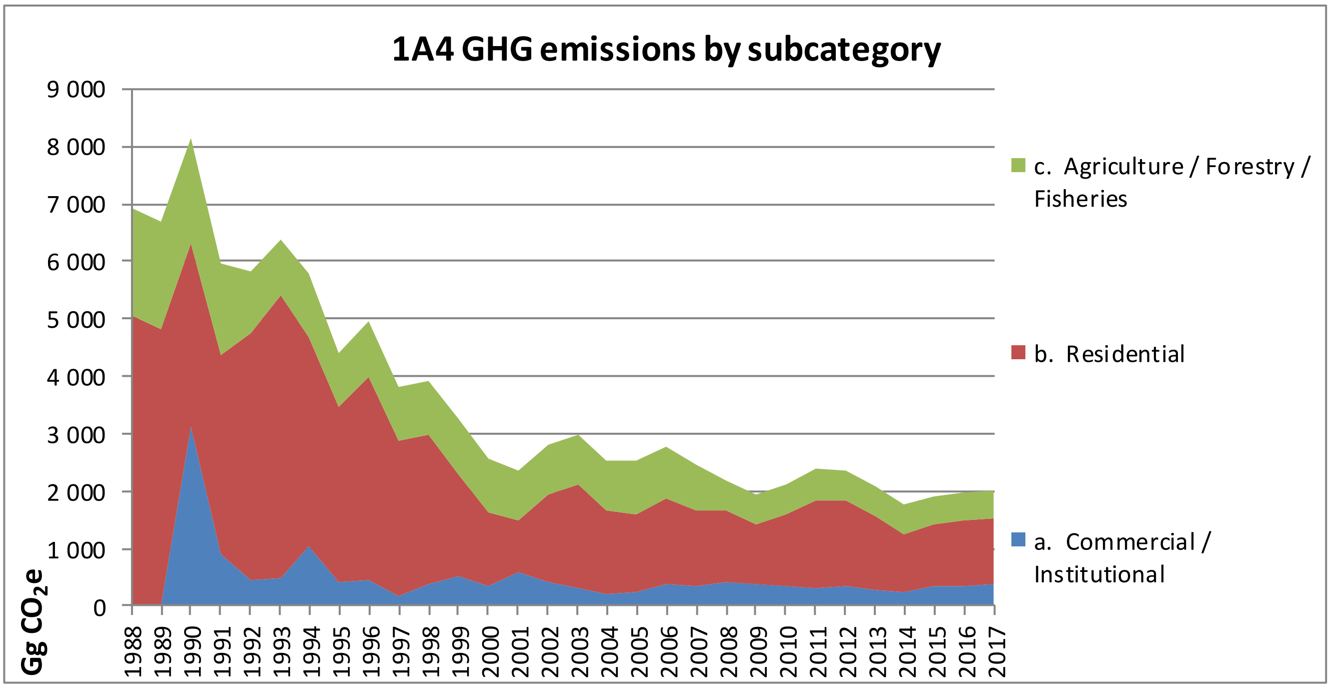

Figure 47 Total GHG emissions from 1.A.4 Other Sectors

The general trend in CRF category 1.A.4 is a decrease of 71.0% compared to base year and an increase of 2.1% compared to last year.

3.3.13.1 Commercial/Institutional (CRF 1.A.4.a.)

Category 1.A.4.a. Commercial/Institutional covers emissions from fuel combustion in the commercial and Institutional sectors.

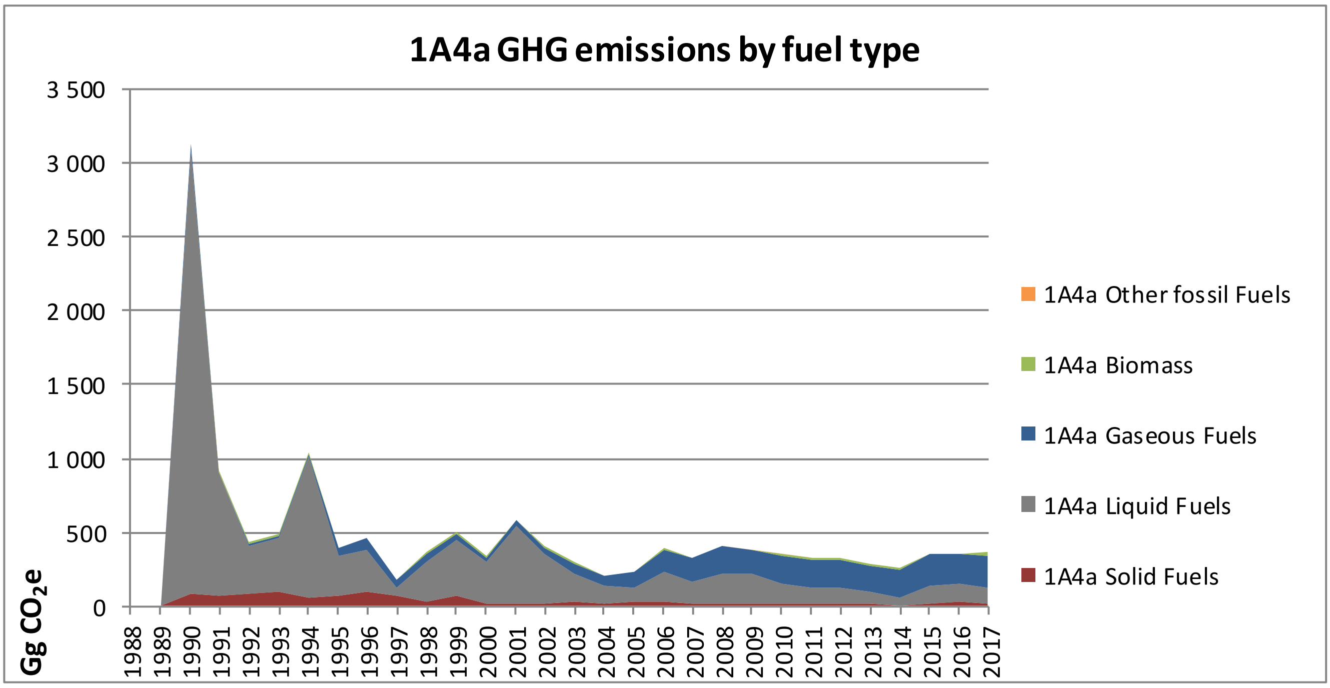

Figure 48 GHG emissions from CRF 1.A.4.a. Commercial/Institutional

The share of this subcategory from sector 1.A is 0.9% for 2017, whereas the share of the total GHG emissions is 0.6%.

For the years before 1990 no consumption is reported in this subcategory. Instead, it is reported under category 1.A.5.

Table 93 CO_2 emissions in CRF 1.A.4.a. Commercial/Institutional

CO_2 (Gg)	CRF 1.A.4.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	3 116.96	2 985.60	89.33	42.03	NO	NO
1995	386.17	268.64	71.08	46.45	125.6640	NO
2000	330.75	290.54	11.89	28.32	45.4720	NO
2005	230.79	105.40	24.68	100.71	63.5040	NO
2010	342.37	139.62	17.40	185.35	50.7290	NO
2011	318.57	108.01	19.52	191.04	52.1136	NO
2012	310.23	106.73	14.77	188.73	231.2226	NO
2013	273.25	73.15	19.31	180.78	129.5672	NO
2014	250.59	48.93	8.63	193.03	28.5838	NO
2015	349.92	120.24	22.27	207.42	75.7148	NO
2016	353.04	120.06	24.23	208.75	57.9292	NO
2017	341.30	105.26	16.00	220.03	282.3675	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	89.1%	96.5%	82.1%	-423.5%	-	-
Decrease	3.3%	12.3%	34.0%	-5.4%	-387.4%	-

CO_2 (Gg)	CRF 1.A.4.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2016-2017						

Table 94 CH_4 emissions in CRF 1.A.4.a. Commercial/Institutional

CH_4 (Gg)	CRF 1.A.4.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	0.4104	0.3977	0.0088	0.0038	NO	NO
1995	0.3840	0.0358	0.0073	0.0042	0.3366	NO
2000	0.1642	0.0387	0.0012	0.0026	0.1218	NO
2005	0.1957	0.0140	0.0025	0.0091	0.1701	NO
2010	0.1570	0.0179	0.0018	0.0168	0.1205	NO
2011	0.1584	0.0135	0.0020	0.0173	0.1257	NO
2012	0.6382	0.0124	0.0015	0.0171	0.6072	NO
2013	0.3602	0.0085	0.0020	0.0163	0.3334	NO
2014	0.0884	0.0058	0.0009	0.0174	0.0643	NO
2015	0.2075	0.0151	0.0023	0.0186	0.1715	NO
2016	0.1337	0.0149	0.0025	0.0188	0.0975	NO
2017	0.7587	0.0127	0.0016	0.0198	0.7245	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	-84.9%	96.8%	81.5%	-420.9%	-	-
Decrease 2016-2017	-467.4%	14.7%	34.6%	-5.7%	-643.0%	-

Table 95 N_2O emissions in CRF 1.A.4.a. Commercial/Institutional

N_2O (Gg)	CRF 1.A.4.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO
1990	0.0252	0.0238	0.0013	0.0001	NO	NO
1995	0.0078	0.0021	0.0011	0.0001	0.0045	NO
2000	0.0042	0.0023	0.0002	0.0001	0.0016	NO
2005	0.0037	0.0008	0.0004	0.0002	0.0023	NO
2010	0.0031	0.0010	0.0003	0.0003	0.0015	NO
2011	0.0030	0.0008	0.0003	0.0003	0.0016	NO
2012	0.0091	0.0006	0.0002	0.0003	0.0079	NO
2013	0.0053	0.0004	0.0003	0.0003	0.0042	NO
2014	0.0015	0.0003	0.0001	0.0003	0.0007	NO
2015	0.0037	0.0009	0.0003	0.0004	0.0021	NO
2016	0.0027	0.0008	0.0004	0.0004	0.0011	NO
2017	0.0107	0.0007	0.0002	0.0004	0.0094	NO
Decrease 1988-2017	-	-	-	-	-	-
Decrease 1990-2017	57.5%	97.1%	81.5%	-420.9%	-	-
Decrease 2016-2017	-304.9%	17.5%	34.6%	-5.7%	-786.6%	-

Table 96 GHG emissions in CRF 1.A.4.a. Commercial/Institutional

GHG (Gg)	TJ	CRF 1.A.4.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	NO	NO	NO	NO	NO	NO	NO
1990	41 464.19	3 134.74	3 002.65	89.94	42.15	NO	NO
1995	6 279.60	398.10	270.17	71.59	46.58	9.7524	NO
2000	4 930.42	336.09	292.20	11.97	28.40	3.5290	NO
2005	4 042.48	236.78	106.00	24.86	100.99	4.9284	NO
2010	5 916.11	347.22	140.38	17.53	185.86	3.4478	NO
2011	5 636.14	323.42	108.57	19.66	191.57	3.6121	NO
2012	7 130.77	328.90	107.23	14.88	189.26	17.5332	NO
2013	5 664.80	283.84	73.50	19.45	181.29	9.5991	NO
2014	4 530.63	253.25	49.17	8.69	193.57	1.8189	NO
2015	6 339.38	356.22	120.87	22.43	208.00	4.9255	NO
2016	6 306.57	357.17	120.69	24.40	209.33	2.7537	NO
2017	8 159.24	363.46	105.79	16.11	220.65	20.9130	NO
Decrease 1988-2017	-	-	-	-	-	-	-
Decrease 1990-2017	80.3%	88.4%	96.5%	82.1%	-423.5%	-	-
Decrease 2016-2017	-29.4%	-1.8%	12.3%	34.0%	-5.4%	-659.5%	-

3.3.13.2 Residential (CRF 1.A.4.b.)

Category 1.A.4.b. Residential covers emissions from fuel combustion in the residential sector.

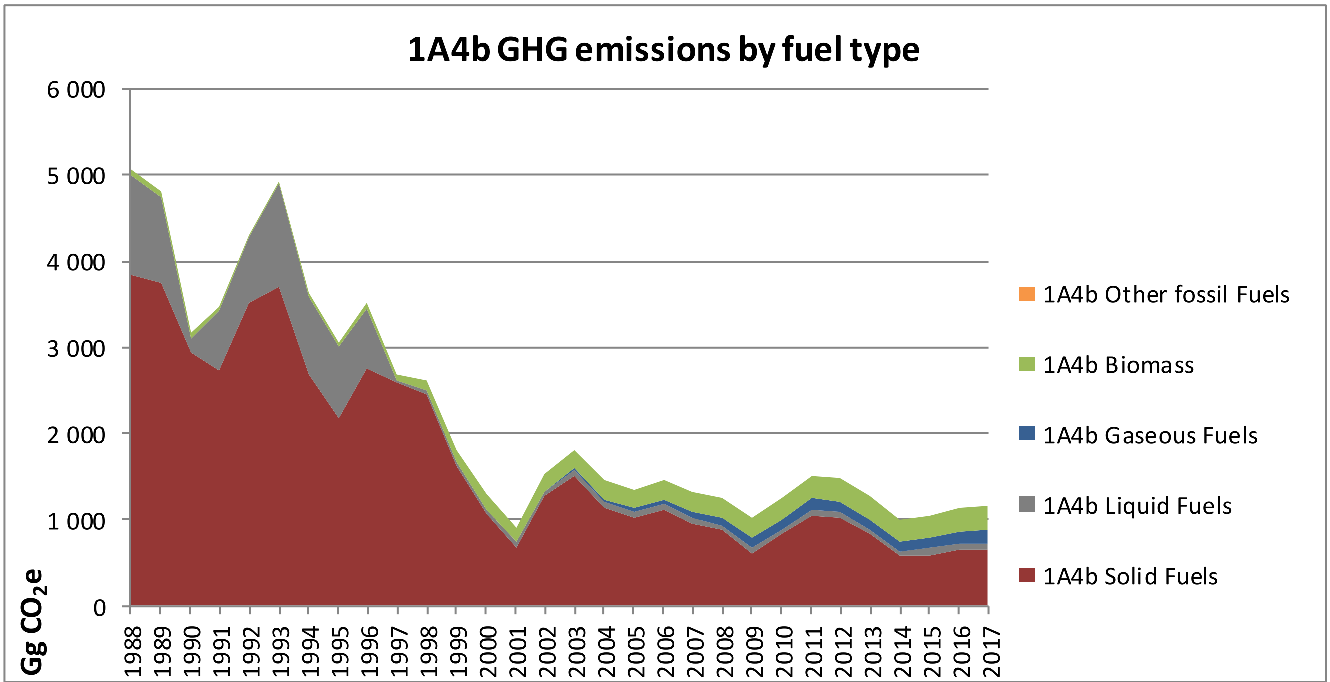

Figure 49 GHG emissions from CRF 1.A.4.b. Residential

The share of this subcategory from sector 1.A is 2.7% for 2017, whereas the share of total GHG emissions is 1.9%. The emissions from this category decreased by 77.1% compared to base year. There are two separate trends contributing to this decrease. At the beginning of the period, due to economic reasons, a transition from liquid fuels occurred. Those fuels, previously used for heating, started to be used for electricity. Some social groups also drastically reduced the consumed energy for heating due to their very low income. The second trend is the increase of the use of biomass – in 2017 about 4 times more biomass was used by the residential sector compared to 1988. This trend is also complimented by the increasing gasification of the households, although to a much smaller extent.

Table 97 CO_2 emissions in CRF 1.A.4.b. Residential

CO_2 (Gg)	CRF 1.A.4.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	4 715.89	1 167.81	3 548.08	NO	889.3920	NO
1990	2 887.26	157.69	2 729.57	NO	808.7520	NO
1995	2 834.67	825.89	2 008.78	NO	674.9120	NO
2000	1 034.19	44.47	989.28	0.45	2 292.0800	NO
2005	1 055.70	69.04	954.11	32.54	2 812.4320	NO
2010	939.08	61.42	763.56	114.10	3 334.1280	NO
2011	1 166.33	72.80	964.07	129.46	3 502.6880	NO
2012	1 137.61	66.99	947.11	123.50	3 557.9040	NO
2013	933.84	63.86	765.79	104.19	3 515.2320	NO
2014	698.66	64.09	529.70	104.87	3 438.6240	NO
2015	743.14	89.98	532.60	120.56	3 357.9840	NO
2016	807.72	72.57	597.96	137.20	3 554.5440	NO
2017	833.23	66.26	608.86	158.11	3 561.9913	NO
Decrease 1988-2017	82.3%	94.3%	82.8%	-	-300.5%	-
Decrease 1990-2017	71.1%	58.0%	77.7%	-	-340.4%	-
Decrease 2016-2017	-3.2%	8.7%	-1.8%	-15.2%	-0.2%	-

Table 98 CH_4 emissions in CRF 1.A.4.b. Residential

CH_4 (Gg)	CRF 1.A.4.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	13.2877	0.1332	10.7722	NO	2.3823	NO
1990	10.4734	0.0134	8.2936	NO	2.1663	NO
1995	8.0763	0.1016	6.1669	NO	1.8078	NO
2000	9.1482	0.0042	3.0045	0.0000	6.1395	NO
2005	10.4843	0.0056	2.9424	0.0029	7.5333	NO
2010	11.3488	0.0052	2.4026	0.0103	8.9307	NO
2011	12.3939	0.0059	2.9941	0.0117	9.3822	NO
2012	12.4494	0.0055	2.9026	0.0112	9.5301	NO
2013	11.8037	0.0051	2.3735	0.0094	9.4158	NO
2014	10.8791	0.0053	1.6538	0.0095	9.2106	NO
2015	10.6887	0.0071	1.6762	0.0108	8.9946	NO
2016	11.4306	0.0058	1.8914	0.0123	9.5211	NO
2017	11.5537	0.0054	1.9930	0.0142	9.5410	NO
Decrease 1988-2017	13.0%	96.0%	81.5%	-	-300.5%	-
Decrease 1990-2017	-10.3%	59.9%	76.0%	-	-340.4%	-
Decrease 2016-2017	-1.1%	6.3%	-5.4%	-15.6%	-0.2%	-

Table 99 N_2O emissions in CRF 1.A.4.b. Residential

N_2O (Gg)	CRF 1.A.4.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0921	0.0064	0.0539	NO	0.0318	NO
1990	0.0707	0.0004	0.0415	NO	0.0289	NO
1995	0.0605	0.0055	0.0308	NO	0.0241	NO
2000	0.0970	0.0002	0.0150	0.0000	0.0819	NO
2005	0.1153	0.0001	0.0147	0.0001	0.1004	NO
2010	0.1314	0.0001	0.0120	0.0002	0.1191	NO
2011	0.1404	0.0001	0.0150	0.0002	0.1251	NO
2012	0.1419	0.0001	0.0145	0.0002	0.1271	NO
2013	0.1377	0.0001	0.0119	0.0002	0.1255	NO
2014	0.1314	0.0001	0.0083	0.0002	0.1228	NO
2015	0.1287	0.0001	0.0084	0.0002	0.1199	NO
2016	0.1368	0.0001	0.0095	0.0002	0.1269	NO
2017	0.1376	0.0001	0.0100	0.0003	0.1272	NO
Decrease 1988-2017	-49.4%	98.1%	81.5%	-	-300.5%	-
Decrease 1990-2017	-94.6%	65.9%	76.0%	-	-340.4%	-
Decrease 2016-2017	-0.6%	-5.1%	-5.4%	-15.6%	-0.2%	-

Table 100 GHG emissions in CRF 1.A.4.b. Residential

GHG (Gg)	TJ	CRF 1.A.4.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	61 036.20	5 075.52	1 173.06	3 833.43	NO	69.0232	NO
1990	37 335.50	3 170.16	158.13	2 949.27	NO	62.7649	NO
1995	38 144.56	3 054.60	830.07	2 172.14	NO	52.3780	NO
2000	31 163.18	1 291.81	44.62	1 068.86	0.45	177.8818	NO
2005	36 595.41	1 352.18	69.22	1 032.06	32.63	218.2648	NO
2010	40 801.64	1 261.97	61.59	827.21	114.42	258.7521	NO
2011	44 743.19	1 518.03	72.99	1 043.38	129.83	271.8336	NO
2012	44 734.15	1 491.14	67.17	1 024.00	123.85	276.1188	NO
2013	42 191.49	1 269.96	64.01	828.66	104.48	272.8071	NO
2014	39 114.84	1 009.79	64.26	573.51	105.16	266.8618	NO
2015	39 162.39	1 048.70	90.20	577.00	120.89	260.6035	NO
2016	41 657.59	1 134.24	72.74	648.06	137.58	275.8580	NO
2017	42 340.78	1 163.07	66.43	661.65	158.55	276.4360	NO
Decrease 1988-2017	30.6%	77.1%	94.3%	82.7%	-	-300.5%	-
Decrease 1990-2017	-13.4%	63.3%	58.0%	77.6%	-	-340.4%	-
Decrease 2016-2017	-1.6%	-2.5%	8.7%	-2.1%	-15.2%	-0.2%	-

3.3.13.3 Agriculture/Forestry/Fisheries (CRF 1.A.4.c.)

Category 1.A.4.c. Agriculture/Forestry/Fisheries covers emissions from fuel combustion in the agriculture, forestry and fisheries sectors.

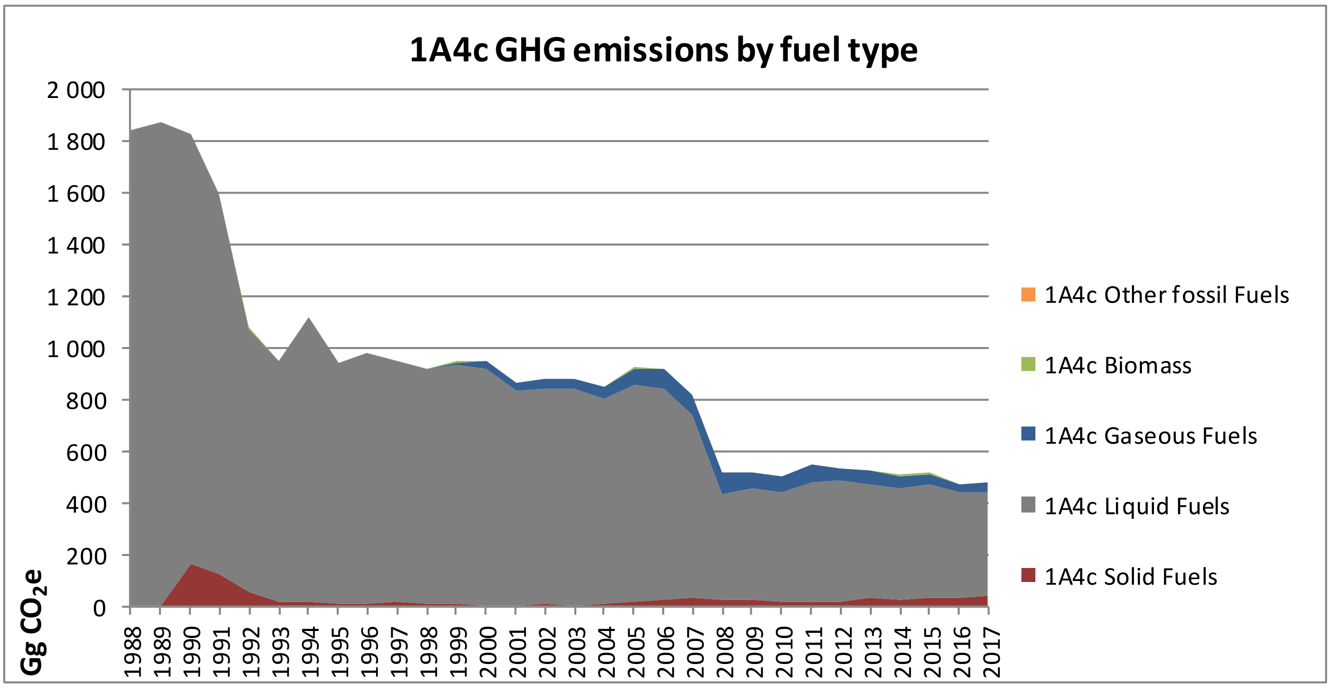

Figure 50 GHG emissions from CRF 1.A.4.c. Agriculture/Forestry/Fisheries

The share of this subcategory from sector 1.A is 1.1% for 2017, whereas the share of total GHG emissions is 0.8%.

Table 101 CO_2 emissions in CRF 1.A.4.c. Agriculture/Forestry/Fisheries

CO_2 (Gg)	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	1 657.25	1 657.25	NO	NO,IE	NO,IE	NO
1990	1 649.29	1 498.15	150.94	0.20	NO,IE	NO
1995	854.38	845.22	9.16	NO,IE	4.1440	NO
2000	860.24	826.57	3.86	29.81	68.4320	NO
2005	841.02	760.55	19.11	61.36	24.8640	NO
2010	457.08	384.40	16.00	56.68	15.6800	NO
2011	498.91	415.76	19.39	63.76	16.8000	NO
2012	487.23	417.36	17.76	52.11	18.7040	NO
2013	475.53	401.03	27.06	47.44	25.8720	NO
2014	461.15	388.93	22.88	49.34	32.2560	NO
2015	464.80	401.43	27.28	36.10	52.6400	NO
2016	428.66	363.74	30.96	33.95	46.2560	NO
2017	433.08	359.22	38.69	35.17	33.5278	NO
Decrease 1988-2017	73.9%	78.3%	-	-	-	-
Decrease 1990-2017	73.7%	76.0%	74.4%	-17597.5%	-	-
Decrease 2016-2017	-1.0%	1.2%	-24.9%	-3.6%	27.5%	-

Table 102 CH_4 emissions in CRF 1.A.4.c. Agriculture/Forestry/Fisheries

CH_4 (Gg)	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.0987	0.0987	NO	NO,IE	NO,IE	NO
1990	0.5496	0.0897	0.4599	0.0000	NO,IE	NO
1995	0.0957	0.0564	0.0283	NO,IE	0.0111	NO

CH_4 (Gg)	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2000	0.2513	0.0537	0.0117	0.0027	0.1833	NO
2005	0.1798	0.0486	0.0591	0.0056	0.0666	NO
2010	0.1194	0.0222	0.0501	0.0051	0.0420	NO
2011	0.1355	0.0242	0.0605	0.0058	0.0450	NO
2012	0.1340	0.0243	0.0550	0.0047	0.0501	NO
2013	0.1812	0.0236	0.0840	0.0043	0.0693	NO
2014	0.1854	0.0230	0.0715	0.0045	0.0864	NO
2015	0.2529	0.0236	0.0851	0.0032	0.1410	NO
2016	0.1518	0.0210	0.0942	0.0031	0.0335	NO
2017	0.2256	0.0203	0.1194	0.0032	0.0827	NO
Decrease 1988-2017	-128.7%	79.4%	-	-	-	-
Decrease 1990-2017	59.0%	77.4%	74.0%	-17508.7%	-	-
Decrease 2016-2017	-48.7%	3.4%	-26.7%	-3.9%	-147.0%	-

Table 103 N_2O emissions in CRF 1.A.4.c. Agriculture/Forestry/Fisheries

N_2O (Gg)	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	0.6116	0.6116	NO	NO,IE	NO,IE	NO
1990	0.5530	0.5507	0.0023	0.0000	NO,IE	NO
1995	0.2809	0.2806	0.0001	NO,IE	0.0001	NO
2000	0.2840	0.2814	0.0001	0.0001	0.0024	NO
2005	0.2618	0.2605	0.0003	0.0001	0.0009	NO
2010	0.1436	0.1426	0.0003	0.0001	0.0006	NO
2011	0.1546	0.1536	0.0003	0.0001	0.0006	NO
2012	0.1563	0.1553	0.0003	0.0001	0.0007	NO
2013	0.1493	0.1478	0.0004	0.0001	0.0009	NO
2014	0.1436	0.1420	0.0004	0.0001	0.0012	NO
2015	0.1503	0.1480	0.0004	0.0001	0.0019	NO
2016	0.1368	0.1358	0.0005	0.0001	0.0005	NO
2017	0.1377	0.1359	0.0006	0.0001	0.0011	NO
Decrease 1988-2017	77.5%	77.8%	-	-	-	-
Decrease 1990-2017	75.1%	75.3%	74.0%	-17508.7%	-	-
Decrease 2016-2017	-0.6%	-0.1%	-26.7%	-3.9%	-136.1%	-

Table 104 GHG emissions in CRF 1.A.4.c. Agriculture/Forestry/Fisheries

GHG (Gg)	TJ	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	22 365.00	1 841.98	1 841.98	NO	NO	NO	NO
1990	21 759.27	1 827.82	1 664.50	163.12	0.20	NO	NO
1995	11 487.90	940.49	930.25	9.91	NO	0.3216	NO
2000	12 319.45	951.15	911.78	4.17	29.89	5.3108	NO
2005	11 781.97	923.52	839.38	20.68	61.53	1.9296	NO
2010	6 540.96	502.85	427.47	17.33	56.84	1.2169	NO

GHG (Gg)	TJ	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2011	7 136.82	548.37	462.13	21.00	63.94	1.3038	NO
2012	6 940.35	537.17	464.25	19.22	52.26	1.4516	NO
2013	6 793.46	524.53	445.67	29.28	47.57	2.0079	NO
2014	6 685.78	508.59	431.83	24.77	49.48	2.5033	NO
2015	6 833.55	515.93	446.11	29.54	36.20	4.0852	NO
2016	6 587.72	473.21	404.74	33.46	34.04	0.9770	NO
2017	6 220.66	479.75	400.23	41.85	35.27	2.3979	NO
Decrease 1988-2017	72.2%	74.0%	78.3%	-	-	-	-
Decrease 1990-2017	71.4%	73.8%	76.0%	74.3%	-17597.3%	-	-
Decrease 2016-2017	5.6%	-1.4%	1.1%	-25.1%	-3.6%	-145.4%	-

3.4 FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS (CRF 1.B)

Fugitive emissions from fuels are responsible for 3.0% of total GHG emissions for 2017. The fugitive emissions from gas and oil have a share of approx. 1.7% of total GHG emissions, whereas the fugitive emissions of solid fuels are approx. 1.4% of total GHG emissions.

3.4.1 COAL MINING (CRF 1.B.1)

This category includes fugitive methane emissions from coal mining and handling activities in underground and surface mines as well as emissions from solid fuel transformation.

Coal mining in Bulgaria is being carried out through both surface mining and underground mining. The main domestic solid fuels are lignite and sub-bituminous coal and they are mined mostly by surface mining in the Maritza Iztok mining complex. At the beginning of the time series the quantities of coal produced through underground mining were equal to about 12% of the total production of coal, but since many of the mines were subsequently closed down, the percentage dropped down to less than 0.5% in 2017. The annual production amounts to 34.1 million tons in 2017, of which 134 thousand tons were produced through underground mining.

Solid fuel transformation is also a source of fugitive emissions, even though the IPCC guidelines are not very explicit regarding this subcategory. Until 2008 the operation of coke ovens in Bulgaria was a source of fugitive emissions, whereas the annual amount of coking coal was varying between 1.4 Mt at the beginning of the time series and 434 kt at the end.

Charcoal production is an additional source of fugitive emissions which are estimated for the entire time series. The indigenous production of charcoal decreases from 18 kt at the beginning of the time series to 2.4 kt in 2017. The activity data and the emission estimates are presented in Table 105.

3.4.2 EXTRACTION, REFINING, TRANSPORTATION AND DISTRIBUTION OF OIL AND NATURAL GAS (CRF 1.B.2)

Unlike fugitive emissions from coal mining, the emissions from Oil and Gas are a lot more complex because of the various sources involved and the various types of activity data. The emission estimates for this category cover methane, carbon dioxide and nitrous oxide fugitive emissions from exploration, production and processing, refining and storage, transport, transmission and distribution of oil and natural gas.

The trends for methane fugitive emissions from oil and gas systems are presented in Table 106 and Table 107.

The current natural gas consumption is almost half of what it was in the base year, due to the collapse of the industrial sector (mainly in fertilizer production and iron & steel industries), which decline had not been compensated by the increasing gas consumption of commercial and residential sectors in the latest years.

Natural gas production in Bulgaria peaked in the period 2005-2006, following the development of a new field (Galata), which was depleted in 2009. Since 2011 there have been several new fields that have been developed (Kaliakra and Kavarna). These fields have also led to a limited increase in the domestic production of natural gas, but have not altered the overall decline observed since 2012. As a requirement from the National Statistics Institute and due to the limited number of oil and natural gas production companies in the country, the domestic production data is notated as confidential and not presented in this report.

The CH_4 and CO_2 fugitive emissions from the transmission and distribution gas networks in the industry and households are estimated based on the quantity of natural gas sold.

The production of crude oil in Bulgaria is in very limited amounts equal to 0.4% of the total consumption in 2017, with only one production company operating. Generally, there is a decreasing trend in the local production of crude oil.

Table 105 Activity data and CH_4 emissions from CRF 1.B.1 Coal mining and Handling

Year	1.B.1.a Coal Mining and Handling						1.B.1.b Solid Fuel Transformation			
	i. Underground Mines			ii. Surface Mines			Coking coal		Charcoal	
	AD	Post-mining emissions	Mining emissions	AD	Post-mining emissions	Mining emissions	AD	Emissions	AD	Emissions
	kt	Gg	Gg	kt	Gg	Gg	kt	Gg	kt	Gg
1988	4098	6.86	49.42	30049	2.01	24.16	1400	0.07	18	0.48
1990	3848	6.45	46.41	27827	1.86	22.37	1854	0.09	20	0.52
1995	3381	5.66	40.77	27449	1.84	22.07	1693	0.08	20	0.52
2000	1621	2.72	19.55	24811	1.66	19.95	1325	0.06	8	0.21
2005	585	0.98	7.06	24110	1.62	19.38	1051	0.05	24	0.62
2010	744	1.25	8.97	28649	1.92	23.03	0	0.00	17	0.44
2011	872	1.46	10.52	36250	2.43	29.15	0	0.00	16	0.42
2012	688	1.15	8.30	32732	2.19	26.32	0	0.00	4	0.10
2013	550	0.92	6.63	28071	1.88	22.57	0	0.00	5	0.13
2014	472	0.79	5.69	30796	2.06	24.76	0	0.00	6	0.16
2015	447	0.75	5.39	35412	2.37	28.47	0	0.00	6	0.16
2016	270	0.45	3.26	30961	2.07	24.89	0	0.00	4	0.10
2017	134	0.23	1.62	34143	2.29	27.45	0	0.00	2	0.06

Table 106 Activity data from oil and gas

Year	1. B. 2. a. Oil			1. B. 2. b. Natural Gas					1. B. 2. c. Venting and Flaring			
									1. B. 2. c. 1 Venting		1. B. 2. c. 2 Flaring	
	1. Exploration	2. Production	4. Refining / Storage	2. Production / Processing	4. Transmission		5. Distribution		i. Oil	ii. Gas	i. Oil	ii. Gas
	10^3m^3	10^3m^3	10^3m^3	10^6m^3	10^6m^3	km	10^6m^3	km	10^3m^3	10^6m^3	10^3m^3	10^6m^3
1988	C	C	15319.3	C	6442.2	1234	6152.2	50	C	C	C	C
1990	C	C	9666.7	C	8789.5	1469	6717.0	50	C	C	C	C
1995	C	C	9314.7	C	9937.1	2044	5638.0	50	C	C	C	C
2000	C	C	6193.5	C	13588.6	2645	3616.0	300	C	C	C	C
2005	C	C	7207.5	C	15500.0	2645	3466.0	1577	C	C	C	C
2010	C	C	6381.1	C	12160.0	2645	2795.0	3493	C	C	C	C

2011	C	C	5924.2	C	15060.0	2645	3188.0	3656	C	C	C	C
2012	C	C	6869.5	C	15000.0	2645	2970.0	3873	C	C	C	C
2013	C	C	6552.4	C	15810.0	2645	2872.0	4035	C	C	C	C
2014	C	C	6007.0	C	14816.2	2645	2834.0	4224	C	C	C	C
2015	C	C	7036.1	C	13505.1	2765	3084.0	4334	C	C	C	C
2016	C	C	7293.7	C	14619.9	2765	3166.0	4444	C	C	C	C
2017	C	C	7907.2	C	16387.4	2765	3272.7	4724	C	C	C	C

Table 107 CH_4 fugitive emissions from oil and gas (Gg)

Year	1. B. 2. a. Oil				1. B. 2. b. Natural Gas				1. B. 2. c. Venting and Flaring			
									1. B. 2. c. 1 Venting		1. B. 2. c. 2 Flaring	
	1. Exploration	2. Production	3. Transport	4. Refining / Storage	2. Production	3. Processing	4. Transmission	5. Distribution	i. Oil	ii. Gas	i. Oil	ii. Gas
1988	0.0181	0.2051	0.0023	0.3340	0.0140	0.0061	1.7587	6.7674	0.8112	0.0019	0.0020	0.0000
1990	0.0181	0.2051	0.0023	0.3340	0.0111	0.0049	2.3568	6.9666	0.8112	0.0015	0.0020	0.0000
1995	0.0131	0.1487	0.0017	0.1168	0.0134	0.0059	2.3568	6.2271	0.5881	0.0018	0.0014	0.0000
2000	0.0072	0.0821	0.0009	0.1767	0.0563	0.0248	2.7342	6.3371	0.3245	0.0076	0.0017	0.0001
2005	0.0077	0.0872	0.0010	0.1360	0.0308	0.0136	3.4671	3.6971	0.3448	0.0042	0.0018	0.0001
2010	0.0063	0.0718	0.0008	0.1807	0.6834	0.3009	4.1496	3.8929	0.2839	0.0928	0.0016	0.0014
2011	0.0050	0.0564	0.0006	0.1368	0.5842	0.2572	4.1114	3.5068	0.2231	0.0794	0.0020	0.0012
2012	0.0054	0.0615	0.0007	0.1571	0.5132	0.2260	4.0950	3.2670	0.2434	0.0697	0.0019	0.0011
2013	0.0063	0.0718	0.0008	0.1512	0.3886	0.1711	4.3161	3.1592	0.2839	0.0528	0.0021	0.0008
2014	0.0059	0.0667	0.0008	0.1385	0.2640	0.1162	4.0448	3.1174	0.2636	0.0359	0.0020	0.0005
2015	0.0057	0.0641	0.0007	0.1614	0.1380	0.0608	3.6869	3.3924	0.2535	0.0187	0.0055	0.0003
2016	0.0054	0.0615	0.0007	0.1678	0.1246	0.0549	3.9912	3.4826	0.2434	0.0169	0.0089	0.0003
2017	0.0054	0.0613	0.0007	0.1816	0.1073	0.0473	4.4738	3.5999	0.2424	0.0146	0.0098	0.0002

3.4.3 METHODOLOGICAL ISSUES

Fugitive emissions from coal mining were estimated by Tier 1 method.

Equations 4.1.1 and 4.1.7 from the 2006 IPCC Guidelines, Vol. 2, Ch. 4 have been applied:

Emissions = Raw coal production ● Emission Factor ● Units conversion factor

Relevant values of emission factors from 2006 IPCC Guidelines were selected, considering that underground mines have an average depth of not more than 400 m, and the surface mines for lignite coal are over 25 m deep.

The estimate of the CO_2, CH_4 and N_2O fugitive emissions from gas and oil systems was conducted by Tier 1 methodology applying Equation 4.2.1 from the 2006 IPCC Guidelines, Vol. 2, Ch. 4.

$$\textit{Emissions}_{\textit{gas, industry segment}} = \textit{Activity data}_{\textit{industry segment}} \bullet \textit{EF}_{\textit{gas, industry segment}}$$

The appropriate EFs from 2006 IPCC Guidelines, Vol. 2, Ch. 4.2.2.3, Table 4.2.4 were applied:

1. B. 2. a. Oil			
i. Exploration		**iii. Transport**	
AD	National Energy Balance	AD	National Energy Balance
EF	CH_4: 0.000194 Gg/10^3m^3 CO_2: 0.0091019 Gg/10^3m^3 2006 IPCC Guidelines	EF	CH_4: 0.000025 Gg/10^3m^3 CO_2: 0.0000023 Gg/10^3m^3 2006 IPCC Guidelines
ii. Production		**iv. Refining / Storage**	
AD	National Energy Balance	AD	National Energy Balance
EF	CH_4: 0.0022 Gg/10^3m^3 CO_2: 0.00028 Gg/10^3m^3 2006 IPCC Guidelines	EF	CH_4: 0.0000218 Gg/10^3m^3 2006 IPCC Guidelines

1. B. 2. b. Natural Gas			
ii. Production		**iv. Transmission**	
AD	National Energy Balance	AD	Bulgartransgaz
EF	CH_4: 0.00134 Gg/10^6m^3 CO_2: 0.000048 Gg/10^6m^3 2006 IPCC Guidelines	EF	CH_4: 0.000273 Gg/10^6m^3 CO_2: 0.00000088 Gg/10^6m^3 2006 IPCC Guidelines
iii. Processing		**v. Distribution**	
AD	National Energy Balance	AD	National Energy Balance
EF	CH_4: 0.00059 Gg/10^6m^3 CO_2: 0.000166 Gg/10^6m^3 2006 IPCC Guidelines	EF	CH_4: 0.0011 Gg/10^6m^3 CO_2: 0.000051 Gg/10^6m^3 2006 IPCC Guidelines

1. B. 2. c. Venting and Flaring			
1. B. 2. c. 1 Venting		**1. B. 2. c. 2 Flaring**	
i. Oil		**i. Oil**	
AD	National Energy Balance	AD	National Energy Balance
EF	CH_4: 0.0087 Gg/10^3m^3 CO_2: 0.0018 Gg/10^3m^3 2006 IPCC Guidelines	EF	CH_4: 0.000021 Gg/10^3m^3 CO_2: 0.034 Gg/10^3m^3 2006 IPCC Guidelines
ii. Gas		**ii. Gas**	
AD	National Energy Balance	AD	National Energy Balance
EF	CH_4: 0.000182 Gg/10^6m^3 CO_2: 0.04 Gg/10^6m^3	EF	CH_4: 2.76E-06 Gg/10^6m^3 CO_2: 4.20E-03 Gg/10^6m^3

1. B. 2. c. Venting and Flaring			
1. B. 2. c. 1 Venting		1. B. 2. c. 2 Flaring	
	2006 IPCC Guidelines		2006 IPCC Guidelines

1.B.1.a Coal Mining and Handling	
i. Underground Mines	
AD	National Energy Balance
EF	Mining CH_4: 18 m^3/t Post-Mining CH_4: 2.5 m^3/t 2006 IPCC Guidelines
ii. Surface Mines	
AD	National Energy Balance
EF	Mining CH_4: 1.2 m^3/t Post-Mining CH_4: 0.1 m^3/t 2006 IPCC Guidelines
1.B.1.b Solid Fuel Transformation	
AD	National Energy Balance, FAO (Charcoal)
EF	Coking coal CH_4: 0.049 kg/t Charcoal CH_4: 1 t/TJ (1996 IPCC Guidelines)

Activity data for crude oil and natural gas has been taken from the Energy balance and Bulgartransgaz.

Emission estimates for exploration of natural gas are included in the estimates for oil exploration because the exploring activities refer to both oil and natural gas.

3.4.4 UNCERTAINTIES

The uncertainty of this emission source category was estimated as follows:

- 200% for coal mining;
- 50% for oil and natural gas systems.

3.4.5 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All activities regarding QC as described in QA/QC System have been undertaken.

3.4.6 SOURCE-SPECIFIC RECALCULATIONS, INCLUDING CHANGES MADE IN RESPONSE TO THE REVIEW PROCESS

For category 1.B.1.a.2.1 Fugitive emissions from surface mines, the previous emission factor of 1.2 m^3/t was changed to 1.5 m^3/t (IPCC GPG 2000, p.2.75), following a recommendation of the ERT during the Centralized review in 2012. For the 2014 submission the EF was changed back to 1.2 m^3/t following the adoption of the 2006 IPCC Guidelines.

For category 1.B.2.b.4 Fugitive emissions from gas transmission, the previous emission factor of 1340 $kgCH_4/km$ was changed to 2500 $kgCH_4/km$ (IPCC GPG 2000, Table 2.16, p.2.86), following a recommendation of the ERT during the Centralized review in 2012. For the latest submission the calculation approach was changed to rely on transited gas quantities following the adoption of the 2006 IPCC Guidelines.

As a result of ERT recommendation during the 2013 review cycle, the emission inventory was improved by adding emission estimates for category 1.B.2.a.iii. Oil transport.

A new category was included in the 2016 emission estimates following the previous review recommendations – Abandoned underground mines. As historical data and current state of the abandoned underground mines is not available for Bulgaria (e.g. whether these mines are now completely flooded or if they had been gassy at the time of operation), proxy data from Hungary is utilized for the emission estimates, as advised during the ESD review in 2016. This assumption rests on the similarity of mining activity between the two countries and extent to which the historical relationship between underground mining emissions and abandoned underground mine emissions reflects past mining activity and mitigation actions. In short, Hungary and Bulgaria had reasonably similar levels of emissions from underground mines operation between 1990 and 2000. Available data on total coal production from 1981 for the two countries is also reasonably similar as is the data for consumption since 1965. Given the specific methodology for this category, it is considered inappropriate to further adjust the emission estimates of Hungary with other factors (e.g. GDP, population, etc). Therefore, the Hungarian estimates were applied directly in this submission.

Another new category was included in the emission inventory as a result of the 2016 review cycle ERT recommendations from – Storage of natural gas. Data from the Ministry of Energy and Bulgartransgaz (the operator of the Chiren natural gas storage facility) regarding the quantities of natural gas extracted, has been used for the emission estimates for the entire time series. The default EFs from Table 4.2.4 of the 2006 IPCC Guidelines (volume 2, chapter 4) have been applied.

In order to address ERT recommendation FCCC/ARR/2016/BGR E.12, we have contacted several of the biggest mines in order to investigate whether there is a difference between the mined raw coal and the saleable coal. It was confirmed, that that lignite, the main type of coal produced in Bulgaria, is not upgraded. Some of the other mines, that we contacted, have explained that there were some coal upgrade facilities in the past, which were closed more than a decade ago. We've also contacted the Ministry of Energy in order to obtain past data provided by coal mining companies in Bulgaria for the beginning of the timeseries, but it was not available for such a distant period in the past. We have concluded, that there might be a possible underestimation for the base year, since coal upgrade facilities existed in the past, but currently the emissions should not be underestimated, as the amount of raw coal is equal to the saleable coal, used for the emission estimates.

Following recommendations FCCC/ARR/2016/BGR E.8 and FCCC/ARR/2016/BGR E.9 were introduced several changes in the 2019 submission. As petroleum coke is combusted in order to restore the catalyst's activity and not for energy purposes, all GHG emissions from petroleum coke, which were previously reported under CRF subcategory 1.A.1.b were reallocated under CRF subcategory 1.B.2.a.4. This subcategory contains other fugitive emissions from oil refining, estimated based on the total quantity of refinery intakes. The refinery intake is reported as activity data for this subcategory, which leads to inconsistent implied emission factor due to the inclusion of GHG emissions from petroleum coke. Similarly, the GHG emissions from hydrogen production, which were previously reported under CRF subcategory 1.A.1.b were reallocated under CRF subcategory 1.B.2.c.2.i. This subcategory also contains other fugitive emissions from oil refining, estimated based on the indigenous production of oil. The indigenous production is reported as activity data for this subcategory, which leads to inconsistent implied emission factor due to the inclusion of GHG emissions from natural gas used for hydrogen production.

3.4.7 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

A national study on abandoned underground mines was started in order to obtain data on the actual state of abandoned underground mines in Bulgaria. We expect that the study will be concluded in 2018, which would lead to revised emission estimates from this subsector.

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF SECTOR 2)

4.1 OVERVIEW OF SECTOR

This chapter includes information on and descriptions of methodologies used for estimating greenhouse gas emissions as well as references for activity data and emission factors reported under IPCC Category 2 Industrial Processes and Product Use (IPPU) for the period from 1988 to 2017. Emissions from this category comprise emissions from the following sub categories:

- 2.A Mineral Industry
- 2.B Chemical Industry
- 2.C Metal Industry
- 2.D Non-energy Products from Fuels and Solvent Use
- 2.E Electronics Industry
- 2.F Product Uses as Substitutes for ODS
- 2.G Other Product Manufacture and Use
- 2.H Other

Only process related emissions are considered in this sector.

Emission Trends

This section briefly describes the emission trends from 1988 to 2017 for each of the IPCC Categories under CRF Sector 2 for which GHG emissions are reported.

Industrial process emissions include emissions from industrial installations, consumption of Solvent Use and halocarbons and SF_6 (the fluorinated gases or F-gases).

In 2017 the most important emitting category is Mineral Industry (89.1% of which are from clinker/cement production (49.1%), lime stone used for DeSOx installation of the LCP/TPP (31.2%) and quick lime production (8.9%)) which share in the total IPPU emissions is 39.3%. The second category by share is Product uses as ODS substitutes (Consumption of Halocarbons) with 28.4%, followed by Chemical Industry (ammonia and nitric acid production) with 27.2% and followed by others subcategory.

These results are presented in the following table:

Table 108 GHG Emission trends in CRF 2 IPPU, 1988 - 2017

IPCC category	Emissions [Gg CO_2 eq]		Share [%]		Trend 1988 – 2017 [%]
	Base year*	2017	Base year*	2017	
2 Industrial processes	13439.32	6412.50	100.00	100.00	-52.29
2.A Mineral Industry	3691.75	2519.73	27.47	39.29	-31.75
2.B Chemical Industry	5422.48	1746.22	40.35	27.23	-67.80
2.C Metal Industry	4024.37	183.08	29.95	2.86	-95.45
2.D Non-energy Products from Fuels and Solvent Use	229.17	86.58	1.71	1.35	-62.22
2.E Electronics Industry	NO	NO	NO	NO	NO
2.F Product Uses as Substitutes for ODS	0.00	1817.91	0.00	28.35	0.00
2.G Other Product Manufacture and Use	64.70	53.60	0.48	0.84	-17.16
2.H Other	6.85	5.38	0.05	0.08	-21.46

* Base year 1988

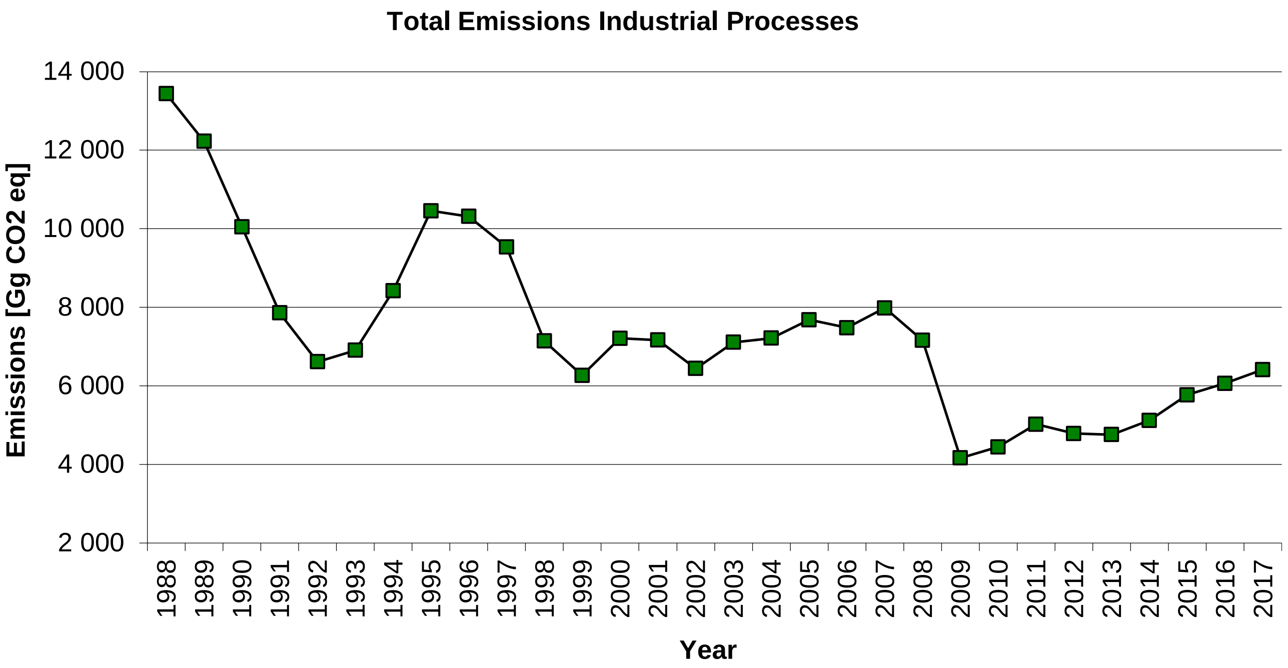

Figure 51 CO2 Emission trends for CRF Sector 2 IPPU for 1988-2017

In the year 2017, 10.4% of national total greenhouse gas emissions (without LULUCF) originated from industrial processes and product use, compared to 11.5% in the base year 1988. In 2017, greenhouse gas emissions from Category 2 IPPU are 6412.50 Gg CO_2 equivalent compared to 13439.32 Gg in the base year.

Greenhouse gas emissions from the IPPU sector fluctuate during the period and reach a minimum in 2009. The reduction for the whole sector is 52.29 % in 2017 while the biggest reduction (compared to the base year) is in Metal Industry category – 95.45% and Chemical Industry – 67.80%.

This is mainly due to economic crisis and in particular the world economic crisis in 2009. The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation. From 2009 onwards the market had recovered.

The general reduction in the emissions in the later years of the time period is influenced also by the starting introduction of better technologies on plant level or plant closures.

Emission trends by gas

The following table presents greenhouse gas emissions of the IPPU sector as well as their share in total greenhouse gas emissions from that sector in the base year and in 2017.

Table 109 GHG emissions from CRF 2 IPPU by gas in 1988 and 2017

GHG	Base year*	2017	Base year*	2017
	CO_2 equivalent [Gg CO_2 eq]		[%]	
Total	13439.32	6412.50	100.00	100.00
CO_2	11419.26	4471.56	84.97	69.73
CH_4	52.13	0.00	0.39	0.0000035
N_2O	1964.63	105.51	14.62	1.65
HFCs	0.00	1817.89	0.00	28.35
PFCs	0.00	0.02	0.00	0.0003
SF_6	3.30	17.51	0.02	0.27

*1988 for: CO_2, CH_4, N_2O and SF_6.
*1995 for: HFCs and PFCs.

The most important GHG of the IPPU sector is CO_2 with 69.73% of the total emissions from this category in 2017, followed by HFCs with 28.35%, N_2O with 1.65 %, SF_6 with 0.27%, PFCs with 0,0003% and finally CH_4 with 0.0000035%.

Table 110 GHG Emissions from CRF 2 IPPU by gases 1988 - 2017

GHG emissions [Gg CO_2 eq]							
Year	**Total**	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**
1988	13439.32	11419.26	52.132	1964.63	0.00	0.000	3.30
1989	12223.76	10417.69	51.775	1750.80	0.00	0.000	3.49
1990	10047.56	8323.96	39.914	1680.00	0.00	0.000	3.69
1991	7856.09	6656.69	30.565	1164.93	0.00	0.000	3.91
1992	6613.27	5593.68	28.519	986.92	0.01	0.000	4.13
1993	6904.33	5993.46	32.897	873.57	0.02	0.000	4.37
1994	8420.17	7428.33	44.718	941.40	1.10	0.000	4.63
1995	10454.38	9014.03	48.967	1383.16	3.33	0.000	4.90
1996	10314.90	8832.45	48.194	1423.24	5.84	0.000	5.18
1997	9536.05	8396.75	51.480	1073.05	9.28	0.000	5.48
1998	7141.99	6415.78	44.296	661.05	15.07	0.000	5.80
1999	6265.30	5647.97	37.079	552.51	21.59	0.000	6.14
2000	7210.78	6314.57	37.616	819.08	33.02	0.000	6.49
2001	7165.94	6253.75	37.926	821.71	45.67	0.000	6.87
2002	6443.01	5657.04	33.940	683.47	61.30	0.000	7.27
2003	7109.23	6266.15	42.282	709.36	83.74	0.000	7.69
2004	7214.52	6208.58	36.398	841.48	119.92	0.000	8.13
2005	7683.61	6540.36	35.122	904.79	195.16	0.000	8.16
2006	7477.03	6638.91	36.044	496.49	297.11	0.000	8.48
2007	7982.51	6946.34	34.914	606.65	385.79	0.000	8.81
2008	7157.72	5920.21	19.412	583.02	625.89	0.021	9.16
2009	4163.11	3224.85	4.871	284.70	639.11	0.056	9.52
2010	4445.32	3477.22	0.016	286.21	663.05	0.064	18.76
2011	5020.54	3998.72	0.005	252.10	752.68	0.055	16.97
2012	4783.99	3790.72	0.001	153.98	823.14	0.046	16.10
2013	4759.34	3632.56	0.001	137.95	968.37	0.039	20.42
2014	5120.17	3855.40	0.001	139.90	1107.96	0.033	16.88
2015	5769.56	4388.72	0.000	140.65	1222.10	0.028	18.07
2016	6062.71	4517.25	0.000	126.70	1399.99	0.023	18.75
2017	6412.50	4471.56	0.000	105.51	1817.89	0.019	17.51

The emission trends of the three GHG – CO_2, CH_4 and N_2O, are presented on the following figure.

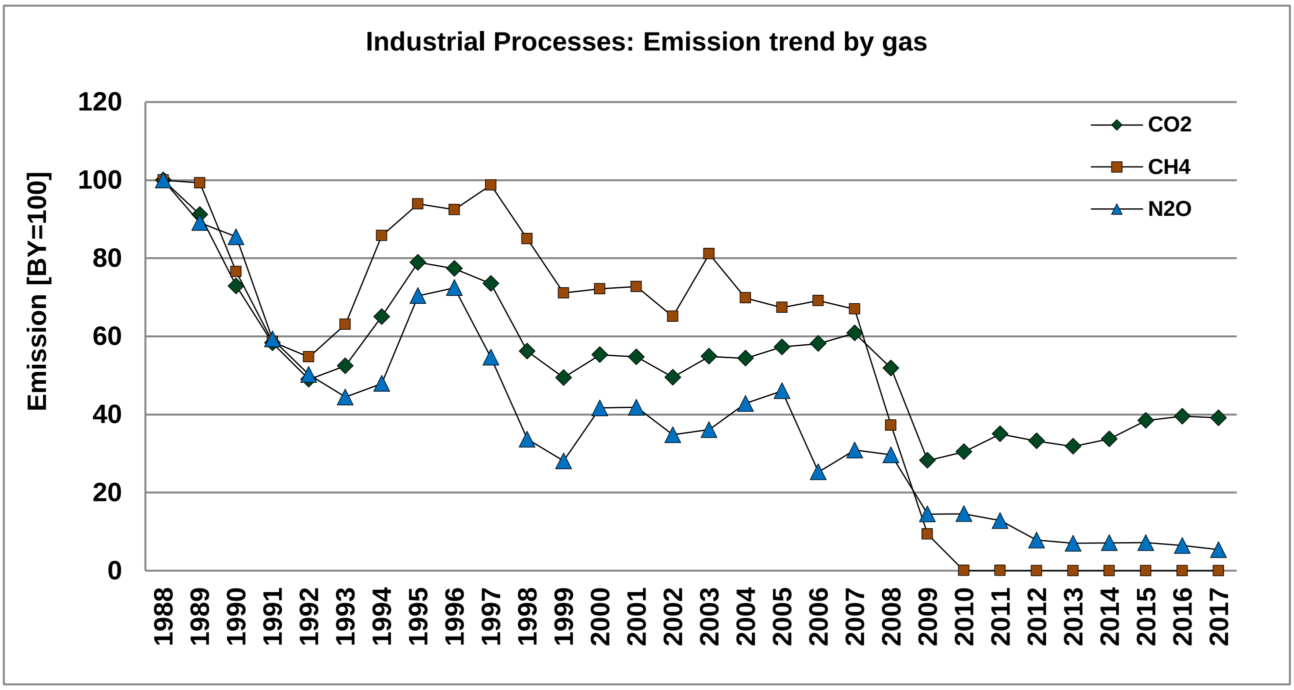

Figure 52 IPPU: Emission trend by gas – CO_2, N_2O, CH_4

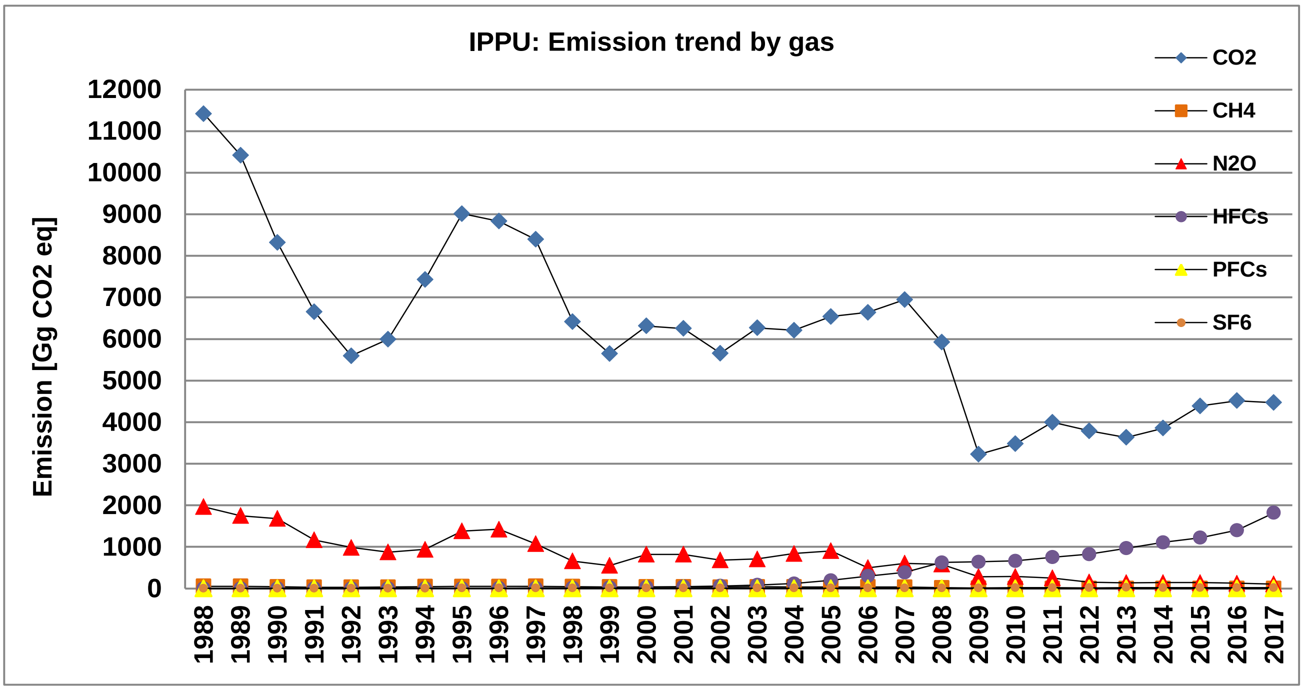

Figure 53 IPPU: Emission trend by gas – CO_2, N_2O, CH_4, HFCs PFCs and SF_6

Emission trends by sources

The main sources of greenhouse gas emissions in the IPPU sector are Mineral Industry and Product uses as ODS substitutes (Consumption of Halocarbons), which cause about 39.3% and 28.4%, respectively, of the emissions from this sector in 2017. There has been an increase over 20% in the past year in CO_2 eq. emissions from the F-gases use (sector 2.F).

Table 111 GHG Emissions from CRF 2 IPPU by sector 1988 to 2017

GHG emissions [Gg CO_2 eq]							
Year	2.A Mineral Industry	2.B Chemical Industry	2.C Metal Industry	2.D Non-energy Products from Fuels and Solvent Use	2.F Product Uses as Substitutes for ODS	2.G Other Product Manufacture and Use	2.H Other
1988	3691.75	5422.48	4024.37	229.17	0.00	64.70	6.85
1989	3511.36	5190.91	3248.14	202.02	0.00	64.29	7.04
1990	3235.85	4943.27	1629.35	169.34	0.00	64.23	5.53
1991	2040.81	3912.54	1710.80	123.48	0.00	64.24	4.22
1992	1725.23	3097.65	1591.97	129.13	0.01	64.17	5.11
1993	1747.20	2856.54	2084.69	147.93	0.02	61.96	5.99
1994	2068.62	3209.15	2939.41	106.48	1.10	89.82	5.60
1995	2692.25	4206.76	3360.40	103.19	3.33	80.91	7.54
1996	2651.25	4397.46	3061.41	108.86	5.84	83.75	6.33
1997	2086.23	3692.04	3580.32	82.27	9.28	79.75	6.16
1998	1526.60	2457.03	2962.70	106.23	15.07	70.23	4.13
1999	1426.78	1896.54	2726.00	123.33	21.59	67.02	4.03
2000	1604.70	2764.01	2631.42	96.61	33.02	76.96	4.06
2001	1630.41	2791.34	2528.25	99.17	45.67	67.55	3.54
2002	1696.84	2209.52	2299.04	101.30	61.30	72.33	2.69
2003	1733.58	2285.62	2827.93	108.82	83.74	66.47	3.06
2004	1960.97	2615.79	2342.86	109.40	119.92	62.86	2.72
2005	2164.67	2784.70	2370.52	105.74	195.16	59.54	3.27
2006	2300.08	2154.13	2556.15	106.54	297.11	59.74	3.28
2007	2786.58	2377.75	2266.69	102.59	385.79	59.85	3.26
2008	2777.36	2314.70	1279.45	95.63	625.91	61.50	3.17
2009	1746.34	1311.03	308.16	93.09	639.17	59.07	6.25
2010	1811.79	1501.86	288.66	100.45	663.11	75.57	3.89
2011	1953.77	1826.29	315.88	98.81	752.74	69.50	3.55
2012	2056.84	1444.80	290.17	94.55	823.19	70.62	3.82
2013	1941.35	1473.39	221.79	90.94	968.41	58.84	4.63
2014	2005.29	1604.66	249.29	91.35	1107.99	56.66	4.93
2015	2385.67	1790.30	224.06	84.82	1222.13	57.43	5.15
2016	2451.38	1837.89	223.42	89.20	1400.01	55.96	4.85
2017	2519.73	1746.22	183.08	86.58	1817.91	53.60	5.38

The following figure presents greenhouse gas emissions from IPCC Category 2 IPPU by sub category for the years 1988 to 2017.

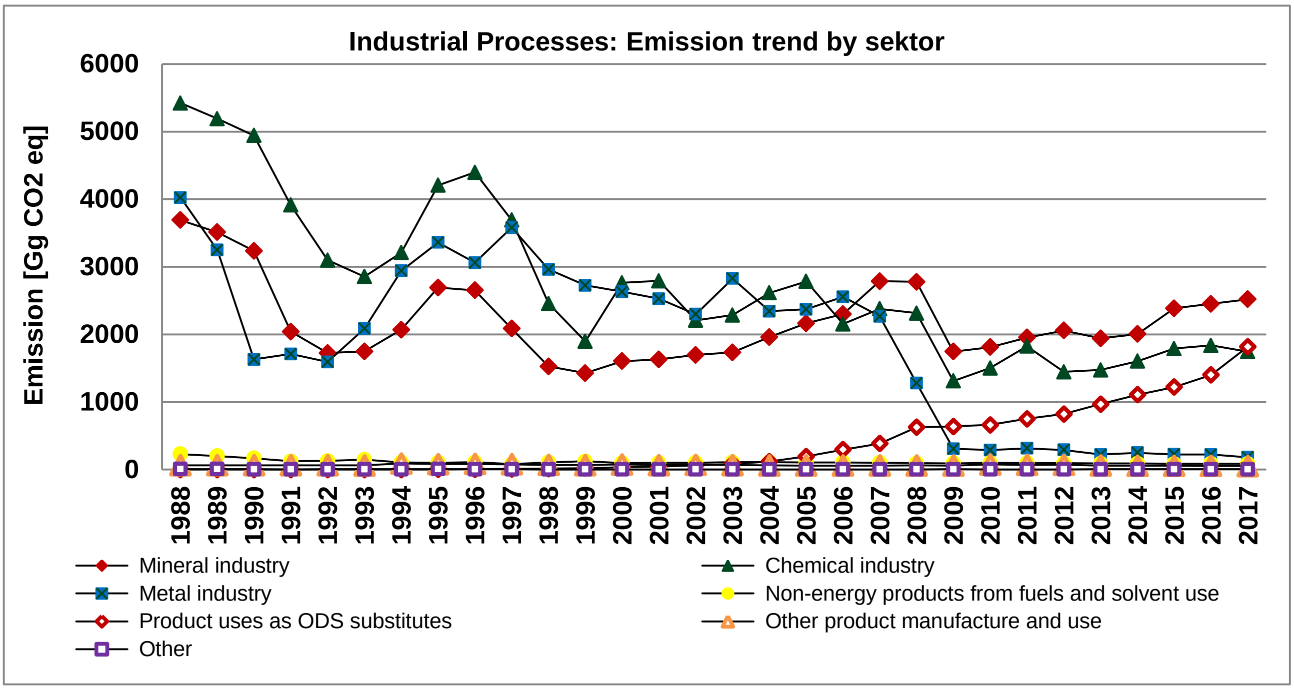

Figure 54 CRF 2 IPPU: Emission trend by sector – [Gg CO2 eq]

The emissions reduction during the whole time period from 1988 to 2017 is due to mainly economic reasons (economic crisis). There are another two such periods – around 1989 - 1991 and 1997 – 1999. The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.

The general reduction in the emissions in the later years of the time period is influenced also by the starting introduction of better technologies on plant level or plant closures.

Greenhouse gas emissions from the IPPU sector fluctuate during the period and reach a minimum in 2009. The reduction for the whole sector is 52.29% in 2017 while the biggest reduction (compared to the base year) is in Metal Industry category – 95.45%, followed by Chemical industry with 67.80, Non-energy products from fuels and solvent use with 62.22%, Mineral Industry with 31.75%, Other with 21.46% and Other Product Manufacture and Use – 17.16% .

One of the most important factors leading to emission reduction in Metal Industry sector is that the biggest plant from this sector (which share in the steel production before 2008 was more than 50%) ceased operation of its pig iron and the following steel making in BOF in November 2008. The total reduction in the sector production comparing the years of 2008 and 2017 is more than 50%.

Ceased operation of existing ammonia and nitric acid plants is the main reason for the emission reduction in Chemical Industry category, too. That led to a reduction of the emissions in the period 1999/2002 for the Chemical Industry as a whole. In 2017 the market was recovered.

In 2017 a slight increase in emissions is observed for the entire IPPU sector. This is mainly due to increase in Mineral Industry category (although three of the factories have ceased operations, two of which in the last five years). There is an increase in the Product uses as ODS substitutes (Consumption of Halocarbons) category.

Methodology

The general method for estimating emissions for the IPPU sector, as recommended by the 2006 IPCC Guidelines, involves multiplying production data for each process by an emission factor per unit of production. For some sub-sectors (for example ammonia production, nitric acid production, etc.) higher tier, i.e. tier 2 or tier 3, are used.

In some categories emission and production data were reported directly by industry or EU ETS, IPPC and/or E-PRTR reports thus represent plant and country specific data. Methodologies are described for all IPCC categories.

Detailed information on the methodology can be found in the corresponding subchapters.

Emission data reported under the European Emission Trading Scheme - EU ETS

Verified CO_2 emissions reported under the EU ETS were available for the years 2007-2017. These emissions have been incorporated in the inventory as far as possible (see respective subchapters for more information). Furthermore the background data for the emission calculations under the EU ETS were used for further QA/QC checks.

Uncertainty Assessment

For the sector IPPU uncertainties are estimated taking into account the recommendations of the 2006 IPCC Guidelines.

For all the sub-sectors uncertainties for the emission factors and activity data as well as combined uncertainty are estimated. When doing so the methods for obtaining the activity data and estimating the emission factors (plant specific, country specific, national statistics) were considered.

Quality Assurance and Quality Control (QA/ QC)

Emission estimations as well as activity data and emission factors are compared with the verified EU ETS emission reports, IPPC reports as well as E-PRTR reports where available.

The availability of quality management systems, such as ISO 9001, ISO 14001 and EMAS, are available for is also taken into account that.

Monitoring data are used in some emissions estimation.

Planned Improvements

All planned improvements (described in the following sub-chapters) have been implemented in this sector.

4.2 MINERAL INDUSTRY (CRF 2.A)

4.2.1 CEMENT PRODUCTION (CRF 2.A.1)

4.2.1.1 Source category description

In the period 1988 to 2017, there are 6 existing/operational cement plants in Bulgaria. One of these (6th) installations was operational from 1988 till 1996 and decommissioned finally during that last year. One from the 5th existing/operational installation was the decrease substantially its production during 2010. In 2011 this factory completely ceases operation and all equipment is decommissioned. In 2013 one more installation ceases operation and all equipment is decommissioned. At present there are only 3 operating plants. All 3 plants are covered by the EU ETS and the IPPC Directive and have been modernized accordingly during the last 10 years. In addition all plant sites are certified at present according to ISO 9001 and 14 001 standards. During 2017 cement produced 99.5% are Portland cement, i.e. the other types of cement are only 0.5% from the total annual national production. All types of produced cements are according to BSS EN 197-125.

Additional information on the above installations (operators) may be obtained through the Bulgarian Association of Cement Industry (BACI) at www.bacibg.org and/or their own internet sites.

[25] Cement. Composition, specifications and conformity criteria for low heat common cements

4.2.1.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.

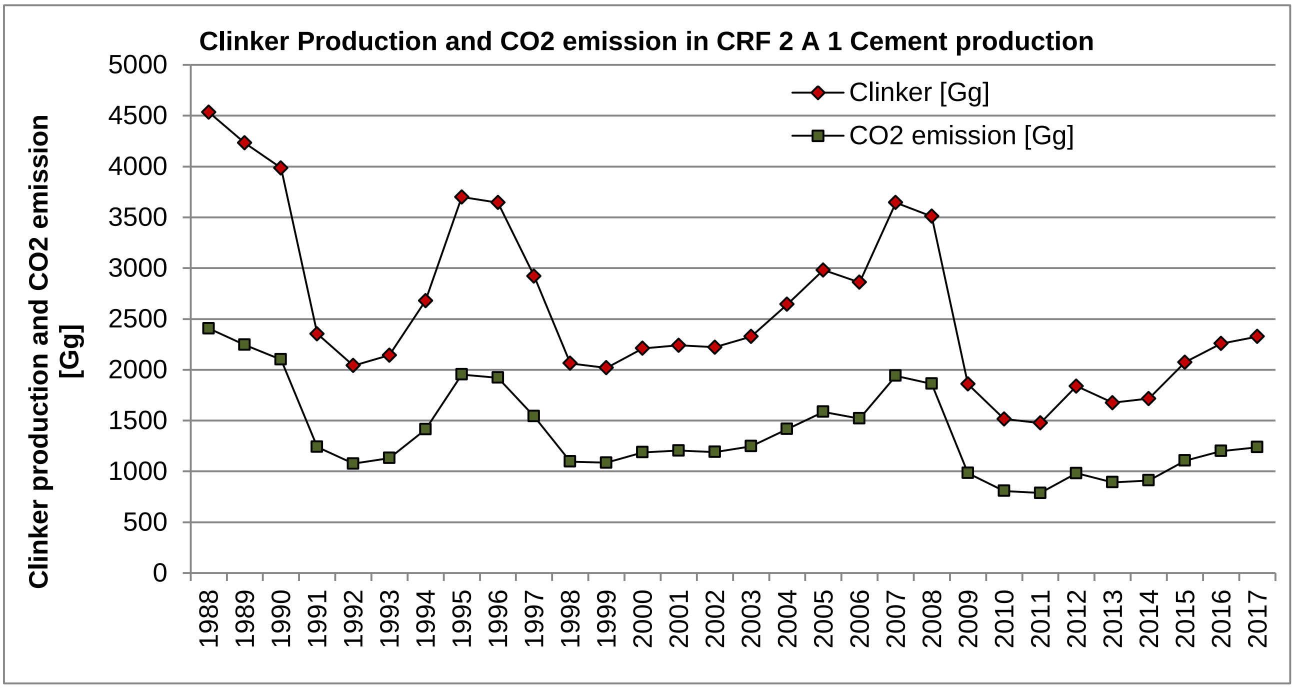

Figure 55 Clinker Production and CO2 emission in CRF 2 A 1 Cement production

4.2.1.3 Methodological issues

4.2.1.3.1 Method

The GHG emissions from the sector are calculated by using a clinker production data and a country specific method, similar to a Tier 2 Method according to item 2.2.1.1 from the 2006 IPCC GL. The aggregated national clinker production (CP) data in t/y are provided by the NSI. Clinker production data was taken from the annual reports under the IPPC permits. In addition, information on the content of calcium and magnesium oxide in the clinker is required from the plants.

The emission calculations and the applied emission factor are respectively according to equation 2.2 on pages 2.9 from item 2.2.1.1 (2006 IPCC GL):

$$\textbf{Emissions} = \textbf{EF}_{\textbf{clinker}} \bullet \textbf{CP} \bullet \textbf{CKD Correction Factor}$$

$$\textbf{EF}_{\textbf{clinker}} = \sum \textbf{M} \bullet \textbf{C}_{\textbf{(MeO)}}$$

$$\textbf{C}_{\textbf{(MeO)}} = ((\sum \textbf{Cn}_{\textbf{(MeO)}}) \bullet \textbf{CPn}) / \textbf{CP})/100$$

Where:
CKD Correction Factor = 1.00
M - Molecular Weight CO_2/ Molecular Weight Me-oxide
$C_{(MeO)}$ – Content (Weight Fraction) in Clinker [%]
CP – clinker production [Gg]
Me – Ca, Mg, other
n – Cement plants (1-5)

The above assumption for the CKD Correction Factor is based on the modern status of cement plants and the total (100%) recycling of their CKD as a raw material.

4.2.1.3.2 Emission factor

In addition, the above calculations are based on the conservative assumption that all of the lime (MeO) comes from a carbonate sources (e.g. limestone/$MeCO_3$) in the lack of reliable data on the use of non-carbonate sources, i.e. assuming 100% calcinations of the carbonate sources present in the raw materials mixture.
Taking into account the above, the final equation is as follows:

Emissions = 0.532• CP (for 2017)

The CO_2 emissions for 2017 are taken from the operators EU ETS reports. In their reports $CaCO_3$, $MgCO_3$ and other carbonates content in the raw materials used is taken into account.

4.2.1.3.3 Activity data

The aggregated national clinker production (CP) data provided by the NSI and plants cover the period from 1988 to 2017. They are presented in the table below together with the relevant coefficients and the calculated CO_2 emissions:
Emissions from this category in 2017 are estimated to 1237.55 kt - the production is 2326.86 kt and the IEF is 0.532 kt/production, respectively data for the base year (1988) are estimated to 2 406.34 kt - the production is 4535.24 kt and the IEF is 0.531 kt/production.

Table 112 Clinker production, weight fraction and CO2 emission

Clinker Production Data		IEF [kt CO2/ kt production]	CO2 Emissions [kt]
Year	[kt/y]		
1988	4535.24	0.531	2406.34
1990	3986.62	0.527	2100.41
1995	3700.60	0.528	1953.59
2000	2211.23	0.537	1187.81
2005	2981.62	0.532	1586.36
2010	1514.55	0.533	807.29
2015	2073.69	0.533	1105.43
2016	2257.05	0.532	1200.00
2017	2326.86	0.532	1237.55

4.2.1.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

AD = 1-2 %

CaO Weight Fraction = 1-2 %

MgO Weight Fraction = 1-2 %

Quantitative uncertainty estimates are provided in Annex 2.

Combined uncertainty	2,12 %
AD	1,5%
EF	1,5%

4.2.1.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.

As a part from the QA activities the aggregated national clinker production data provided by the NSI were compared with the production data reported by the cement plants in the annual reports for compliance with their IPPC permits (EPRTR data), as well as in their verified EU ETS emission reports .

All verification EU ETS reports are public available at: http://eea.government.bg/bg/r-r/r-te/verifitsirani-dokladi-16/dokladi-1r

The following improvements were undertaken

Improvements with regard to TACCC of method, EF and relevant other parameters used to estimate these emissions were made.

4.2.1.6 Source specific recalculations

There are no source specific recalculations for this category.

4.2.1.7 Source specific planned improvements

Improvements in this category are not planned.

4.2.2 LIME PRODUCTION (CRF 2.A.2)

4.2.2.1 Source category description

The production of lime involves a series of steps comparable to those used in the production of Portland cement clinker. These include quarrying the raw materials, crushing and sizing, calcining (i.e., high temperature heat processing ~ 1100°C) the raw materials to produce lime, hydrating the lime to calcium hydroxide followed by miscellaneous transfer, storage and handling operations.

Calcium oxide (CaO or quicklime) is formed by heating limestone to decompose the carbonates. This is usually done in shaft or rotary kilns at high temperatures and the process releases CO_2. Depending on the product requirements (e.g., metallurgy, pulp and paper, construction materials, effluent treatment, water softening, pH control, and soil stabilisation), primarily high calcium limestone (calcite) is utilized in accordance with the following reaction (2006 IPCC Guidelines):

$CaCO_3$ (high-purity limestone) + heat = CaO (quicklime) + CO_2

Currently there are 5 lime producing plants in Bulgaria which fall under the IPPC and the EU ETS. They produce high calcium quicklime. After the largest metallurgic plant ceases operation in 2008 there is virtually no production of dolomitic lime. In 2013 letters were sent to all quicklime producing plants (including the ones producing quicklimes for their own needs) and all of them declared that they do not produce dolomitic lime.

4.2.2.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.

The reduction in 2009 is ceased operation (in November 2008) of one of the lime producers (integrated steel making plant), reduction in the construction works and other quicklime consuming production processes and world economic crises.

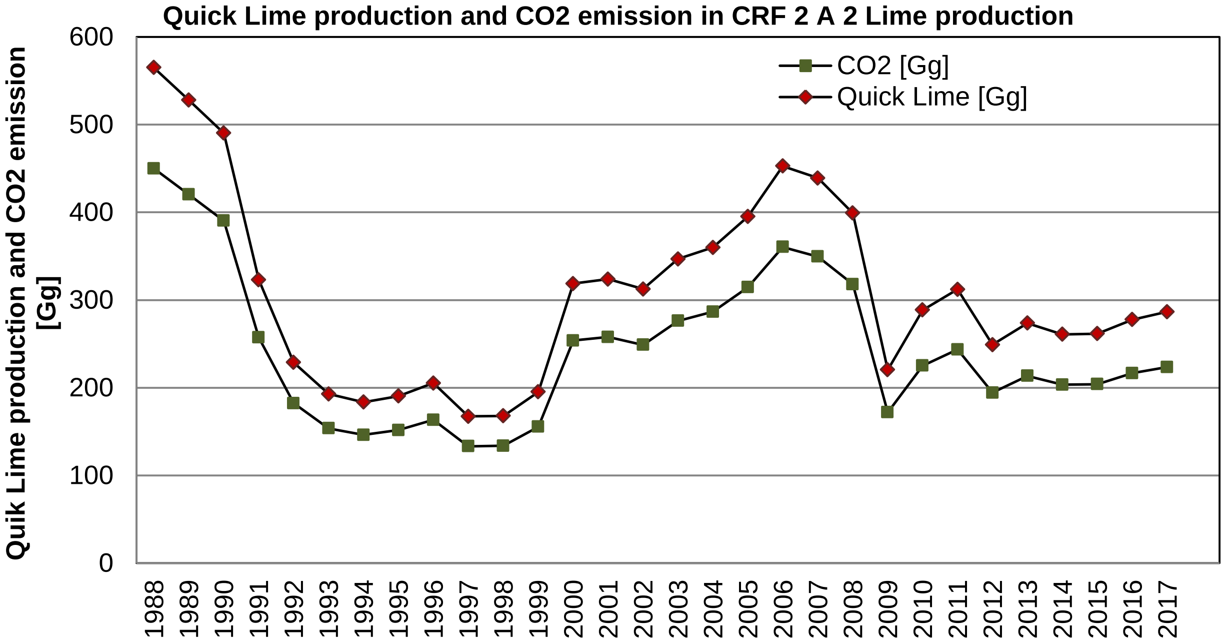

Figure 56 Lime Production and CO2 emission in CRF 2.A.2 Lime production

4.2.2.3 Methodological issues

4.2.2.3.1 Method

The emissions from the sector are calculated using country specific data on the total amount of lime produced provided by NSI. Default emission factor is applied.
The emissions are estimated following the general approach and using the following equation similar to equation 2.6, p.2.21 (2006 IPCC Guidelines):

$$\mathbf{CO_2\ Emissions = \sum (EF_{Lime,i} \bullet M_{Lime,i} \bullet CF_{LKD,I})}$$

Where:
CO_2 Emissions = emissions of CO_2 from lime production, tonnes
$EF_{Lime,i}$ = emission factor for lime of type i, tonnes CO_2/tonne lime
$M_{Lime,i}$ = lime production of type i, tonnes
$CF_{LKD,I}$ = correction factor for LKD for lime of type i, dimensionless = 1.02
The following is taken into account:
2006 IPCC Guidelines (Table 2.4, p. 2.22) recommend a default emission factor of 0.785 tonnes CO_2/tonne quicklime produced and 0.913 tonnes CO_2/tonne dolomitic lime produced.
It is assumed that the whole quantity of $CaCO_3$, $MgCO_3$, и $CaMg(CO_3)_2$ is carbonised to CaO и MgO – 100% and the ratio of high-calcium lime to Dolomitic lime is: 85% High-calcium lime to 15% Dolomitic lime.
$M_{Lime} = 0.85 \bullet M_{high\ calciumlime} + 0.15 \bullet M_{dolomitic\ lime}$
Thus an approach in line with Tier 2 method (2006 IPCC Guidelines, p.2.21) is used to estimate CO_2 emissions from lime production.

4.2.2.3.2 Emission factor

To estimate the emission factors are used the following equations:

EQUATION 3.5A

$$\mathbf{EF_{high\ calciumlime} = Stoichiometric\ ratio\ (CO_2/CaO) \bullet CaO\ content + Stoichiometric\ ratio\ (CO_2/MgO) \bullet MgO\ content}$$

Where: $EF_{high\ calciumlime}$ = emission factor for quicklime

EQUATION 3.5B

$EF_{dolomitic\ lime}$ = Stoichiometric ratio (CO_2/ CaO·MgO) • (CaO·MgO) content (Stoichiometric ratio (CO_2 /CaO) • CaO content + Stoichiometric ratio (CO_2 /MgO) • MgO content)

Where: $EF_{dolomitic\ lime}$ = emission factor for dolomitic quicklime

The above equations are used to estimate the emission factor.

4.2.2.3.3 Activity data

Country specific data on the total lime production (quicklime) are provided by NSI.

The following is taken into consideration: It is good practice to assess the available national statistics for completeness, and for the ratio of limestone to dolomite used in lime production (2006 IPCC Guidelines).

Thus statistical data on total amount of lime produced are used to estimate the emissions of CO_2 from lime production.

Issues of double counting:
CO_2 emissions from Lime production are reported in this chapter and are not included in Limestone and dolomite use chapter.

Emissions from this category in 2017 are estimated to 223.53 kt - the production is 286.55 kt and the IEF is 0.780 kt/production, respectively data for the base year (1988) are estimated to 450.07 kt - the production is 565.21 kt and the IEF is 0.796 kt/production.

Table 113 Lime production and CO2 emissions

Year	Lime Production [kt/y]	IEF (with LKD) [kt CO_2/ kt production]	CO_2 Emissions [kt CO_2]
1988	565.21	0.796	450.07
1990	490.39	0.796	390.49
1995	190.48	0.796	151.67
2000	318.70	0.796	253.78
2005	395.12	0.796	314.63
2010	288.60	0.780	225.13
2015	261.59	0.780	204.06
2016	277.69	0.780	216.61
2017	286.55	0.780	223.53

4.2.2.3.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	2,83 %
AD	2%
EF	2%

Uncertainty for AD:

The following is taken into account (2006 IPCC GL, p. 2.25, see also Table 2.5):

The uncertainty for the activity data is likely to be much higher than for the emission factors, based on experience in gathering lime data.

Uncertainty for EF:

The following is taken into account (2006 IPCC GL, p. 2.25, see also Table 2.5):

In Tier 2 and Tier 1, the stoichiometric ratio is an exact number and therefore the uncertainty of the emission factor is the uncertainty of lime composition.
There is uncertainty associated with determining the CaO content and/or the CaO•MgO content of the lime produced.
Quantitative uncertainty estimates are provided in Annex 2.

4.2.2.4 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.

4.2.2.5 Source specific recalculations

There are no source specific recalculations for this category.

4.2.2.6 Source specific planned improvements

No source specific improvements are planned.

4.2.3 GLASS PRODUCTION (CRF 2.A.3)

4.2.3.1 Source category description

Currently there are six glass plants in Bulgaria mainly producing flat, container and domestic glass. All of them fall under the IPPCD and the EU ETS.
According to the information given in the Reference Document on Best Available Techniques in the Glass Manufacturing Industry, December 2001, the general description of the main types of glass produced in the country are:

Container glass
The forming process is carried out in two stages, the initial forming of the blank either by pressing with a plunger, or by blowing with compressed air, and the final moulding operation by blowing to obtain the finished hollow shape. These two processes are thus respectively termed "press and blow" and "blow and blow". Container production is almost exclusively by IS (Individual Section) machines.

Flat glass
Flat glass is produced almost exclusively with cross-fired regenerative furnaces. The basic principle of the float process is to pour the molten glass onto a bath of molten tin, and to form a ribbon with the upper and lower surfaces becoming parallel under the influence of gravity and surface tension. From the exit of the float bath the glass ribbon is passed through the annealing lehr, gradually cooling the glass to reduce residual stresses. On-line coatings can be applied to improve the performance of the product (e.g. low emissivity glazing).

Domestic glass
Domestic glass is a diverse sector involving a wide range of products and processes. Ranging from intricate handmade lead crystal, to high volume, mechanised methods used for mass produced tableware.
The forming processes are automatic processing, hand made or semi-automatic processing, and following production the basic items can be subjected to cold finishing operations (e.g. lead crystal is often cut and polished).

4.2.3.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.
One of the glass producing plants is new and has started working in the period 2005/2006. Another one had reduced capacity, operational time, during 2008 – 2009 and had stopped in 2010.

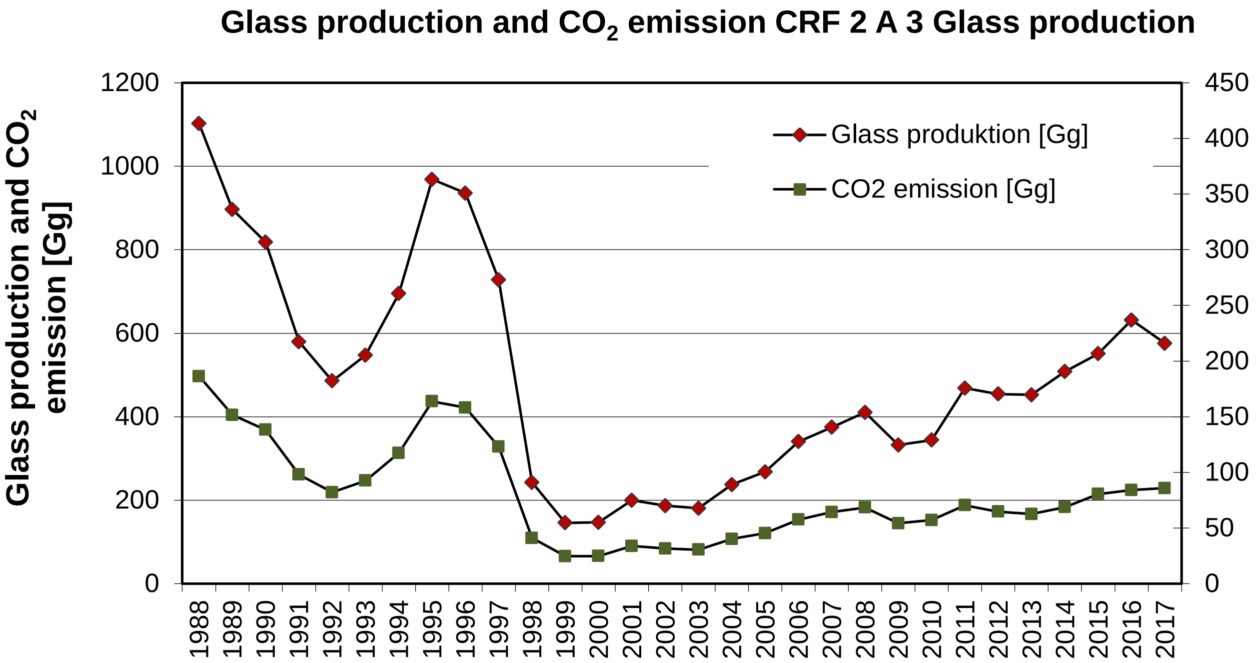

Figure 57 Glass Production and CO2 emission in CRF 2.A.3 Glass production

4.2.3.3 Methodological issues

4.2.3.3.1 Method

Emissions are estimated based on the carbonate used from data presented in verified reports, it is similar to equation 2.12, page 2.28, 2006 IPCC GL. This section does not report emissions from soda ash use, they are reported in the sub-sector 2A4b Other uses of Soda Ash.
The emissions were estimated using the following equation:

Emissions CO_2 = Emission factor • Glass production

For the period 2007 - 2015 plant specific emissions and production data were used based on the data reported by operators under the EU ETS (except one plant) and the IPPC. Thus plants specific emission factors were obtained which from an implied emission factor was delivered.

4.2.3.3.2 CO_2 Emission factor

For the period 2007 - 2008 plant specific (for five plants) emission factors were calculated on the basis of data from the IPPCD and the EU ETS reports (see Table 114). These emission factors were used to calculate an implied emission factor which was further used to recalculate the emissions for the rest of the time series.

4.2.3.3.3 Activity data

Plant specific data from the IPPCD and the EU ETS reports are available for the years 2007 - 2017. For the time series 1988 – 2017 statistical activity data were used. The quantity of glass produced was recalculated by NSI in tones due to differences in the measurement units reported.
Issue of double counting:
Only the emissions from the use of lime stone in the glass production process are estimated in this category. The quantities of soda ash and fuel used are reported under Soda ash use and Energy Chapter respectively.

Emissions from this category in 2017 are estimated to 85.78 kt - the production is 575.64 kt and the IEF is 0.149 kt/production, respectively data for the base year (1988) are estimated to 186.24kt - the production is 1102.09 kt and the IEF is 0.169 kt/production.

Table 114 Glass production and CO2 emission in CRF 2.A.3 Glass production

Year	Glass Production (GP) [kt/y]	Emission Factor (EF CO_2) [kt CO_2/kt GP]	CO_2 Emissions [kt CO_2]
1988	1102.09	0.169	186.24
1990	818.04	0.169	138.24
1995	968.79	0.169	163.72
2000	146.66	0.169	24.78
2005	267.94	0.169	45.28
2010	344.16	0.166	57.11
2015	550.91	0.146	80.41
2016	631.60	0.133	84.01
2017	575.64	0.149	85.78

4.2.3.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	14,14 %
AD	±10 %
EF	10%

Uncertainty for AD:

"Glass production data are typically measured fairly accurately (+/-5 percent) for Tier 1 and Tier 2. As mentioned above, inventory compilers should be cautious where activity data are not originally available in mass, but rather as a unit (e.g., bottle) or area (e.g., m2). If activity data have to be converted to mass, this may result in additional uncertainty." (2006 IPCC GL, p. 2.31)
Taking the above into account the uncertainty of the emission factor was assumed as ±6 %.

Uncertainty for EF:

Uncertainty associated with use of the Tier 1 emission factor and cullet ratio is significantly higher, and may be on the order of +/- 60 percent.
Quantitative uncertainty estimates are provided in Annex 2.

4.2.3.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.
Revision of the activity data by using IPPCD and EU ETS reports as well as statistical data.
Development of country specific emission factor for glass production based on IPPCD and EU ETS data.
ISO 9001 and 14 001 standards.

4.2.3.6 Source specific recalculations

There is a change of glass production data for 2015 and 2016 which is due to technical errors and lead to the recalculations of emission factors values for the relevant years.

4.2.3.7 Source specific planned improvements

No source specific improvements are planned.

4.2.4 OTHER PROCESS USES OF CARBONATES (CRF 2.A.4): CERAMICS PRODUCTION (CRF 2.A.4.A)

4.2.4.1 Source category description

According to the Reference Document on Best Available Techniques in the Ceramic Manufacturing Industry, August 2007, the fundamental methods and steps in the production processes hardly differ in the manufacture of the various ceramic products, besides the fact that, for the manufacture of, e.g. wall and floor tiles, table - and ornamentalware (household ceramics), sanitaryware and also technical ceramics, often a multiple stage firing process is used.

The manufacture of ceramic products takes place in different types of kilns, with a wide range of raw materials and in numerous shapes, sizes and colours. The general process of manufacturing ceramic products, however, is rather uniform, besides the fact that, for the manufacture of wall and floor tiles, table- and ornamentalware (household ceramics), sanitaryware and also technical ceramics, often a multiple stage firing process is used. In general, raw materials are mixed and cast, pressed or extruded into shape. Water is regularly used for a thorough mixing and shaping. This water is evaporated in dryers and the products are either placed by hand in the kiln (especially in the case of periodically operated kilns) or placed onto carriages that are transferred through continuously operated kilns. In most cases, the kilns are heated with natural gas, but liquefied petroleum gas, fuel oil, coal, petroleum coke, biogas/biomass or electricity are also used.

The currently operating ceramic plants in Bulgaria are producing mostly bricks, roof and wall tiles and other ceramic products. Those of them which cover the capacity criteria according to the IPPC Directive have IPPC permits as well as ETS permits.

4.2.4.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.

A relatively stable production amount is observed for the period after the world economic crisis. This level is stable but significantly lower than the previous years. The production in this sector is highly dependent on the construction business. As this business flourishes in 2004-2005 there is also a great increase in the production of ceramics. After 2009 the demand is considerably lower and the market is oversaturated with goods which brings the production of a collapse in 2009.

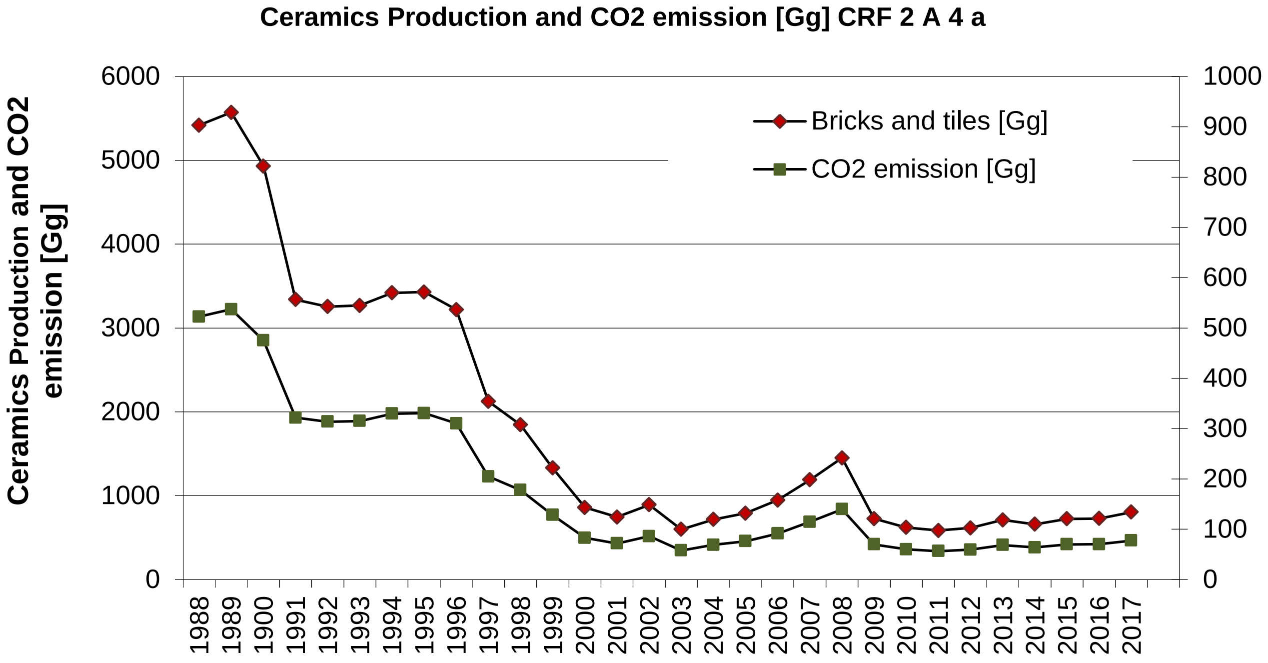

Figure 58 Ceramics Production and CO_2 emission in 2A4a "Other Process Uses of Carbonates"

4.2.4.3 Methodological issues

4.2.4.3.1 Method

The emissions estimation is according to the definitions in the 2006 IPCC Guidelines and default emission factor.
In emissions estimations the general approach described in the 2006 IPCC Guidelines is applied using the following equation:

$$\textbf{TOTAL } CO_2 = (AD \cdot EF)$$

where:
TOTAL CO_2 = the process emission (tonnes) of CO_2
AD = production of ceramics production (tonnes/yr)
EF = the emission factor for CO_2 for ceramics produced.

4.2.4.3.2 CO_2 Emission factor

A default emission factor is used according to:
COMMISSION REGULATION (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council - ANNEX IV Activity-specific monitoring methodologies related to installations (Article 20(2))
12. Manufacture of ceramic products as listed in Annex I to Directive 2003/87/EC - Method B (Output based) Tier 1: A conservative value of 0,123 tonnes of CaO (corresponding to 0,09642 tonnes of CO_2) per tonne of product shall be applied for the calculation of the emission factor instead of the results of analyses.

4.2.4.3.3 Activity data

Statistical data on production are used for the whole time series. Conversion of the production data (from m^3 and units) was performed in order to obtain them in tones.

Issue of double counting:

In order to avoid double counting, the quantity fuel used is reported under Energy Chapter respectively.
Emissions from this category in 2017 are estimated to 77.61 kt and the production is 804.92 kt and the IEF is 0.096 kt/production, respectively data for the base year (1988) are estimated to 522.51 kt and the production is 5419.1 kt and the IEF is 0.096 kt/production.

Table 115 Ceramic production and CO2 emission in CRF 2.A.4.a

Year	Ceramic Production (CP) [kt/y]	Emission Factor [kt CO_2/kt CP]	CO_2 Emissions [kt CO_2]
1988	5419.1	0.096	522.51
1990	4929.8	0.096	475.33
1995	3428.1	0.096	330.53
2000	859.7	0.096	82.89
2005	790.0	0.096	76.17
2010	621.63	0.096	59.94
2015	723.89	0.096	69.80
2016	728.17	0.096	70.21
2017	804.92	0.096	77.61

* Ceramic Production = Bricks and Tiles

4.2.4.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	5.83 %
AD	3%
EF	5%

Uncertainty for AD:

The following is relevant (2006 IPCC GL, p. 2.39)
Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty associated with weighing or proportioning the carbonates for any given industry is 1-3 percent. The uncertainty of the overall chemical analysis pertaining to carbonate content and identity also is 1-3 percent.

Uncertainty for EF:

The following is relevant (2006 IPCC GL, p. 2.39)
Assuming that the activity data are collected correctly, and thus the correct emission factor is applied, there is negligible uncertainty associated with the emission factor. There may be some uncertainty associated with assuming a fractional purity of limestone and dolomite in cases where only carbonate rock data are available (+/- 1-5 percent).

Quantitative uncertainty estimates are provided in Annex 2.

4.2.4.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.
Check with IPPC reports on the activity data used.

4.2.4.6 Source specific recalculations

There is a change of CO_2 emissions values for 2015 and 2016 which is due to technical errors.

4.2.4.7 Source specific planned improvements

No source specific improvements are planned.

4.2.5 OTHER PROCESS USES OF CARBONATES (CRF 2.A.4): SODA ASH USE (CRF 2.A.4.B)

4.2.5.1 Source category description

In this category CO_2 emissions from soda ash use in glass production and non-ferrous metal processing are considered and other industries.

4.2.5.2 Trend description

The use of soda ash depends mainly on production where it is used, as most strongly is influenced by the glass industry (glass production), because there is used about 80-90% of the total quantity use in the country.

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production. Third period with major fluctuations is worldwide economic crisis in 2009-2010.

There was a peak in 2006 which is due to approach to calculate the amounts of soda ash used in the country as = production + export – import, and not on the actual use amounts. This approach is assumed in order to avoid underestimation of emissions, because all enterprises using soda ash in manufacturing processes cannot be covered (approximately 5-6% lower than reported). This peak is due to approximately 100 000 t less quantities exported than previous years, approximately the same amount of output and about 2000 t more imported quantity compared to 2005.

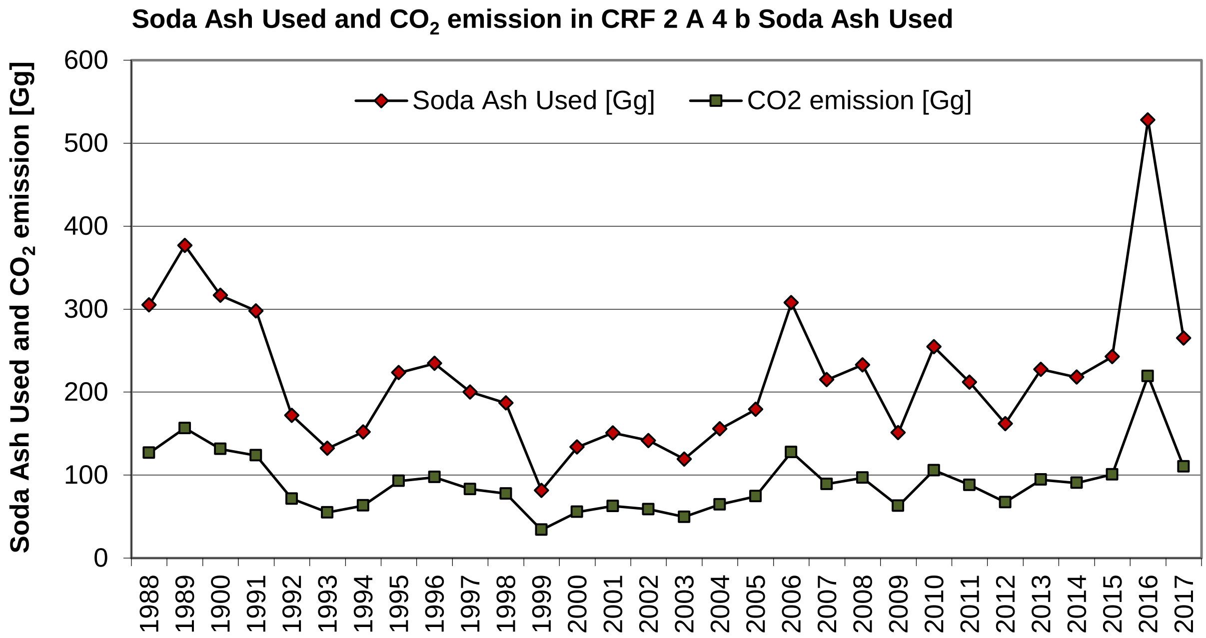

Figure 59 Soda ash used and CO2 emission in CRF 2.A.4.b "Other Process Uses of Carbonates"

4.2.5.3 Methodological issues

For the period 1988 - 2009 a recalculation of the emissions from soda ash use is made. The following is taken into account: Statistics on soda ash production, imports and exports are obtained from NSI. Based on that a balance is made to obtain the quantity of soda ash used. This quantity is further used as AD for the calculations of the emissions from category 2.A.4.b. The EF for these recalculations is estimated stoichiometrically from Na_2CO_3.
In order to avoid double counting emissions from soda ash used in Glass productions are reported only here under 2.A.4.b and are not considered under Glass production (2.A.3).

4.2.5.3.1 Method

Emissions of CO_2 from Soda ash use are estimated using the methodology described in recommendations of the 2006 IPCC Guidelines and a default emission factor from the same guidelines (415.229 kg CO_2/t soda). Plant specific and country specific data were used to estimate CO_2 emissions from Soda ash use.
In emissions estimations the general approach is applied using the following equation:

$$\textbf{TOTAL CO}_2 = \textbf{AD} \bullet \textbf{EF}$$

where:
TOTAL = the process emission (tonnes) of CO_2
AD = soda ash used (tonnes/yr) – it is assumed that the pure substance is 100% (in fact it is in the range of 99.75-99.85%, a slight overestimation of emissions by 0.2%)
EF = the emission factor for CO_2 (EF = 415.229 kg CO_2/t soda)

4.2.5.3.2 CO_2 Emission factor

Default emission factor (stoichiometry) of 415.229 kg CO_2/t soda ash used for the whole time series was used as described in the 2006 IPCC Guidelines

4.2.5.3.3 Activity data

The activity data is calculated based on the material balance for the production, import and export of soda ash in the country, according to the recommendation of the ERT during 2012.

Emissions from this category in 2017 are estimated to 110.01 kt and the soda ash used is 264.95 kt and the IEF is 0.415 kt/production, respectively data for the base year (1988) are estimated to 126.58 kt and the soda ash used is 304.86 kt and the IEF is 0.415 kt/production

Table 116 Soda ash used and CO2 emission in CRF 2.A.4 b

Year	Soda ash used [kt/y]	CO_2 EF [t CO_2/kt soda]	CO_2 Emissions [Gg CO_2]
1988	304.86	415.229	126.58
1990	316.39	415.229	131.37
1995	223.34	415.229	92.74
2000	133.50	415.229	55.43
2005	179.07	415.229	74.35
2010	254.42	415.229	105.64
2015	242.46	415.229	100.68
2016	376.99	415.229	156.54
2017	264.95	415.229	110.01

4.2.5.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	2.24 %
AD	2 %
EF	+/-1 %

Uncertainty for AD:

The two following aspects are relevant (2006 IPCC GL, Chapter 2.5.2)
Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty associated with weighing or proportioning the carbonates for any given industry is 1-3 percent.
The uncertainty of the overall chemical analysis pertaining to carbonate content and identity also is 1-3 percent.
Taking the above into account as well as that for the part of the time series statistical (and not plant specific) data were used an uncertainty of 2 % for activity data is assumed.

Uncertainty for EF:

The following is taken into account:
In theory the uncertainty associated with the emission factor for this source category should be relatively low, as the emission factor is the stoichiometric ratio reflecting the amount of CO_2 released upon calcination of the carbonate. In practice, there are uncertainties due, in part, to variations in the chemical composition of the limestone and other carbonates. For example, in addition to calcium carbonate, limestone may contain smaller amounts of magnesia, silica and sulphur. Assuming that the activity data are collected correctly, and thus the correct emission factor is applied, there is negligible uncertainty associated with the emission factor. There may be some uncertainty associated with assuming a fractional purity of limestone and dolomite in cases where only carbonate rock data are available (+/- 1-5 percent) (2006 IPCC GL, Chapter 2.5.2).
On the basis of the above as well as taking into account that for the part of the time series statistical (and not plant specific) data were used the emission factor uncertainty is assumed as ± 1 % - stoichiometric ratio.
Quantitative uncertainty estimates are provided in Annex 2.

4.2.5.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.
Revised the emission estimation method, by using soda ash mass balance

ISO 9001 and 14 001 standards.
EU ETS reports - emission from soda ash used in glass production (calculated by plants in the reports) and using the mass balance approach are compared.

4.2.5.6 Source specific recalculations

There are no source specific recalculations for this category

4.2.5.7 Source specific planned improvements

No source specific improvements are planned

4.2.6 OTHER PROCESS USES OF CARBONATES (CRF 2.A.4): DESULPHURISATION CRF 2.A.4.D

4.2.6.1 Source category description

Flue gas desulphurization (FGD) is a technology used to remove sulphur dioxide (SO_2) from the exhaust flue gas if fossil fuels power plants. Fossil fuels such as coal, peat and oil contain varying amounts of sulphur. To avoid high emissions of sulphur dioxide to the atmosphere, large combustion plants (in particular plants over 100 MWth) are usually equipped with FGD.

Nowadays there are many different ways of reducing the SO_2 emissions generated by the combustion of fossil fuels. In Bulgaria two following desulphurization techniques are applied:

Use of adsorbents in fluidised bed combustion systems

This is a primary measure to reduce the sulphur oxide emissions. The use of adsorbents in fluidised bed combustion systems are integrated desulphurisation systems. This limits the combustion temperature to about 850°C. The adsorbent utilised is typically CaO, $Ca(OH)_2$ or $CaCO_3$. The reaction needs a surplus of adsorbent with a stoichiometric ratio (fuel/adsorbent) of 1.5 to 7 depending on the fuel. Due to chlorine corrosion effects, the desulphurisation rate is limited by 75%. This technique is mainly utilised in coalfired LCPs and is described in Chapter 4. (LCP BREF, p. 65).

Wet scrubbers

This is a secondary measure to reduce sulphur oxide emissions. Wet scrubbers, especially the limestone-gypsum processes, are the leading FGD technologies. They are used in large utility boilers. This is due to their high SO_2 removal efficiency and their high reliability. Limestone is used in most cases as the sorbent, as it is available in large amounts in many countries and is cheaper to process than other sorbents. By-products are either gypsum or a mixture of calcium sulphate/sulphite, depending on the oxidation mode. (LCP BREF, p. 66 - 67).

Limestone and quicklime are used for desulphurisation in the large combustion plants (LCP) in Bulgaria. CO_2 emissions in this sector are estimated only for these LCP's which use limestone for desulphurisation. Currently there are five LCP in Bulgaria applying desulphurization for the flue gas cleaning with lime stone. Four of them have desulphurization installations applying wet scrubbing process and the fifth one is using fluidized bed combustion system where the desulphurisation is incorporated into the combustion process.

4.2.6.2 Trend description

The first desulphurization installation started its operation in 2002. The next desulphurization installations started operation in 2006 - 2012.
In 2005 there was only one plant with such instillations and during that year its boilers with desulphurization installations had reduced capacity.
There is a reduced demand for electrical energy in 2012 compared to 2011, due to which the emissions are lower despite the fact that one of the installations switched from quick lime to limestone.

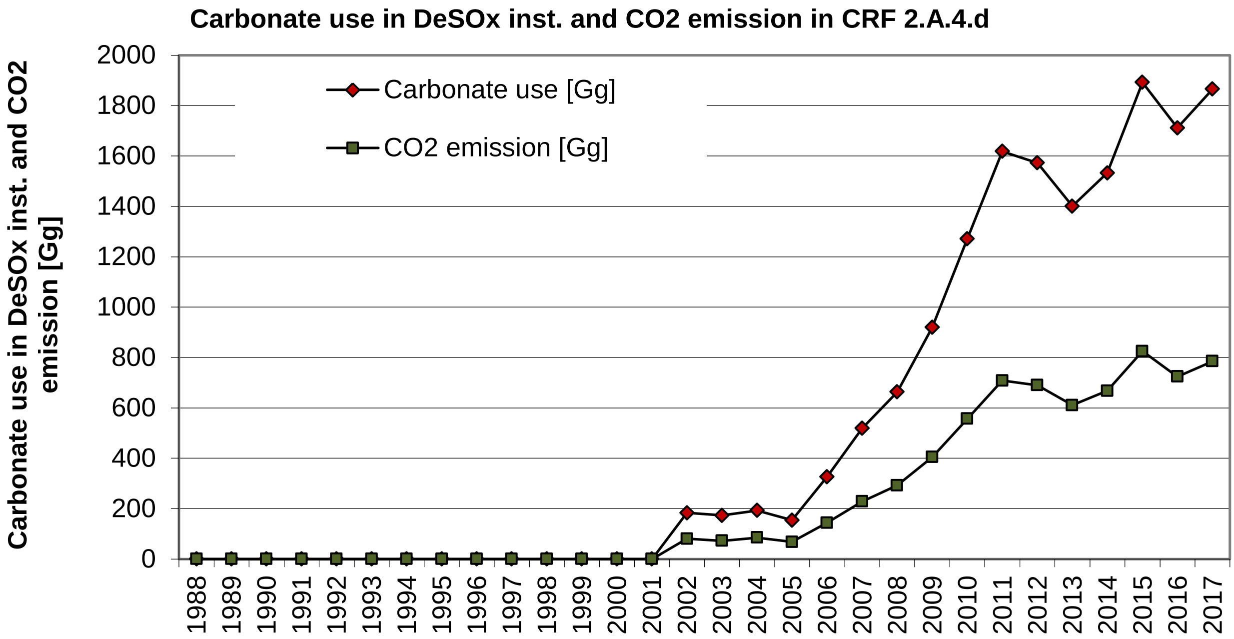

Figure 60 CaCO3, MgCO3 use and CO2 emission in CRF 2.A.4.d "Other Process Uses of Carbonates"

4.2.6.3 Methodological issues

Tier 2 method for the CO_2 emissions estimation is used. The CO_2 emissions estimated using the above equation are taken from the LCP operators the EU ETS reports. The quantities of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) used for the estimations are also taken form the EU ETS reports thus allowing to take into account the pure carbonates used in the process.

4.2.6.3.1 Method

Tier 2 method for the CO_2 emissions estimation is used. Under Tier 2, the amount of CO_2 emitted from the use of limestone and dolomite is estimated from a consideration of consumption and the stoichiometry of the chemical processes.
The equation used to estimate the emissions is as follows:

$$\mathbf{CO_2\ Emissions = (M_{Ca} \cdot EF_{Ca}) + (M_{Mg} \cdot EF_{Mg})}$$

Where:
CO_2 Emissions = emissions of CO_2 from other process uses of carbonates - desulphurisation, tonnes
M_{Ca} or M_{Mg} = mass of Ca Carbonate and Mg Carbonate (consumption), tonnes.
EF_{Ca} or EF_{Mg} = emission factor for Ca Carbonate and Mg Carbonate calcination respectively, tonnes CO_2/tonne carbonate
The CO_2 emissions estimated using the above equation are taken from the operators EU ETS reports.

4.2.6.3.2 CO_2 Emission factor

The emission factor is based on the mass of CO_2 released per mass of carbonate consumed (2006 IPCC GL, p. 2.7).
The EFs used to estimate CO_2 emissions from desulphurization processes are the following:
EF_{CaCO3} = 0.440,
EF_{MgCO3} = 0.522.

4.2.6.3.3 Activity data

Plant specific activity data on the amount of carbonates use are obtained from the EU ETS reports.
Issue of double counting:

The quantity of carbonates used in desulphurization are not considered in CRF 2.A.3 Limestone and dolomite use.
Emissions from this category in 2017 are estimated to 785.25 kt and the carbonate use is 1865.33 kt and the IEF is 0.421 kt/production, respectively data for the base year (1988) are estimated to 0,0 kt and the carbonate use is 0,0 kt.

Table 117 Carbonate use in DeSOx inst.(CaCO3 and MgCO3) use and CO2 emission in CRF 2.A.4.d

Year	Ca Carbonate and Mg Carbonate use [kt/y]	CO_2 EF [kt CO_2/kt Lime]	CO_2 Emissions [Gg CO_2]
1988	0.0	-	0.0
1990	0.0	-	0.0
1995	0.0	-	0.0
2000	0.0	-	0.0
2002	183.58	0.440	80.77
2005	154.26	0.440	67.87
2010	1271.65	0.438	556.68
2015	1892.29	0.436	825.29
2016	1711.54	0.423	724.01
2017	1865.33	0.421	785.25

4.2.6.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	2.12 %
AD	±1.5 %
EF	±1.5 %

Uncertainty for AD:

Activity data uncertainties are greater than the uncertainties associated with emission factors. Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty associated with weighing or proportioning the carbonates for any given industry is 1-3 percent. The uncertainty of the overall chemical analysis pertaining to carbonate content and identity also is 1-3 percent (2006 IPCC GL, p. 2.39).

Uncertainty for EF:

In theory the uncertainty associated with the emission factor for this source category should be relatively low, as the emission factor is the stoichiometric ratio reflecting the amount of CO_2 released upon calcination of the carbonate. In practice, there are uncertainties due, in part, to variations in the chemical composition of the limestone and other carbonates. For example, in addition to calcium carbonate, limestone may contain smaller amounts of magnesia, silica and sulphur. Assuming that the activity data are collected correctly, and thus the correct emission factor is applied, there is negligible uncertainty associated with the emission factor. There may be some uncertainty associated with assuming a fractional purity of limestone and dolomite in cases where only carbonate rock data are available (+/- 1-5 percent) (2006 IPCC GL, p. 2.39).

4.2.6.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.
AD compared with the annual reports under IPPC.

ISO 9001 and 14 001 standards.

EU ETS reports

4.2.6.6 Source specific recalculations

There are no source specific recalculations for this category.

4.2.6.7 Source specific planned improvements

No source specific improvements are planned.

4.3 CHEMICAL INDUSTRY (CRF 2.B)

4.3.1 AMMONIA PRODUCTION (CRF 2.B.1)

4.3.1.1 Source category description

Ammonia is synthesised from nitrogen and hydrogen by the following reaction:

$$N_2 + 3H_2 = 2NH_3.$$

The technological process for Ammonia production in both of the currently operating plants is similar. Ammonia (NH_3) is produced by catalytic steam reforming of natural gas. The feedstock is reformed with steam in a heated primary reformer and subsequently with air in a second reformer in order to produce the synthesis gas.
The reaction taking place during primary reforming is:

$$CH_4 + H_2O = CO + 3H_2$$

$$CO + H_2O \rightarrow CO_2 + H_2$$

The main objective of secondary reforming is to add the nitrogen required for the synthesis and to complete the conversion of the hydrocarbon feed.
The synthesis gas then undergoes processes of heat and CO_2 removal and reaction of methanation due to the fact that small amounts of CO and CO_2, remaining in the synthesis gas, are poisonous for the ammonia synthesis catalyst. The synthesis gas is then compressed in a compressor to the required pressure for Ammonia synthesis.
Currently ammonia is produced in two plants in Bulgaria. Both plants are falling under the IPPC Directive and EU ETS. Until the year of 2002 there were four plants operating.

Urea production

The basic process, developed in 1922, is also called the Bosch–Meiser urea process after its discoverers. The various commercial urea processes are characterized by the conditions under which urea formation takes place and the way in which unconverted reactants are further processed. The process consists of two main equilibrium reactions, with incomplete conversion of the reactants. The first is carbamate formation: the fast exothermic reaction of liquid ammonia with gaseous carbon dioxide (CO2) at high temperature and pressure to form ammonium carbamate (H2N-COONH4):

$$2NH_3 + CO_2 \rightleftharpoons H_2N\text{-}COONH_4$$

The second is urea conversion: the slower endothermic decomposition of ammonium carbamate into urea and water:

$$H_2N\text{-}COONH_4 \rightleftharpoons (NH_2)_2CO + H_2O$$

The overall conversion of NH_3 and CO_2 to urea is exothermic, the reaction heat from the first reaction driving the second. Like all chemical equilibria, these reactions behave according to Le Chatelier's principle, and the conditions that most favour carbamate formation have an unfavourable effect on the urea conversion equilibrium. The process conditions are, therefore, a compromise: the ill-effect on the first reaction of the high temperature (around 190°C) needed for the second is compensated for by conducting the process under high pressure (140–175 bar), which favours the first reaction. Although it is necessary to compress gaseous carbon dioxide to this pressure, the ammonia is available from the ammonia plant in liquid form, which can be pumped into the system much more economically. To allow the slow urea formation reaction time to reach equilibrium a large reaction space is needed, so the synthesis reactor in a large urea plant tends to be a massive pressure vessel

4.3.1.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation, which is the case in 1999/2000 and 2002 when two of the ammonia producing plants stopped working.

The emissions decrease with 28% in 2012 compared to those in 2011 is due to the shrinking market of ammonia and nitric acid. Because of the lowest production demand, one of the operators has performed basic capital repairs concerning the optimization of the ammonia manufacturing process.

Urea production is discontinued after 2003 with termination / suspension of operations of two of the four factories for the production of fertilizers in Bulgaria.

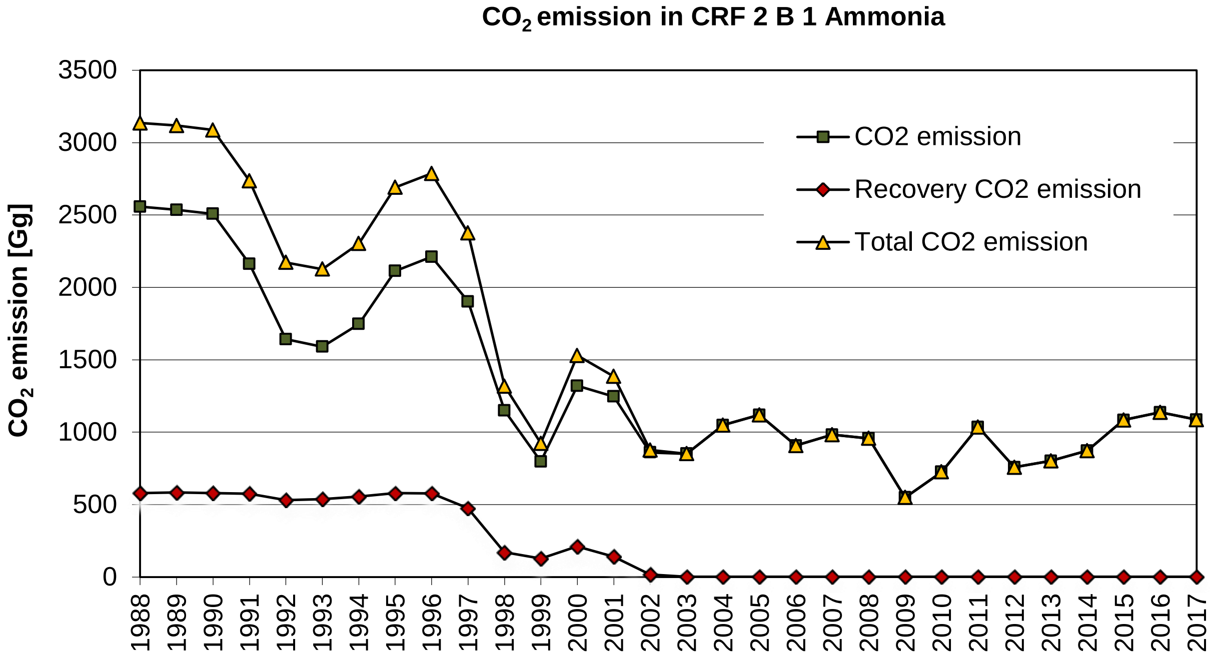

Figure 61 Ammonia Production and CO2 emission in CRF 2 B 1 Ammonia production

4.3.1.3 Methodological issues

4.3.1.3.1 Method

Tier method – Tier 2, is applied using the following equations from the 2006 IPCC Guidelines (Chapter 3: Chemical Industry Emissions, equation 3.2).

TOTAL FUEL REQUIREMENT FOR AMMONIA PRODUCTION – TIER 2

$$TFR_i = \sum_j (AP_{ij} \times FR_{ij})$$

Where:
TFR_i = total fuel requirement for fuel type i, GJ
AP_{ij} = ammonia production using fuel type i in process type j, tonnes
FR_{ij} = fuel requirement per unit of output for fuel type i in process type j, GJ/tonne ammonia produced

CO_2 EMISSIONS FROM AMMONIA PRODUCTION – TIER 2

$$E_{CO_2} = \sum_i \left(TFR_i \times CCF_i \times COF_i \times \frac{44}{12} \right) - R_{CO_2}$$

Where:

E_{CO2} = emissions of CO_2, kg

TFR_i = total fuel requirement for fuel type i, GJ

CCF_i = carbon content factor of the fuel type i, kg C/GJ

COF_i = carbon oxidation factor of the fuel type i, fraction – "1"

R_{CO2} = CO_2 recovered for downstream use (urea production, CO_2)

Data on COF are default (1, fraction) and they are taken from Table 3.1 from the 2006 IPCC Guidelines (Chapter 3, p. 3.15). All other parameter and data are plant specific.

4.3.1.3.2 CO_2 Emission factor

Based on plant specific data of the currently operating plants emission factors for the whole time series are estimated.

An implied emission factor is used to recalculate CO_2 emissions for the rest of the ammonia producing plants.

4.3.1.3.3 Activity data

For the whole time series (where available) plant specific activity data were used. An adjustment with statistical data from NSI has been made for the periods where no activity data for all the ammonia producing plants were available.

The following questionnaire is regularly sent to the plant operator:

Table 118 Questionnaire to plant operator of Ammonia production

1	Ammonia production (100%)	t
2	Amount of natural gas per t Ammonia	$Nm^3/t\ NH_3$
3	Amount of natural gas used	Nm^3
4	Natural gas input (Net caloric value)	GJ
5	Amount of natural on the base of the density of natural gas	t
6	Carbon content	t
7	Carbon content	kg/GJ
8	Carbon stored	t

Issue of double counting:

In order to avoid double counting, the quantity of gas used is subtracted from the quantity reported under energy and non-energy use in the Energy Chapter.

Table 119 Ammonia production and CO2 emission in CRF 2.B.1 Ammonia production

Year	Ammonia Production (NH_3) [kt/y]	Ammonia Production (NH_3) [kt/y]	CO_2 IEF [kt CO_2/kt NH_3]	Total CO_2 Emissions [Gg CO_2]	CO_2 Emissions [Gg CO_2]	Recovery CO_2 Emissions [Gg CO_2]
1988	PS data / NSI	C	C	3135.83	2557.48	578.35
1990	PS data / NSI	C	C	3086.75	2507.86	578.89
1995	PS data / NSI	C	C	2690.85	2113.66	577.19
2000	PS data / NSI	C	C	1530.19	1320.60	209.59
2002	PS data / NSI	C	C	876.68	859.89	16.79
2005	PS data	C	C	1119.75	1119.75	0.00
2010	PS data	C	C	726.12	726.12	0.00
2015	PS data	C	C	1084.78	1084.78	0.00
2016	PS data	C	C	1137.61	1137.61	0.00
2017	PS data	C	C	1086.48	1086.48	0.00

C - Confidential data

Confidentiality issue

In accordance with the 'Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11. As mentioned in § 27 emissions and removals should be reported at the most disaggregated level of each source/sink category, taking into account that a minimum level of aggregation may be required to protect confidential business and military information (FCCC/SBSTA/2006/9).

In CRF 2.B.1 Ammonia production the production data and the EF as well as IEF is marked as confidential "C", because these information could lead to the disclosure of confidential information provided by the plant operator.

4.3.1.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	7.28 %
AD	±2,0 %
EF	7%

Uncertainty for AD:

The two following aspects are relevant (2006 IPCC GL, Chapter 3.2.3)
Where activity data are obtained from plants, uncertainty estimates can be obtained from producers.
These activity data are likely to be highly accurate (i.e., with uncertainty as low as ±2 percent).
Where uncertainty values are not available from other sources, a default value of ±5 percent can be used.
For two plants, which stopped in 1999/2000 and 2002 respectively, statistical data had to be used. Therefore an uncertainty of 3.5 % for activity data is assumed.

Uncertainty for EF:

The uncertainty for the EF is about 7%. This values is derived from European average values for specific energy consumption (Mix of modern and older plants) Average value – natural gas (2006 IPCC GL, Chapter 3, Table 3.1)
Quantitative uncertainty estimates are provided in Annex 2.

4.3.1.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.
Check if the estimated emission factors are within the range of default emission factors provided for the Tier 1 method
Check of CO_2 generation rate
ISO 9001 and 14 001 standards, EMAS.

4.3.1.6 Source specific recalculations

There are no source specific recalculations for this category.

4.3.1.7 Source specific planned improvements

No source specific improvements are planned.

4.3.2 NITRIC ACID PRODUCTION (CRF 2.B.2)

4.3.2.1 Source category description

Currently nitric acid is produced in two plants in Bulgaria. Both plants are falling under the IPPC Directive and ETS. Until 1999/2000 there were three plants operating.
The nitric acid is produced by following general technological steps:
Oxidation of NH_3

NH_3 is reacted with air on a catalyst in the oxidation section. Nitric oxide and water are formed in this process according to the main equation:

$$4\ NH_3 + 5\ O_2 = 4\ NO + 6\ H_2O$$

Nitrous oxide, nitrogen and water are formed simultaneously in accordance with the following equations:

$$4\ NH_3 + 3\ O_2 = 2\ N_2 + 6\ H_2O$$

$$4\ NH_3 + 4\ O_2 = 2\ N_2O + 6\ H_2O$$

The reaction is carried out in the presence of a catalyst.

Oxidation of NO and absorption in H_2O

Nitric oxide is oxidised to nitrogen dioxide as the combustion gases are cooled, according to the equation:

$$2\ NO + O_2 = 2\ NO_2$$

For this purpose, secondary air is added to the gas mixture obtained from the ammonia oxidation. Demineralised water, steam condensate or process condensate is added at the top of the absorption column. The weak acid solution (approximately 43 %) produced in the cooler condenser is also added to the absorption column. The NO_2 in the absorption column is contacted counter currently with flowing H_2O, reacting to give HNO_3 and NO:

$$3\ NO_2 + H_2O = 2\ HNO_3 + NO$$

The oxidation, absorption of the nitrogen dioxide and its reaction to nitric acid and nitric oxide take place simultaneously in the gaseous and liquid phases. Both reactions (oxidation and HNO_3 formation) depend on pressure and temperature and are favoured by higher pressure and lower temperature.

The most common treatment techniques for tail gases from nitric acid plants are:

SCR (Selective Catalytic Reduction, for NOx abatement)

NSCR (Selective Non-Catalytic Reduction, for NOx and N_2O abatement)

One of the currently operating plants conducts both reactions of oxidation and absorption at normal pressure and the other plant – at high pressure. Both of the plants are using NSCR as emissions abatement technology.

4.3.2.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation, which is the case around 1999/2000 with one of the nitric acid producing plants.

There is 44% reduction of the total emission in the sector in 2012 compared to 2011, which is due to production decrease with 28% in November 2011 as well as utilisation of new treatment facilities in one of the plants to reduce the N_2O emissions the following treatment facilities are utilised after 2005.

- Catalytic converter for N_2O reduction since September 2005 – average efficiency 75%
- Since November 2011 catalyst DN_2O(BASF) – 85% efficiency for N_2O

This is connected with the decrease of the Ammonia production which is performed by the same plants.

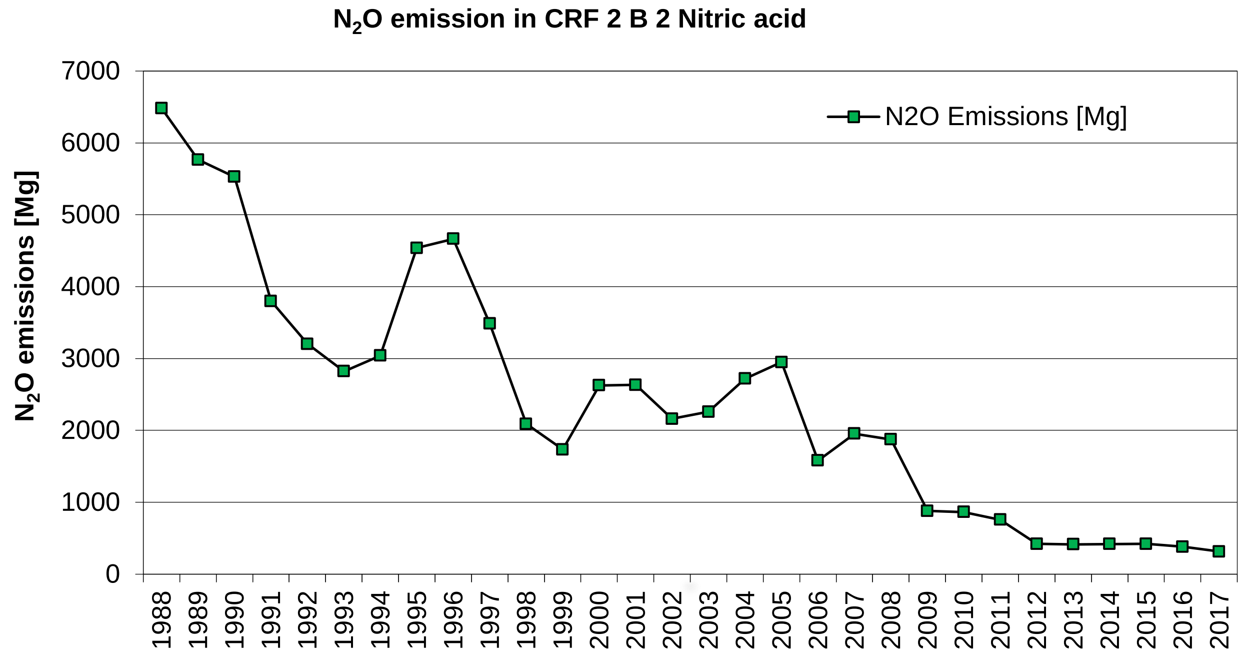

Figure 62 Nitric acid production and N2O emission in CRF 2 B 2 Nitric acid production

4.3.2.3 Methodological issues

4.3.2.3.1 Method

Taking into account the recommendations of the ERT for N_2O emissions from the nitric production, plant specific data are used and a country specific emission factor was developed. Following the Decision tree for N_2O emissions from nitric acid production (IPCC GPG 2000, p. 3.32) plant specific data on N_2O emissions and destruction were obtained. A higher tier method (referred as Tier 3 in 2006 IPCC Guidelines, Chapter 3, p. 3.21) is applied, which means that the N_2O emissions are based on real measurement data.
For completing the time series additional data from NSI were also used. The emissions were recalculated using the following equation:

$$\textbf{Emission } N_2O = IEF * NAP$$

Where:
IEF – Implied emission factor,
NAP – Nitric acid production.

4.3.2.3.2 N_2O Implied Emission factor

For the years 2000 to 2012 a plant specific emission factor was calculated on the basis measured data from plants operators.
For the period 1988 – 2000 the IEF was applied, assuming that technology and abatement types are similar. A default emission factor was applied for the third plant where no information is available and which stopped working in period 1999/2000.

4.3.2.3.3 Activity data

For the 2000 to 2012 emission data from plant operators were available; for the entire time series the production data were available. Following the recommendations of 2006 IPCC GL as a good practice in order to reduce uncertainty all activity data obtained were for 100 % HNO_3.
For the third plant activity data from NSI were used.
The following questionnaire is regularly sent to the plant operator:

Table 120 Questionnaire to plant operator of Ammonia production

1	Nitric acid production (100%)	t
2	N_2O emissions	t/y

Table 121 Nitric acid production and N2O emission

Year	Nitric acid Production (HNO_3) [kt/y]	Nitric acid Production (HNO_3) [kt/y]	Emission Factor [kt N_2O/kt HNO_3]	N_2O Emissions [kt N_2O]
1988	PS data / NSI	C	C	6.48
1990	PS data / NSI	C	C	5.53
1995	PS data / NSI	C	C	4.54
2000	PS data	C	C	2.63
2005	PS data	C	C	2.95
2010	PS data	C	C	0.86
2015	PS data	C	C	0.42
2016	PS data	C	C	0.38
2017	PS data	C	C	0.31

Confidential issue
In accordance with the 'Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11. As mentioned in § 27 emissions and removals should be reported at the most disaggregated level of each source/sink category, taking into account that a minimum level of aggregation may be required to protect confidential business and military information (FCCC/SBSTA/2006/9).
In CRF 2.B.2 Nitric acid production the production data and the EF as well as IEF is marked as confidential "C", because these information could lead to the disclosure of confidential information provided by the plant operator.

4.3.2.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	10.2 %
AD	±2 %
EF	10%

Uncertainty for AD:

The following aspects are relevant
Typical plant-level production data is accurate to ±2% due to the economic value of having accurate information (2000 IPCC GPG, Chapter 3.2).
A properly maintained and calibrated monitoring system can determine emissions within ±5% at the 95% confidence level (2000 IPCC GPG, Chapter 3.2).
Where uncertainty values are not available from other sources, a default value of ±2 percent can be used (2006 IPCC GL, Chapter 3.3.3.2).
Only for one plant, which stopped in 1999 - 2000, statistical data had to be used. Therefore an uncertainty of 3 % for activity data is assumed.

Uncertainty for EF:

The following aspects are relevant
Default EF uncertainty for Plants with NSCRa is ±10% (2000 IPCC GPG, Table 3.8, Chapter 3).
Default EF uncertainties for Plants with NSCRa (all processes) and Atmospheric pressure plants (low pressure) is ±10% (2006 IPCC GL, Chapter 3.3.2.2).
A properly maintained and calibrated monitoring system can determine emissions within ±5% at the 95% confidence level (2000 IPCC GPG, Chapter 3.2).
Only for one plant, which stopped in 1999 - 2000, data on the abatement technology were unavailable. Therefore an EF uncertainty of about 7 % is assumed.

Quantitative uncertainty estimates are provided in Annex 2.

4.3.2.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.

Check with the activity data provided by NSI.

Check of AD with IPPC and E-PRTR reports.

ISO 9001 and 14 001 standards, EMAS.

4.3.2.6 Source specific recalculations

There are no source specific recalculations for this category.

4.3.2.7 Source specific planned improvements

No source specific improvements are planned.

4.3.3 ADIPIC ACID PRODUCTION (2.B.3)

Adipic Acid production does not occur in Bulgaria.

4.3.4 CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID PRODUCTION (2.B.4)

Caprolactam, Glyoxal and Glyoxylic Acid Production production does not occur in Bulgaria.

4.3.5 CARBIDE PRODUCTION AND USE (CRF 2.B.5.B)

4.3.5.1 Source category description

Carbide production

There is one carbide producing plant in Bulgaria. It reports under the EU ETS and has the IPPC permit. The process which is used to produce carbide in it is as follows:

Calcium carbide (CaC_2) is made by reducing calcium oxide CaO with carbon e.g., anthracite coal, in electric arc furnaces. The reaction is:

$$CaO + 3C \rightarrow CaC_2 + CO \; (+ \tfrac{1}{2} O_2 \rightarrow CO_2)$$

The CaO used for carbide production is produced by the same plant from limestone. This limestone usage is included in CRF 2.A.2 Lime production in order to avoid double counting with the quicklime production.

The most important application of calcium carbide is producing acetylene (C_2H_2) by reacting CaC_2 with water. A substantial use of acetylene is welding applications

Production and use of acetylene for welding applications is summarised by reaction:

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2 \; (+ 2.5O_2 \rightarrow 2CO_2 + H_2O)$$

4.3.5.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.

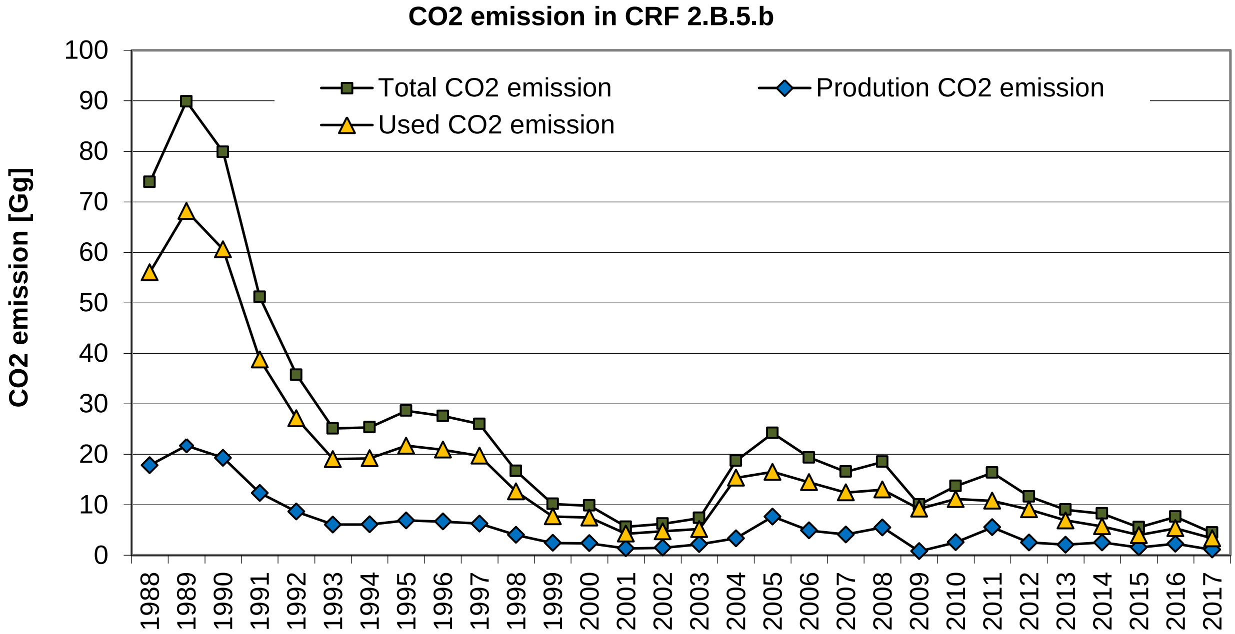

Figure 63 CO2 emission of Carbide production and use in CRF 2.B.5.b

4.3.5.3 Methodological issues

Tier 3 has been applied from the 2006 IPCC Guidelines, Chapter 3, p. 3.42, additional data are required by the factory for the consumed quantities of coal and graphite electrodes. Data for the period 2003-2013 have been provided. The average ratio for that period has been determined and it is applied for the period 1988-2002.

For calcium carbide use is applied approach that the whole amount of calcium carbide is consumed for the acetylene production, which is used for welding / cutting of scrap metal.

To estimate CO_2 emission is used data from National Statistical Institute and producing factory.

4.3.5.3.1 Method

The emissions of calcium carbide production is calculated using the following equation:

$$\mathbf{E_{CO2} = (ADc \cdot EFc + ADe \cdot EFe - ADp \cdot EFp) \cdot 44/12}$$

E_{CO2} - emissions of CO_2, tonnes
ADc - activity data on coal (antratcit) consumption, tonnes
ADe - activity data on graphite electrodes, tonnes
ADp - activity data on calcium carbide, tonnes
EFc - emission factor of carbon content in coals (based on data described in sector Energy - CCF , COF – 100%).
EFe - emission factor of carbon content in graphite electrodes (100%)
EFp- emission factor of carbon content in calcium carbide (based on stoichiometric ratio)

The emissions of calcium carbide use is calculated based on the following equation

$$\mathbf{E_{CO2} = ADp \cdot EFp \cdot 44/12}$$

The recovered carbon from calcium carbide production is reported as 100% used.

4.3.5.3.2 CO_2 Emission factor

For the consumed amount of fuels using the same emission factors as described in Chapter energy. For Graphite electrodes (100% "C" CO_2 / C - 44/12) and calcium carbide ($2CO_2$ / CaC_2 - 1.373 / 2C / Ca - 0,375) have been used the stoichiometric ratios.

4.3.5.3.3 Activity data

Activity data are obtained from producing factory and data from NSI.

Issue of double counting:

The following is considered:
Note that the CaO (lime) might not be produced at the carbide plant. In this case, the emissions from the CaO step should be reported as emissions from lime production and only the emissions from the reduction step and use of the product should reported as emissions from calcium carbide manufacture.
The amount of fuel used is also provided by the NSI in the form of EUROSTAT balance (see sector Energy).

Table 122 CO2 emission of Carbide production and use in CRF 2.B.5.b

Year	Carbide production [kt/y]	CO_2 IEF [kt CO_2/kt CaC_2]	Total CO_2 Emissions [Gg CO_2]	Production CO_2 Emissions [Gg CO_2]	Used CO_2 Emissions [Gg CO_2]
1988	C	C	73.90	73.90	73.90
1990	C	C	79.85	79.85	79.85
1995	C	C	28.64	28.64	28.64
2000	C	C	9.85	9.85	9.85
2005	C	C	24.20	24.20	24.20
2010	C	C	13.70	13.70	13.70
2015	C	C	5.54	5.54	5.54
2016	C	C	7.63	7.63	7.63
2017	C	C	4.46	4.46	4.46

Confidential issue
In accordance with the 'Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11. As mentioned in § 27 emissions and removals should be reported at the most disaggregated level of each source/sink category, taking into account that a minimum level of aggregation may be required to protect confidential business and military information (FCCC/SBSTA/2006/9).
In CRF 2.B.5.b Carbide production the production data and the EF as well as IEF is marked as confidential "C", because these information could lead to the disclosure of confidential information provided by the plant operator.

4.3.5.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	11.18 %
AD	±5 %
EF	±10 %

Uncertainty for AD:

The two following aspects are relevant (2006 IPCC GL, p. 3.45)
Where activity data are obtained directly from plants, uncertainty estimates can be obtained from producers. This will include uncertainty estimates for petroleum coke and limestone used and for carbide production data. Data that are obtained from national statistical agencies or from industrial and trade organizations usually do not include uncertainty estimates. It is good practice to consult with national statistical agencies to obtain information on any sampling errors. Where national statistic agencies collect carbide production data from production facilities, uncertainties in national statistics are not expected to differ from uncertainties estimated from plant-level consultations. Where uncertainty values are not available from other sources, a default value of ±5 percent can be used.

Uncertainty for EF:

The following is taken into account:
In general, the default CO_2 emission factors are relatively uncertain because industrial-scale carbide production processes differ from the stoichiometry of theoretical chemical reactions. The uncertainty in the emission factors for CH_4 is due to the possible variations in the hydrogen-containing volatile compounds in the raw material (petroleum coke) that are used by different manufacturers and due to the possible variations in production process parameters. Where uncertainty values are not available from other sources, a default value of ±10 percent can be used.
It is good practice to obtain uncertainty estimates at the plant level which should be lower than uncertainties associated with default values. (2006 IPCC GL, p. 3.45)

4.3.5.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.

AD compared with the annual reports under IPPC.

ISO 9001 and 14 001 standards

EU ETS reports

4.3.5.6 Source specific recalculations

There are no source specific recalculations for this category.

4.3.5.7 Source specific planned improvements

No source specific improvements are planned.

4.3.6 TITANIUM DIOXIDE PRODUCTION (CRF 2.B.6)

There are no production of Titanium Dioxide In Bulgaria.

4.3.7 SODA ASH PRODUCTION (CRF 2.B.7)

4.3.7.1 Source category description

There is one soda ash producing plant in Bulgaria. It applies Solvay process which is CO_2-neutral except for coke used for calcination of limestone. This coke used in soda ash production was considered as fuel in the energy sector (subcategory 1.A.2.C).
The concomitant production of quicklime is performed in vertical (shaft) kilns, as the captured flying ash from high-performing filters is fully utilized in the production of soda ash, together with the quantities produced quicklime.

Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production.
Highest drop in 2009 is due to global economic crisis, this trend is observed also in all sectors of the economy in the country.

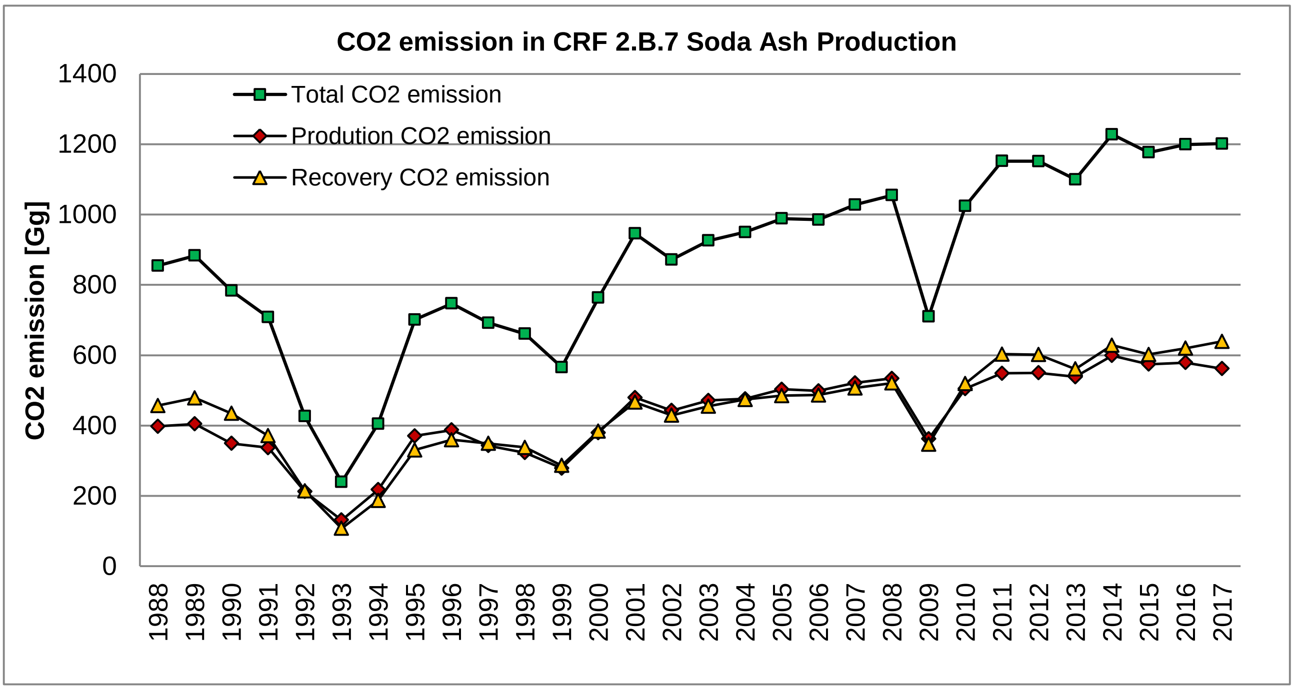

Figure 64 Soda ash production and CO2 emission in CRF 2.B.7

4.3.7.2 Methodological issues

4.3.7.2.1 Method

Emissions of CO_2 from Soda ash production are estimated using the methodology described in the 2006 IPCC Guidelines. Plant specific and country specific data were used to estimate CO_2 emissions from Soda ash production.
Tier 2 method is applied and data for amount of fuel used and quicklime production was required by the operator. The following equation is used:

$$\mathbf{E_{CO2} = E_{CO2}\ (used\ coal) + E_{CO2}\ (production\ quick\ lime) - Recovery\ E_{CO2}}$$

E_{CO2} (used coal) - Emissions from fuel used are calculated in the manner described in chapter Energy.
E_{CO2} (production quick lime) - Emissions from lime production are calculated using the formula described in Lime production – sector 2.A.2. (without the usage of LKD – 1,02)
Recovery E_{CO2} - Recovery CO_2 emissions are calculated using the formula specified in Sector 2.A.4.b Soda ash use.

4.3.7.2.2 CO_2 Emission factor

Data for the calorific value of fuels and the relevant emission factors, attached in the verified (EU ETS) reports on emissions trading, are used.

EF for the lime production is provided by the enterprise and stoichiometric ratios.

The LKD correction coefficient is not applied as according to the 2006 IPCC Guidelines, p.2.24 – „Vertical shaft kilns generate relatively small amounts of LKD, and it is judged that a correction factor for LKD from vertical shaft kilns would be negligible and do not need to be estimated".

The other reason LKD correction coefficient not to be used is that the captured dust is accounted together with the quicklime and is utilized in the process of soda ash production.

For recovery emissions see sector 2.A.4.b Soda ash use.

4.3.7.2.3 Activity data

Activity data is provided by producing factory and data from NSI.

Issue of double counting:

To avoid double counting of emissions amount of used fuel is removed from the data provided by the NSI in the form Eurostat balance (see the Energy Sector). Also from sector 2.A.2 Lime production, is subtracted the amount of lime produced by the enterprise due to data for sector 2.A.2 provided by the NSI, including data and factory producing soda ash.

Table 123 Soda ash production and CO2 emission in CRF 2.B.7

Year	Soda ash production [kt/y]	CO_2 IEF [t CO_2/kt soda]	Total CO_2 Emissions [Gg CO_2]	Production CO_2 Emissions [Gg CO_2]	Recovery CO2 Emissions [Gg CO2]
1988	C	C	854.42	397.64	456.78
1990	C	C	783.55	349.14	434.41
1995	C	C	701.22	370.68	330.54
2000	C	C	763.55	379.54	384.01
2005	C	C	988.47	503.30	485.17
2010	C	C	1024.44	504.88	519.55
2015	C	C	1176.72	574.38	602.35
2016	C	C	1199.04	579.24	619.79
2017	C	C	1201.30	561.80	639.49

4.3.7.3 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	2.83 %
AD	2 %
EF	+/-2 %

Uncertainty for AD:

The two following aspects are relevant (2006 IPCC GL, Chapter 2.5.2)
Assuming that carbonate consumption is allocated to the appropriate consuming sectors/industries, the uncertainty associated with weighing or proportioning the carbonates for any given industry is 1-3 percent.
The uncertainty of the overall chemical analysis pertaining to carbonate content and identity also is 1-3 percent.
Taking the above into account as well as that for the part of the time series statistical (and not plant specific) data were used an uncertainty of 2 % for activity data is assumed.

Uncertainty for EF:

The following is taken into account:
In theory the uncertainty associated with the emission factor for this source category should be relatively low, as the emission factor is the stoichiometric ratio reflecting the amount of CO_2 released upon calcination of the carbonate. In practice, there are uncertainties due, in part, to variations in the chemical composition of the limestone and other carbonates. For example, in addition to calcium carbonate, limestone may contain smaller amounts of magnesia, silica and sulphur. Assuming that the activity data are collected correctly, and thus the correct emission factor is applied, there is negligible uncertainty associated with the emission factor. There may be some uncertainty associated with assuming a fractional purity of limestone and dolomite in cases where only carbonate rock data are available (+/- 1-5 percent) (2006 IPCC GL, Chapter 2.5.2).
On the basis of the above as well as taking into account that for the part of the time series statistical (and not plant specific) data were used the emission factor uncertainty is assumed as ± 1 % - stoichiometric ratio.
Quantitative uncertainty estimates are provided in Annex 2.

4.3.7.4 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.
Revised the emission estimation method, by using soda ash mass balance
ISO 9001 and 14 001 standards
EU ETS reports - emission from soda ash used in soda ash production (calculated by plants in the reports) and using the mass balance approach are compared.

4.3.7.5 Source specific recalculations

There are no source specific recalculations for this category.

4.3.7.6 Source specific planned improvements

No source specific improvements are planned.

4.3.8 PETROCHEMICAL AND CARBON BLACK PRODUCTION (CRF 2.B.8)

4.3.8.1 Source category description

Methanol (2.B.8.a)

Methanol production does not occur in Bulgaria.

Ethylene (2.B.8.b)

In Bulgaria the production of ethylene had been done in petrochemical plant, where the production stopped in 2009 and has not been reopened.

The technological process of production of ethylene is based on the steam cracking of naphtha.

Ethylene production is a non-key category.

Ethylene Dichloride (2.B.8.c)

A plant for production of ethylene dichloride was opened in 1988 and stopped in 2005, after which the plant is in liquidation.

The technological process of production of ethylene dichloride is based on the direct chlorination process, that involves gas-phase reaction of ethylene with chlorine to produce ethylene dichloride.

Direct chlorination - $\mathbf{C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2}$

Ethylene Dichloride production is a non-key category.

Ethylene Oxide (2.B.8.d)

Production of ethylene oxide does not occur in Bulgaria.

Acrylonitrile (2.B.8.e)

Production of acrylonitrile does not occur in Bulgaria.

Carbon Black (2.B.8.f)

Production of carbon black does not occur in Bulgaria.

4.3.8.2 Trend description

Ethylene (2.B.8.b)
In the period 1990-1995 the country passes through economic and political crisis. After 1996 the privatization of enterprises started and some of them modernize and continue to work while others cease their activities.

After 2009 the production of ethylene was discontinued due to lack of market (the production of ethylene dichloride from the other plant also ceased) and the need for introduction of new treatment facilities that meet the new environmental requirements (emission standards) - lower emissions of harmful substances.

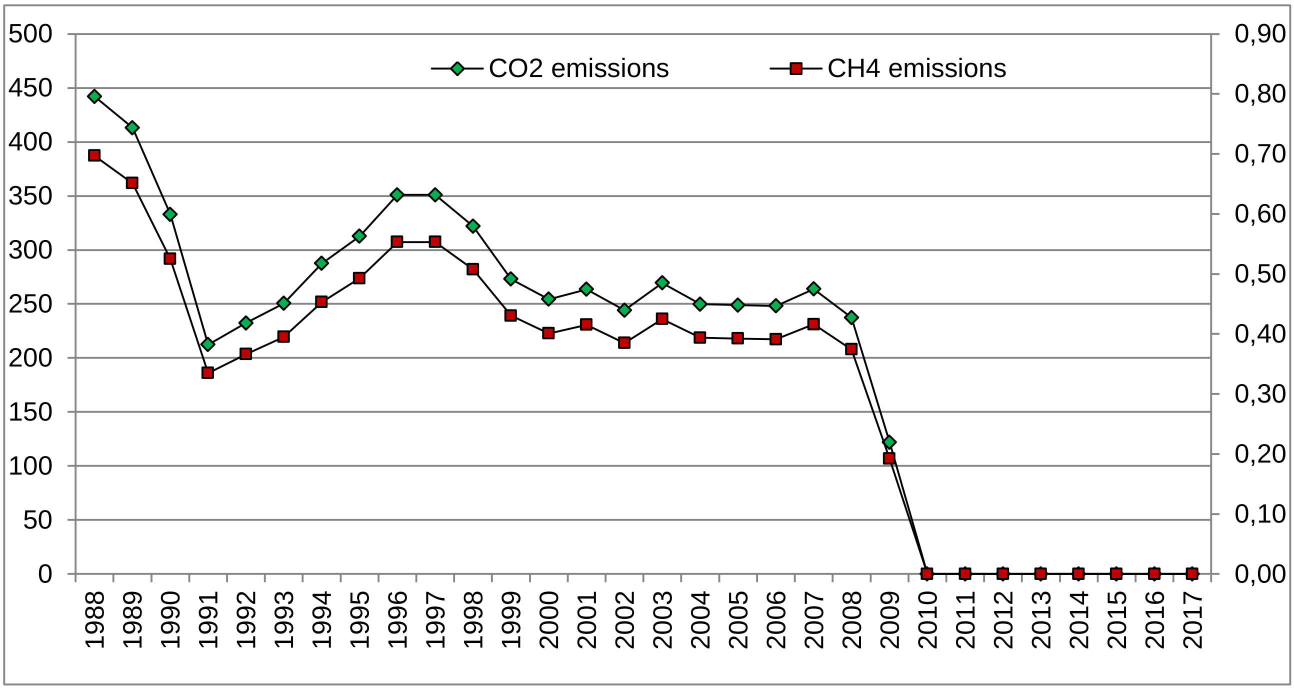

Figure 65 CO2 and CH4 emissions in CRF 2.B.2.b Ethylene production

Ethylene Dichloride (2.B.8.c)

In the period 1990-1995 the country passes through economic and political crisis. After 1996 the privatization of enterprises started and some of them modernize and continue to work while others cease their activities.

After the privatization of the plant around 1999-2000 the production of ethylene dichloride sharply decreases until its final termination in 2005. Since then it has not been restored.

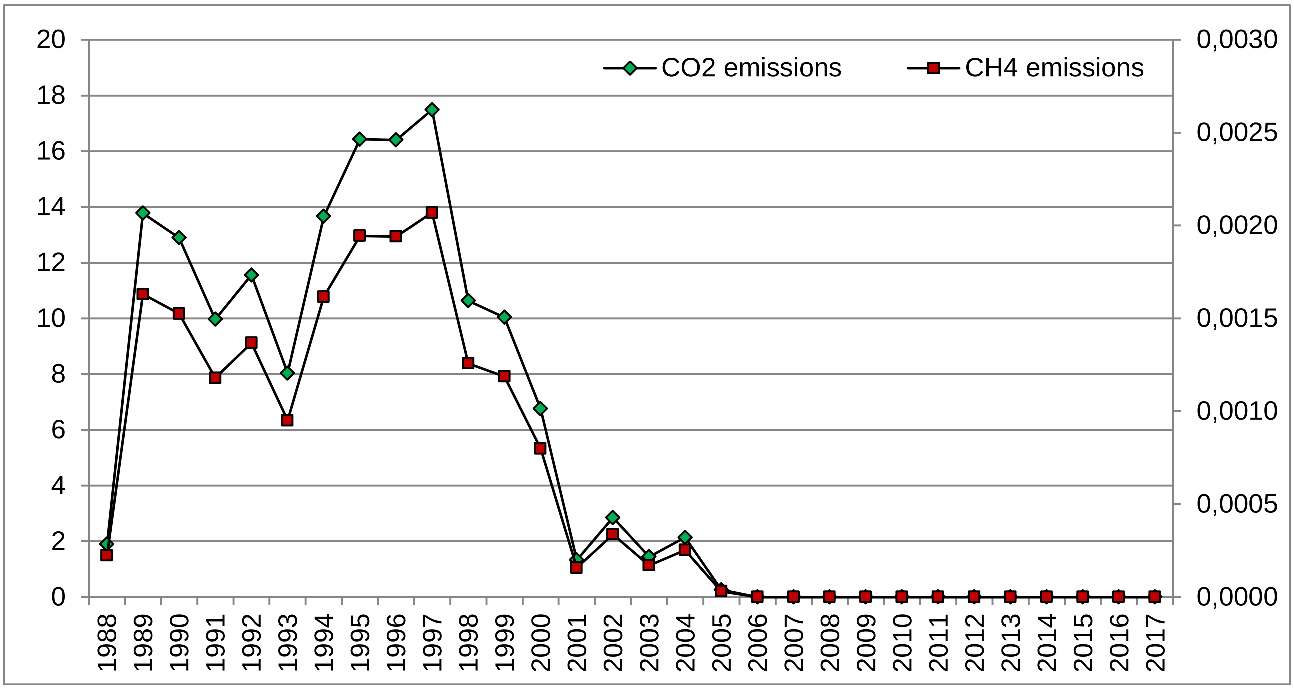

Figure 66 CO2 emissions in CRF 2.B.2.c Ethylene Dichloride production

4.3.8.3 Methodological issues

The Tier 1 method based on default values and national statistics is used.
The ethylene and ethylene dichloride production is taken from NSI. This quantity is used as AD for the calculations of the emissions from categories 2.B.2.b and 2.B.2.c.

4.3.8.4 Method

Ethylene (2.B.8.b)
Emissions of CO_2 and CH_4 from ethylene production is estimated using the methodology described in the 2006 IPCC Guidelines and default emission factor from the same guidelines (table 3.14, p. 3.75 and table 3.16, p. 3.76) with default geographic adjustment factor for Tier 1 CO_2 emission factor for steam cracking ethylene production (table 3.15, p. 3.75 - Eastern Europe).
In emissions estimations the general approach described in the 2006 IPCC Guidelines is applied using the following equation:

$$\textbf{TOTAL } \mathbf{CO_2/CH_4} = \sum(\mathbf{AD \bullet EF \bullet DGAF})$$

where:
TOTAL CO_2 / CH_4= the process emission (tonnes) of CO_2/ CH_4
AD = production of ethylene (tonnes/yr)
EF = the emission factor for CO_2 and CH_4 for ethylene produced.
DGAF = default geographic adjustment factor for Eastern Europe

Ethylene Dichloride (2.B.8.c)
Emissions of CO_2 from ethylene dichloride production is estimated using the methodology described in the 2006 IPCC Guidelines and default emission factor from the same guidelines (table 3.17, p. 3.77).
In emissions estimations the general approach described in the 2006 IPCC Guidelines is applied using the following equation:

$$\textbf{TOTAL } \mathbf{CO_2/CH_4} = \sum(\mathbf{AD \bullet EF})$$

where:
TOTAL CO_2 = the process emission (tonnes) of CO_2
AD = production of ethylene dichloride (tonnes/yr)
EF = the emission factor for CO_2 for ethylene dichloride produced.

4.3.8.4.1 CO_2 and CH_4 Emission factor

Ethylene (2.B.8.b)
The EF for these calculations is taken as default (table 3.14, p. 3.75, table 3.15, p. 3.75 table 3.16, p. 3.76).
Default emission of 1.73 t CO_2/t Ethylene and 3 kg CH_4/t Ethylene applied for the whole time series was used as described in the 2006 IPCC Guidelines. Correction default geographic adjustment factor for Tier 1 CO_2 emission factor for steam cracking ethylene production – 110%
Ethylene Dichloride (2.B.8.c)
The EF for these calculations is taken as default (table 3.17, p. 3.77).
Default emission (Direct Chlorination Process - Total CO_2 Emission Factor) of 0.191 t CO_2/t Ethylene dichloride used for the whole time series was used as described in the 2006 IPCC Guidelines.

4.3.8.4.2 Activity data

Activity data for ethylene and ethylene dichloride are confidential and obtained from NSI for the whole time series.

Ethylene (2.B.8.b)

The quantity of emissions from this activity for the base year (1988) is 442.12 kt CO_2 and 0,70 kt CH_4 (summary 459.5 CO_2 eq) and for the last year of plant exploitation (2009) 121,9 kt CO_2 and 0,20 kt CH_4 (summary 126,9 CO_2 eq.).

Ethylene Dichloride (2.B.8.c)

The quantity of emissions from this activity for the base year (1988) is 1.9 kt CO_2 and 0,0002 kt CH_4 (summary 1.9 CO_2 eq.) and for the last year of plant exploitation (2005) 0.26 kt CO_2 and 0,000003 kt CH_4 (summary 0.26 CO_2 eq.).

4.3.8.5 Uncertainties and time series consistency

Ethylene (2.B.8.b)

	CO_2	CH_4
Combined uncertainty	30.4 %	11.2 %
AD	± 5 %	± 5 %
EF	± 30 %	± 10 %

Ethylene Dichloride (2.B.8.c)

	CO_2
Combined uncertainty	20.6 %
AD	± 5 %
EF	± 20 %

4.3.8.6 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.

4.3.8.7 Source specific recalculations

There are no source specific recalculations for this category.

4.3.8.8 Source specific planned improvements

There are no source-specific planned improvements.

4.3.9 FLUOROCHEMICAL PRODUCTION (2.B.9)

Fluorochemical production does not occur in Bulgaria.

4.4 METAL INDUSTRY (CRF 2.C)

4.4.1 IRON AND STEEL PRODUCTION (CRF 2.C.1.A)

4.4.1.1 Source category description

According to the information given in Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001, p. 16, four routes are currently used for the production of steel: the classic blast furnace/basic-oxygen furnace route, direct melting of scrap (electric arc furnace), smelting reduction and direct reduction. At present (1998), EU (15) steel production is based

on the blast furnace/ basic-oxygen route (approximately 65%) and the electric arc furnace (EAF) route (approximately 35%).[26]
The following steel making processes are present in Bulgaria:

Open hearth furnace (**until** ***1993)***

A type of furnaces where excess carbon and other impurities are burnt out of pig iron to produce steel. Since steel is difficult to manufacture due its high melting point, normal fuels and furnaces are insufficient and the open hearth furnace overcomes this difficulty. Compared to Bessemer steel, which it displaced, its main advantages are that it doesn't expose the steel to excessive nitrogen (which would cause the steel to become brittle), is easier to control, and it permits the melting and refining of large amounts of scrap iron and steel.

The process is far slower than that of Bessemer converter and thus easier to control and take samples for quality control. As the process is slow, it is not necessary to burn all the carbon away as in Bessemer process, but the process can be terminated at given point when desired carbon contents has been achieved.

Basic oxygen steelmaking (**until November** ***2008)***

The objective in oxygen steelmaking is to burn (i.e., oxidise) the undesirable impurities contained in the metallic feedstock. The main elements thus converted into oxides are carbon, silicon, manganese, phosphorus, and sulphur. The purpose of this oxidation process, therefore, is:
to reduce the carbon content to a specified level (from approximately 4% to less than 1%, but often lower)
to adjust the contents of desirable foreign elements
to remove undesirable impurities to the greatest possible extent
The production of steel by the basic oxygen furnace (BOF) process is a discontinuous process which involves the following steps:

- transfer and storage of hot metal
- pre-treatment of hot metal (desulphurisation)
- oxidation in the BOF (decarburisation and oxidation of impurities)
- secondary metallurgical treatment
- casting (continuous or/and ingot)

Electric steelmaking

The direct smelting of iron-containing materials, such as scrap is usually performed in electric arc furnaces (EAF). The major feed stock for the EAF is ferrous scrap, which may comprise of scrap from inside the steelworks (e.g. offcuts), cut-offs from steel product manufacturers (e.g. vehicle builders) and capital or post-consumer scrap (e.g. end of life products).
With respect to the end-products distinction has to be made between production of ordinary, so called carbon steel as well as low alloyed steel and high alloyed steels/stainless steels. In the EU about 85% of steel production is carbon or low alloyed steel [EC Study, 1996].For the production of carbon steel and low alloyed steels, following main operations are performed:

- raw material handling and storage
- furnace charging with/without scrap preheating
- EAF scrap melting
- steel and slag tapping
- ladle furnace treatments for quality adjustment
- slag handling
- continuous casting

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[26] (ftp://ftp.jrc.es/pub/eippcb/doc/isp_bref_1201.pdf)

For high alloyed and special steels, the operation sequence is more complex and tailor-made for the end-products. In addition to the mentioned operations for carbon steels various ladle treatments (secondary metallurgy) are carried out like

desulphurisation

degassing for the elimination of dissolved gases like nitrogen and hydrogen

decarburisation (AOD=Argon-Oxygen-Decarburisation or VOD=Vacuum-Oxygen-Decarburi-sation)

The steel making plant which produced sinter, pig iron and steel (BOF) ceased operation in November 2008.

Currently in Bulgaria steel is produced only in EAF.

4.4.1.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.

There is general reduction of the total emission in the sector in 2009 compared to 2008. This is mainly due to the world economic crisis in 2009 which lead to a reduction of the production processes rates. The total reduction in the sector production is about 45%.

Another factor leading to this reduction is that the biggest plant from this sector (which share in the steel production before 2008 was more than 50%) ceased operation of its pig iron and the following steel making in BOF in November 2008.

Fluctuations in emissions and production of steel is determined by the largest currently producer in the country and depends on the market for products made from it (the share of other producers is under 5%).

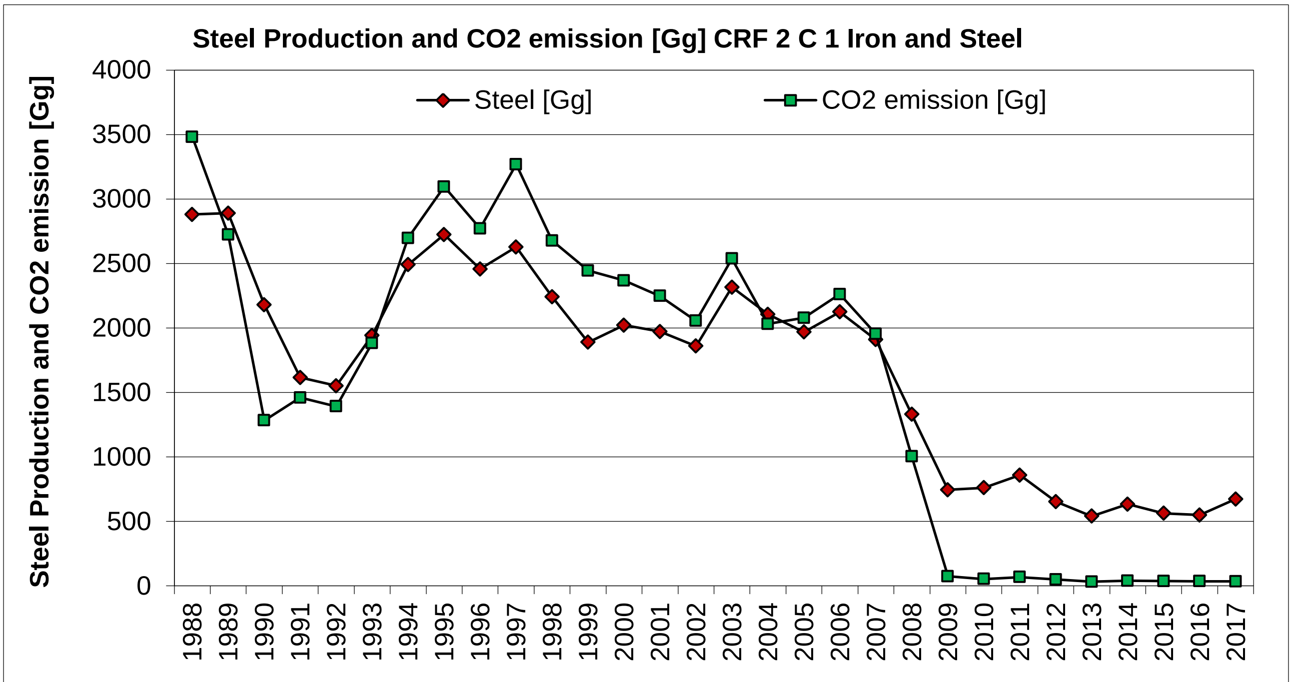

Figure 67 Iron and Steel Production and CO2 emission in CRF 2.C.1.a Iron and Steel production

4.4.1.3 Methodological issues

4.4.1.3.1 Method

Open hearth furnace

To estimate the CO_2 emissions for this category Tier 1 method is used because the production of steel with this method terminated in 1993 and no information is available to apply a higher Tier method

Basic oxygen steelmaking

To estimate the CO_2 emissions for this category a Tier 2 balance approach is used – carbon contents in the raw materials and the final product. The emissions include the entire production process for this type of steel – including the intermediate pig iron production in the BOF. This method for emissions estimation is implemented during the 2012 ESD review in cooperation with the ESD review experts.

Electric steelmaking

The CO_2 emissions from the sector are calculated using country specific data from the EU ETS reports. Data for 2012 from Bulgarian association of metallurgical industry (BAMI, http://www.bcm-bg.com/) as well as data from World Steel Association (WSA, http://worldsteel.org) are used for crosscheck.
Total emissions are the sum of Equation:

$$\textbf{Iron \& Steel: } ECO_2\textbf{, non-energy} = BOF \cdot EF_{BOF} + EAF \cdot EF_{EAF} + OHF \cdot EF_{OHF}$$

4.4.1.3.2 Emission factor

Open hearth furnace – default emission factor is used – 1.72 t CO_2/t Steel (TABLE 4.1)
TIER 1 DEFAULT CO_2 EMISSION FACTORS FOR COKE PRODUCTION AND IRON & STEEL PRODUCTION - 2006 IPCC GL, Chapter 4.2.2.3, p. 4.25)

Basic oxygen steelmaking

A production specific EF is calculated based on the amount of carbon in the raw materials and the final products. The EF varies for the period 1989 – 2009.

Electric steelmaking

Country specific emission factor was developed for the EAF steel based on data from EU ETS reports for the period 2007 - 2016. In the calculation of ETS emissions the operators performed a mass balance of the Carbon content in the raw materials used and the produced end product. Thus CO_2 emissions are estimated by an approach similar to the following equation (IPCC GPG 2000, p. 3.25):

EQUATION 3.6B

Emissions crude steel = (Mass of Carbon in the Crude Iron used for Crude Steel Production – Mass of Carbon in the Crude Steel) • 44/12 + Emission FactorEAF • Mass of Steel produced in EAF

4.4.1.3.3 Activity data

Country specific data from the EU ETS reports as well as from BAMI and WSA on total crude steel production were received.
Issue of double accounting:
In order to avoid double counting, the quantity the fuel used is subtracted from the quantity reported under energy and non-energy use in the Energy Chapter.

Table 124 Iron and Steel production and CO2 emission

Year	Steel Production	Steel Production [kt/y]	Emission Factor [kt CO_2/kt Steel]	CO_2 Emissions [kt CO_2]
1988	BAMI / WSA	2880.00	1.209	3481.44
1990	BAMI / WSA	2180.00	0.589	1283.24
1995	BAMI / WSA	2724.00	1.136	3095.68
2000	BAMI / WSA	2022.00	1.171	2368.01
2005	BAMI / WSA / ETS	1969.00	1.055	2078.16
2010	BAMI / WSA / ETS	761.41	0.070	53.47
2013	BAMI / WSA / ETS	541.23	0.060	32.65
2015	BAMI / WSA / ETS	563.76	0.066	37.22
2016	BAMI / WSA / ETS	549.04	0.065	35.86
2017	BAMI / WSA / ETS	673.47	0.052	35.17

As can be seen in Table 124 the emission factor for 2008 is lower than the ones for the previous years. This is mainly due to the fact that in 2008 the biggest steel making plant (which is also the only one producing steel in BOF) significantly decreased and subsequently stopped BOF steel production. This leads to a decrease in the production as well as in the CO_2 emissions.
For the period 2009-2012, there is no BOF steel production in Bulgaria since the abovementioned steelmaking company stopped its BOF furnaces from operation in November 2008.
Currently the steel in Bulgaria is produced only in EAF hence the IEF takes into account only this type of steel making. In 2008 the IEF includes also BOF steel. Due to the described facts the IEF in 2009-2012 decreases significantly.

4.4.1.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	7.07 %
AD	5 %
EF	5%

Uncertainty for AD:

The two following aspects are relevant
According to IPCC GPG 2000 (Chapter 3, p 3.28):

For both Tier 1 and 2 the most important type of activity data is the amount of reducing agent used for iron production. According to Chapter 2, Energy, energy data have a typical uncertainty of about 5% (about 10% for countries with less developed energy statistics). For calculating the carbon storage term Tier 2 requires additional activity data on amounts of pig iron and net crude steel production that have a typical uncertainty of a few percent. In addition, Tier 2 requires information on the carbon content of pig iron, crude steel, and of iron ore that may have an uncertainty of 5% when plant-specific data are available. Otherwise the uncertainty in the carbon content could be of the order of 25 to 50%. Finally, the uncertainty in the emission factors for the reducing agent (e.g. coke) are generally within 5% (see Section 2.1.1.6, CO_2 Emissions from Stationary Combustion, Uncertainty Assessment).
Taking into account that plant specific data from EU ETS reports were used to estimate emissions an uncertainty of 5% is considered.

Uncertainty for EF:

According to Table 4.4 (2006 IPCC GL, Chapter 4.2.3) applying Tier 2 material-specific carbon contents would be expected to have an uncertainty of 10 percent. This uncertainty is considered due to using EU ETS data.
Quantitative uncertainty estimates are provided in Annex 2.

4.4.1.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Section 1.6.
CO_2 emissions were taken from ETS reports.

Aggregated national steel production data provided by BAMI and reported by World Steel Association are used for crosscheck.

4.4.1.6 Source specific recalculations

There are recalculations of CO_2 emissions for 2013 and 2016 which are due to the submitted annual emissions report (after the deadline for 2013) by one of the ETS operator and missed report for 2016 of the same ETS operator.

4.4.1.7 Source specific planned improvements

No source specific improvements are planned.

4.4.2 PIG IRON PRODUCTION (CRF 2.C.1.B)

4.4.2.1 Source category description

There is one pig iron production plant in Bulgaria. Currently it has ceased operation (since November 2008).

4.4.2.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.
In particular in pig iron production case the only plant ceased operation in November 2008 (see also "Iron and steel production" chapter).

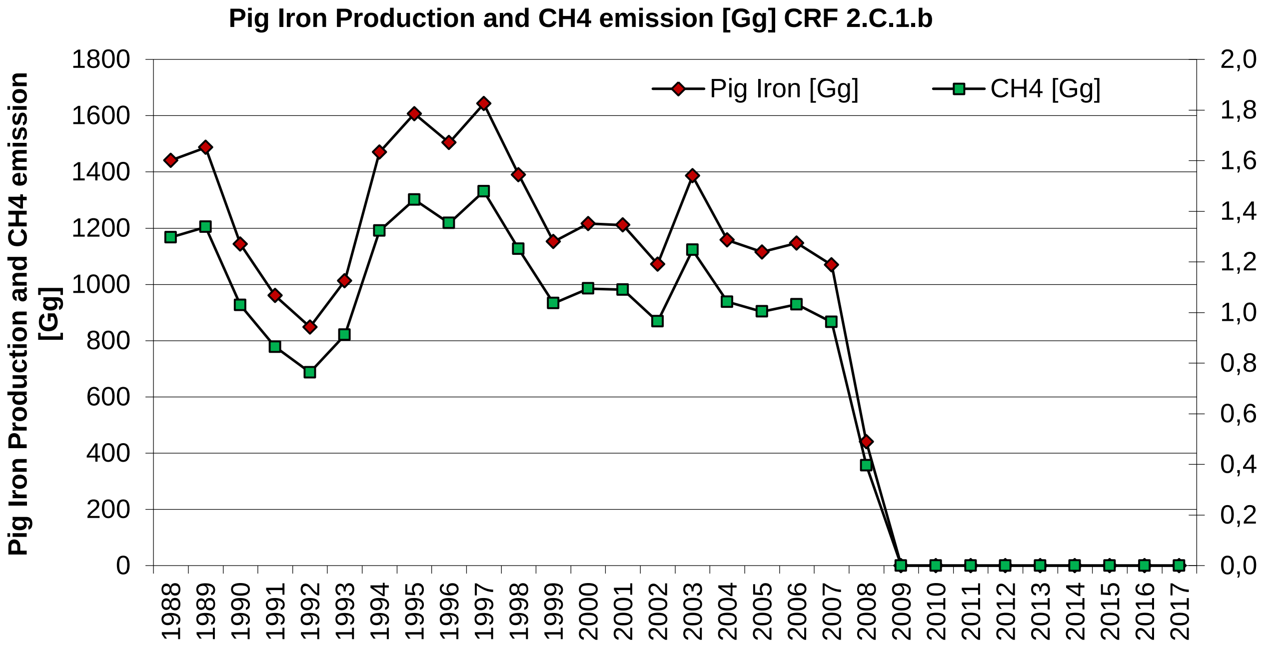

Figure 68 Pig iron Production and CH4 emission in CRF 2.C.1.b Pig iron production

4.4.2.3 Methodological issues

4.4.2.3.1 Method

Tier 1 methodology for CH_4 based on emission factors and national production statistics is applied (2006 IPCC GL, p. 4.24).The emissions from the sector are calculated using country specific data on the total amount of pig iron produced taken from WSA Yearbooks. Default emission factor is applied. The emissions are estimated using the following equation (2006 IPCC GL, p. 4.24, equation 4.13).

EQUATION 4.13

CH_4 EMISSIONS FROM BLAST FURNACE PRODUCTION OF PIG IRON (TIER 1)

$$E_{CH4,non-energy} = PI \cdot EF_{PI}$$

Where
E_{CH4},non−energy – non-energy CH_4 emissions from pig iron production
PI – pig iron production (kt)
EF_{PI} – emission factor for pig iron

4.4.2.3.2 Emission factor

The following is taken into account: "The conversion factors provided in Table 4.1 of the IPPC I&S BAT Document are 940 kg pig iron per tonne liquid steel" (2006 IPCC GL, p. 4.25, BAT Reference Document on the Production of Iron and Steel, December 2001).
Thus an emission factor of 0.9 [kg CH_4/ton production] is obtained.

4.4.2.3.3 Activity data

Country specific data on the total pig iron production are taken from WSA.
The following is also taken into account (2006 IPCC Guidelines, p. 4.28):
"The Tier 1 method requires only the amount of steel produced in the country by process type, the total amount of pig iron produced that is not processed into steel, and the total amount of coke, direct reduced iron, pellets, and sinter produced; in this case the total amount of coke produced is assume to be produced in integrated coke production facilities. These data may be available from governmental agencies responsible for manufacturing statistics, business or industry trade associations, or individual iron and steel companies."
Issue of double counting:
In order to avoid double counting, the CO_2 emissions from pig iron production are reported under BOF steel production (see *Basic oxygen steelmaking*).

Table 125 Pig iron production and CH4 emission

Year	Pig Iron Production [kt/y]	Emission Factor [t CH_4/ kt production]	CH_4 Emissions [kt CH_4]
1988	1441.00	0.900	1.30
1990	1143.00	0.900	1.03
1995	1607.00	0.900	1.45
2000	1216.00	0.900	1.09
2005	1115.00	0.900	1.00
2008	440.00	0.900	0.40
2010	0.00	0.900	0.00
2015	0.00	0.900	0.00
2016	0.00	0.900	0.00
2017	0.00	0.900	0.00

4.4.2.4 Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 and 1997/1998 all data and time series shall be regarded as consistent.

Combined uncertainty	26.9 %
AD	± 10 %
EF	± 25%

Uncertainty for AD:
For Tier 1 the most important type of activity data is the amount of steel produced using each method. National statistics should be available and likely have an uncertainty of ± 10 percent. (2006 IPCC GL, p. 4.30, see also Table 4.4).

Uncertainty for EF:
The default emission factors for coke production and iron and steel production used in Tier 1 may have an uncertainty of ± 25 percent. (2006 IPCC GL, p. 4.30, see also Table 4.4).
Quantitative uncertainty estimates are provided in Annex 6.

4.4.2.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.
Aggregated national pig iron production data and default emission factor are used.
Comparison with NSI and BAMI data on pig iron production.

4.4.2.6 Source specific recalculations

There are no source specific recalculations for this category.

4.4.2.7 Source specific planned improvements

The only pig iron production plant has ceased operation.
No source specific improvements are planned.

4.4.3 DIRECT REDUCED IRON (CRF 2.C.1.C)

There is not direct reduced iron production In Bulgaria..

4.4.4 SINTER (CRF 2.C.1.D)

This is a process of preparation of the ore for its utilization in blast furnaces to produce pig iron. Process represents conversion of fine grain and dust materials (ores and concentrates) into big particles by sintering. The agglomeration takes place in a temperature range bounded by the range of softening and connecting of the separate particles directly or with the aid of easily melting substances that cement the particles. The heat necessary for the functioning of the agglomeration is obtained by fuel (coke) which was added to the batch.
Quantities of fuels used for this process are included in the calculation of emissions from the production of convection steel (BOF).

4.4.5 PELLET (CRF 2.C.1.E)

There is not Pellet production In Bulgaria.

4.4.6 FERROALLOYS PRODUCTION (CRF 2.C.2)

4.4.6.1 Source category description

Ferroalloys production is a non-key category.
Ferroalloys production involves a metallurgical reduction process that results in CO_2 emissions.
This is only a minor source of CO_2 and CH_4 emissions in Bulgaria: in 2015, emissions account for the 0.002% of total emissions from Industrial Processes sector.
There is one ferroalloys producer in Bulgaria. Recovered CO_2 emissions in ferroalloys production are not included.

4.4.6.2 Trend description

The periods around 1989/1991 and 1997/1999 represent the economic crisis time after which stabilization and increase in the production rates begins. After 1996 a process of privatization begins which leads to decrease in the plants' production. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation.
There is a significant decrease of the total emission in the sector aftern 2008. This is due to the fact that a steel making plant which produced sinter, pig iron and steel ceased operation in November 2008.

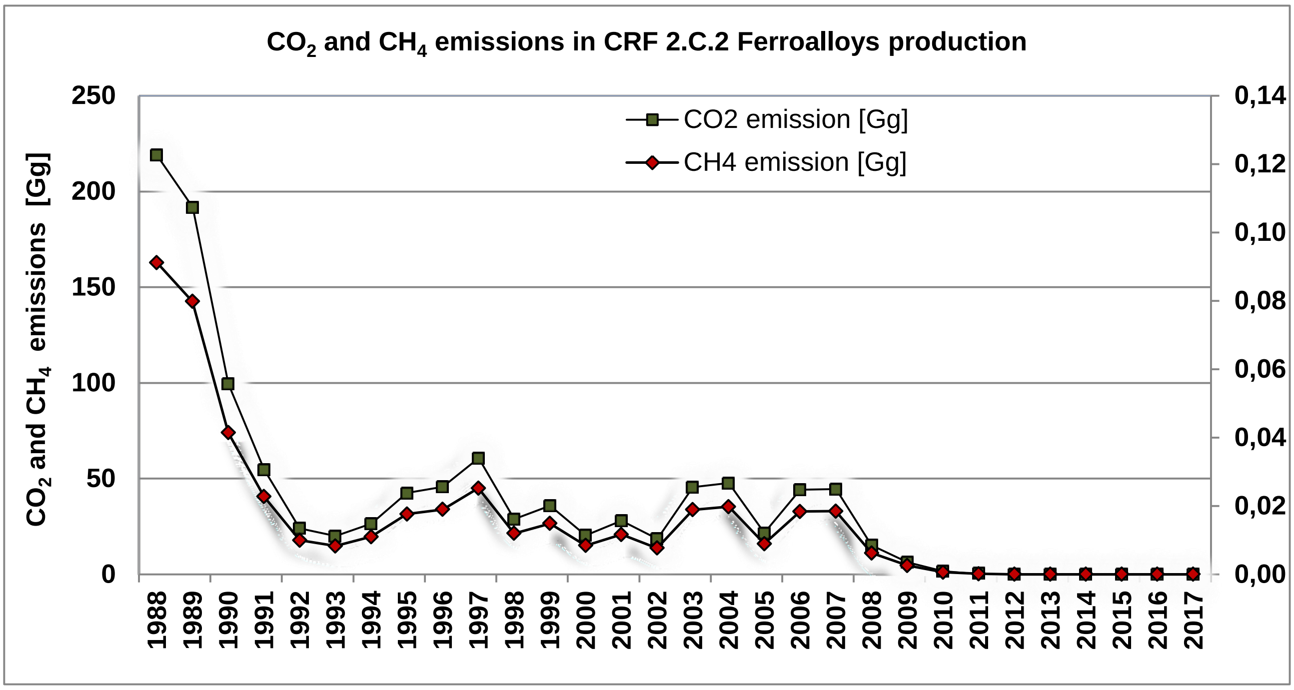

Figure 69 CO2 and CH4 emission in CRF 2.C.2 Ferroalloys production

4.4.6.2.1 Methodological issues

The Tier 1 method based on default values and national statistics is used.
The ferroalloys production is taken from NSI. This quantity is used as AD for the calculations of the emissions from category 2.C.2.

4.4.6.2.2 Method

Emissions of CO_2 and CH_4 from ferroalloys production is estimated using the methodology described in the 2006 IPCC Guidelines and an average default emission factor from the same guidelines (table 4.5, p. 4.37 and table 4.7, p. 4.39).
In emissions estimations the general approach described in the 2006 IPCC Guidelines is applied using the following equation:

$$\text{TOTAL } CO_2/CH_4 = \sum(AD_i \bullet EF_i)$$

where:
TOTAL CO_2 / CH_4= the process emission (tonnes) of CO_2/ CH_4
AD_i = production of ferroalloy type „I" (tonnes/yr)
EF_i = the emission factor for CO_2 and CH_4 for ferroalloys produced.

4.4.6.2.3 CO_2 and CH4 Emission factor

The EF for these calculations is taken as default (table 4.5, p. 4.37 and table 4.7, p. 4.39).
Average EFs are used for CO_2 emissions and they are presented in the table below by the types of available products and an average EF for CH_4 - 1kg /t.

Table 126 CO2 emission factors used for different types of products

Ferroalloy types	IEF [kg CO_2/t. product]
Ferroalloys	2.82
Ferromanganese - natura	1.40
Ferrosilicone - natura	3.73
Ferrosilicone - 45% Si (natura)	2.50
Ferromanganese, with <2% carbon by weight	1.50
Other Ferroalloys - natura	2.57

4.4.6.2.4 Activity data

Country-specific activity data on the amount of ferroalloys produced and use are obtained from NSI for the whole time period.

Table 127 Ferroalloys production, CO2 and CH4 emission in CRF 2.C.2

Year	Ferroalloys production [kt/y]	CH_4 Emissions [kt CH_4]	CO_2 Emissions [kt CO_2]
1988	C	0.09118	254.94
1990	C	0.04145	129.37
1995	C	0.01766	55.82
2000	C	0.00845	21.88
2005	C	0.00897	20.10
2010	C	0.00065	2.35
2015	C	0.00001	0.04
2016	C	0.00002	0.04
2017	C	0.00001	0.02

In CRF 2.C.2 Ferroalloys production the production data, because these information could lead to the disclosure of confidential information provided by the plant operator.

4.4.6.3 Uncertainties and time series consistency

Combined uncertainty	25.5 %
AD	± 5 %
EF	± 25 %

4.4.6.4 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.

4.4.6.5 Source specific recalculations

There are no source specific recalculations for this category.

4.4.6.6 Source specific planned improvements

There are no source-specific planned improvements.

4.4.7 ALUMINIUM PRODUCTION (CRF 2.C.3)

In Bulgaria primary production of aluminum does not occur. There is secondary production and emissions generated by the quantities of used in the process fuels are reported in sector Energy.

4.4.8 MAGNESIUM PRODUCTION (CRF 2.C.4)

In Bulgaria magnesium production does not occur.

4.4.9 LEAD PRODUCTION (CRF 2.C.5)

4.4.9.1 Source category description

Now there is only one plant for primary lead production in Bulgaria. The production is based on application of modern technology of autogenic melting of lead raw materials to black lead with following scarfing refining.
Until 2011 in Bulgaria there has been two enterprises for primary lead production (from ore). After 2011 one of these enterprises ceases its activity as it is impossible to face the modern requirements in the environmental legislation.

The CO_2 emissions are calculated based on data from reports (EU ETS) of verified emissions of the firms, as well as data from the annual environmental reports.

4.4.9.2 Trend description

As it is in other productions in the country, here are also observed periods of economic crisis, privatization processes and ceased productions as a consequence of the necessity of large investments for meeting the ecological requirements and not in the last place the influence of the world market.

At the end of 2015, a new plant for the production of lead with a higher efficiency was introduced and by 2016 the production in the old plant was reduced to its full stop.

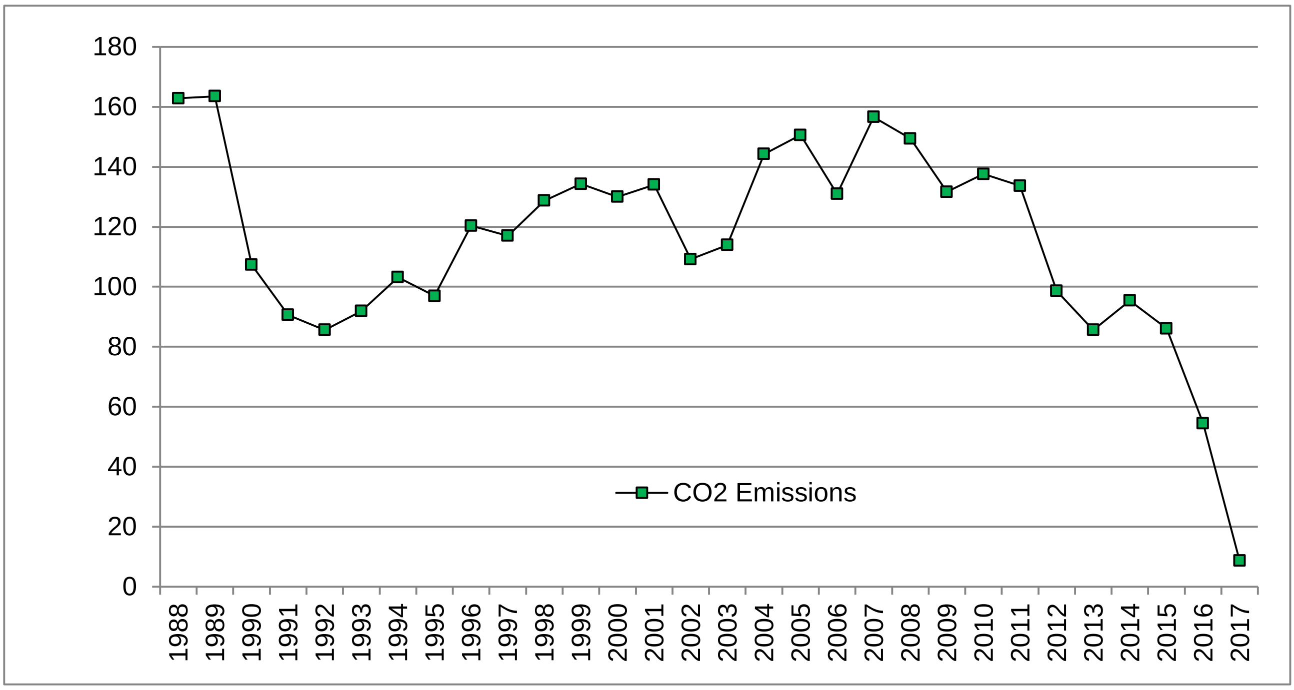

Figure 70 CO2 emissions in CRF 2.C.5 Lead production

4.4.9.3 Methodological issues

The applied data are from the used quantities of solid fuels in the process of lead production from ore (for the period 2005-2015) and also the slag forming materials (mineral flour and other) from verifies reports and annual environmental reports.
The used methodology is analogical to this described in the IPCC Guidelines 2006. For the period 1988-2004 average coefficients are applied for the used quantities of fuels and other materials, based on those averaged for the period 2005-2015 and assigned to the manufactured quantities primary lead.
Data from NSI are also used for the manufactured quantities lead in the country for the whole time period.

4.4.9.3.1 Method

The method is based on the used quantities of solid fuels (reducing agents) in the process of primary lead production in the separate technological processes, the relevant calorific values and the EF for each fuel, as well as the quantities of the used slag forming materials and the relevant analyses of the carbon content in them.

4.4.9.3.2 CO_2 Emission factor

The used emission factors are those described in the verified reports of emissions trading, as some of them are plant-specific, while others are default factors. The applied factors depend on the approved algorithm of the firms throughout the different reporting periods.

4.4.9.3.3 Activity data

For the period 2005-2015 the used data are for the manufactured quantities of primary lead from reports of the firms.
The manufactured quantities of lead for the whole time-series is obtained by NSI and are indicated as confidential.
The quantities of primary manufactured lead for the period 1988-2004 are calculated, based on the calculated average coefficient (2005-2015) from data, obtained by NSI and the enterprises.
The quantities of emissions from this activity for 2017 are evaluated to: 8.61 kt CO_2 and for the base year (1988) 162,82 kt CO_2.

4.4.9.4 Uncertainties and time series consistency

Combined uncertainty	15.8 %
AD	± 5 %
EF	± 15 %

4.4.9.5 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.

4.4.9.6 Source specific recalculations

The emissions from this category are described for the first time in the category "Industrial processes". Till now the emissions have been accounted under sector "Energy".
There are no source specific recalculations for this category.

4.4.9.7 Source specific planned improvements

There are no source-specific planned improvements.

4.4.10 ZINC PRODUCTION (CRF 2.C.6)

4.4.10.1 Source category description

Now in Bulgaria there is only one plant for primary zinc production. The production is based on the application of different metallurgical processes, such as roasting, electrolysis and others.
Until 2011 in Bulgaria there has been two enterprises for primary zinc production (from ore). After 2011 one of these enterprises ceases its activity as it is impossible to face the modern requirements in the environmental legislation.
The CO_2 emissions are calculated based on data from reports of verified EU ETS emissions of the plants, as well as data from the annual environmental reports.

4.4.10.2 Trend description

As it is in other productions in the country, here are also observed periods of economic crisis, privatization processes and ceased productions as a consequence of the necessity of large investments for meeting the ecological requirements and not in the last place the influence of the world market.

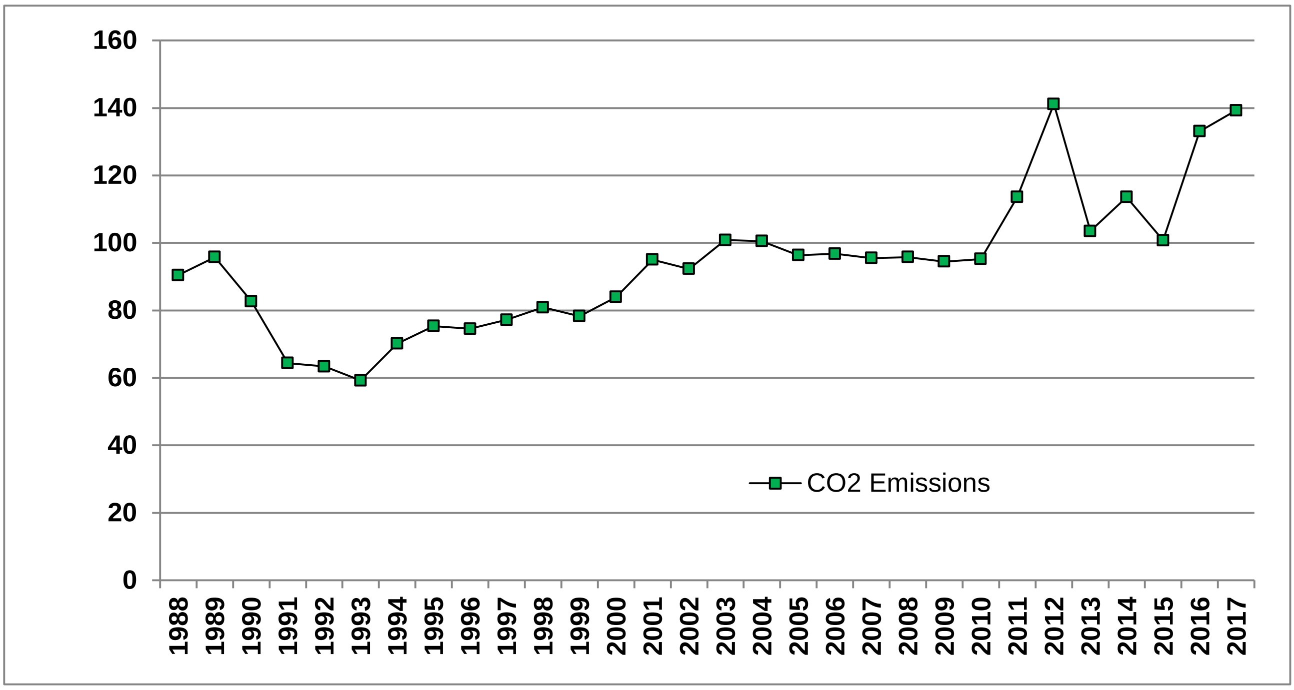

Figure 71 CO2 emissions in CRF 2.C.Zinc production

4.4.10.3 Methodological issues

The applied data are from the used quantities of solid fuels in the process of zinc production from ore (for the period 2005-2015) and also the slag forming materials (mineral flour and other) from verifies EU ETS reports and annual environmental reports.
The used methodology is analogical to this described in the IPCC Guidelines 2006. For the period 1988-2004 average coefficients are applied for the used quantities of fuels and other materials, based on those averaged for the period 2005-2015 and assigned to the manufactured quantities primary zinc.
Data from NSI are also used for the manufactured quantities zinc in the country for the whole time period.

4.4.10.3.1 Method

The method is based on the used quantities of solid fuels (reducing agents) in the process of primary zinc production in the separate technological processes, the relevant calorific values and the EF for each fuel, as well as the quantities of the used slag forming materials and the relevant analyses of the carbon content in them.

4.4.10.3.2 CO_2 Emission factor

The used emission factors are those described in the verified EU ETS reports, as some of them are plant-specific, while others are default factors. The applied factors depend on the approved algorithm of the firms throughout the different reporting periods.

4.4.10.3.3 Activity data

For the period 2005-2015 the used data are for the manufactured quantities of primary zinc from reports of the firms.
The manufactured quantities of zinc for the whole time-series is obtained by NSI and are indicated as confidential.
The quantities of primary manufactured zinc for the period 1988-2004 are calculated, based on the calculated average coefficient (2005-2015) from data, obtained by NSI and the enterprises.
The quantities of emissions from this activity for 2017 are evaluated to : 139.28 kt CO_2 and for the base year (1988) 90.47 kt CO_2.

4.4.10.4 Uncertainties and time series consistency

Combined uncertainty	15.8 %
AD	± 5 %
EF	± 15 %

1.1.1.1 Source specific QA/QC and verification

The quality objectives and the QA/QC plan are presented in Chapter 1.6.

4.4.10.5 Source specific recalculations

The emissions from this category are described for the first time in the category "Industrial processes". Till now the emissions have been accounted under sector "Energy".
There are no source specific recalculations for this category.

4.4.10.6 Source specific planned improvements

There are no source-specific planned improvements.

4.5 NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE (CRF 2.D)

SOURCE CATEGORY DESCRIPTION

Source category 2D Non-energy products from fuels and solvent use comprises process emissions from lubricant and paraffin wax use, NMVOC emissions from coating applications, degreasing, dry cleaning as well as production and processing of chemical products, precursor emissions from road paving with asphalt and asphalt roofing as well as emissions from urea use in SCR catalysts of diesel engines (heavy motor vehicles).

4.5.1 LUBRICANT USE (CRF 2.D.1)

4.5.1.1 Source category description

Lubricants are mostly used in industrial and transportation applications. They can be subdivided into motor oils, industrial oils and greases, which differ in terms of physical characteristics, commercial applications and environmental fate.

4.5.1.2 Trend description

The trend of CO_2 emissions is presented in the following figure.

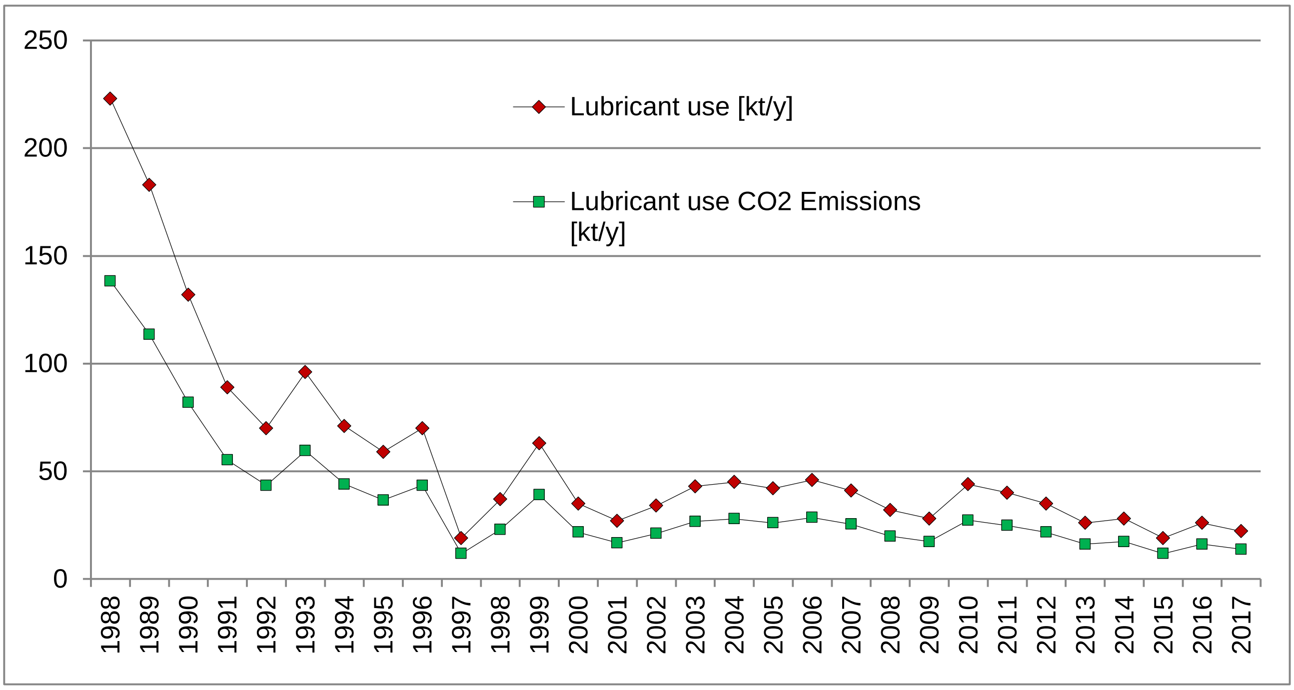

Figure 72 Lubricant use and CO2 emissions in CRF 2.D.1

4.5.1.3 Methodological issues.

4.5.1.3.1 Methods

The use of lubricants in engines is primarily for their lubricating properties and associated CO_2 emissions are therefore considered as non-combustion emissions reported in 2D1 Lubricant use.
For the calculation of CO_2 emissions from oxidation of lubricants a Tier 1 approach according to the 2006 IPCC Guidelines, vol. 3, chap. 5.2 (IPCC 2006) is applied based on the following formulas:

$$\mathbf{CO_2,Emissions = AD \cdot EFlubricant,\ CO_2}$$

$$\mathbf{EFlubricant,\ CO_2 = NCVlubricant \cdot CClubricant \cdot ODUlubricant \cdot 44/12}$$

Where AD is the activity data, NCV the net calorific value, CC the carbon content and ODU the fraction of lubricants oxidized during use.

4.5.1.3.2 Emission Factors

The emission factor is composed of a specific carbon content factor (tonne C/TJ) multiplied by the ODU factor.
A further multiplication by 44/12 (the mass ratio of CO_2/C) yields the emission factor (expressed as tonne CO_2/TJ). For lubricants the default carbon contents factor is 20.0 kg C/GJ on a Lower Heating Value basis. Tier 1: Having only total consumption data for all lubricants (i.e., no separate data for oil and grease), the weighted average ODU factor for lubricants as a whole is used as default value in the Tier 1 method. Assuming that 90 percent of the mass of lubricants is oil and 10 percent is grease, applying these weights to the ODU factors for oils and greases yields an overall (rounded) ODU factor of 0.2. This ODU factor can then be applied to an overall carbon content factor, which may be country-specific or the default value for lubricants to determine national emission levels from this source when activity data on the consumption of lubricants is known.

4.5.1.4 Activity Data

Data obtained by the NSI and the Eurostat Balances are used.

Table 128 Lubricant use and CO2 emissions in CRF 2.D.1.

CRF 2.D.1 - Lubricant use		
Year	**Lubricant use [kt/y]**	**CO2 Emissions [kt]**
1988	223.0	138.35
1990	132.0	81.89
1995	59.0	36.60
2000	35.0	21.71
2005	42.0	26.06
2010	44.0	27.30
2015	19.0	11.79
2016	26.0	16.13
2017	22.20	13.77

4.5.1.5 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in the following table.

Table 129 Uncertainty of subcategory 2D1 - Lubricant use, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2	No	CO_2	10	30	31.62

4.5.1.6 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Plausibility checks of the results (due to the national statistic and national VOC register);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);
- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.5.1.7 Source specific recalculation

The recalculations are based on all the quantities of lubricants, obtained by the NSI. Before that only the quantities from road transportation, obtained through the COPERT model, were used.

4.5.1.8 Source specific planned improvements

No source specific improvements are planned.

4.5.2 PARAFFIN WAX USE (CRF 2.D.2)

4.5.2.1 Source category description

The category, as defined here, includes such products as petroleum jelly, paraffin waxes and other waxes, including ozokerite (mixtures of saturated hydrocarbons, solid at ambient temperature). Paraffin waxes are separated from crude oil during the production of light (distillate) lubricating oils. Paraffin waxes are categorized by oil content and the amount of refinement.

4.5.2.2 Trend description

The trend of CO_2 emissions is presented in the following figure.

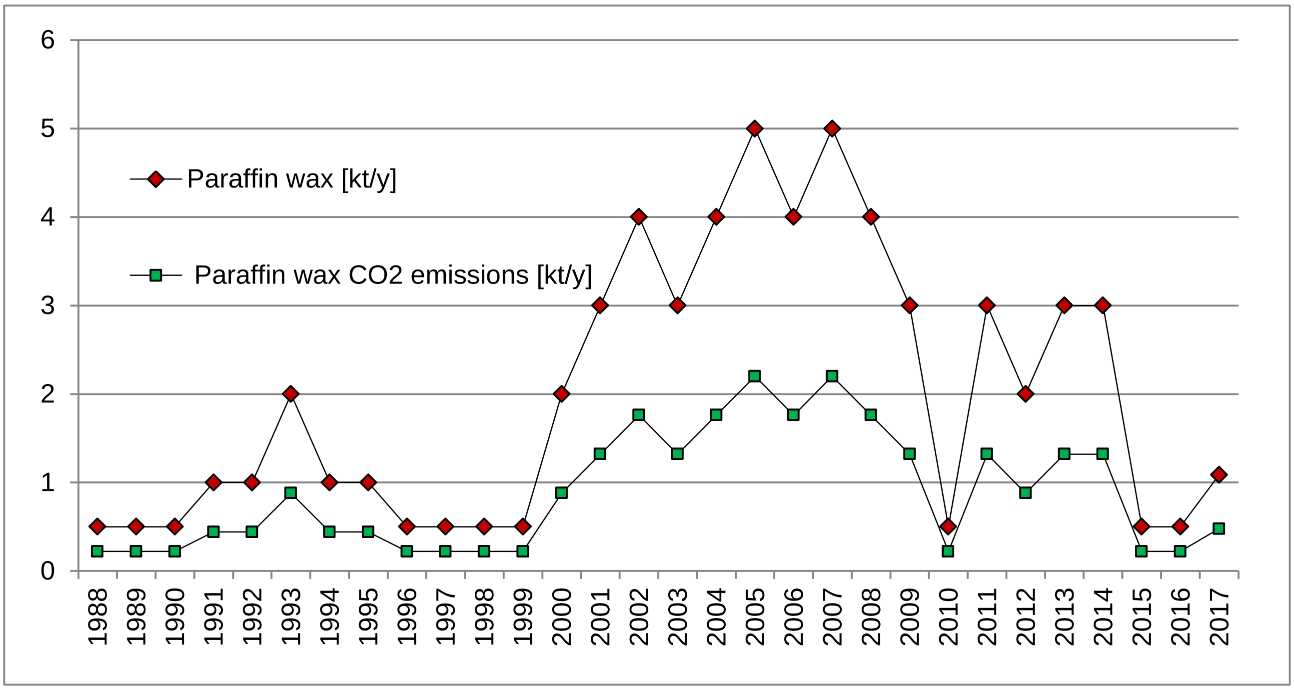

Figure 73 Paraffin wax use and CO2 emissions in CRF 2.D.2.

4.5.2.3 Methodological issues.

4.5.2.3.1 Methods

Waxes are used in a number of different applications. Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffinsare combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or inwastewater treatment (for surfactants). In the cases of incineration and wastewater treatment the emissionsshould be reported in the Energy or Waste Sectors.

There are two methodological tiers for determining emissions and storage from paraffin waxes. Both Tier 1 and Tier 2 rely on essentially the same analytical approach, which is to apply emission factors to activity data on the amount of paraffin waxes consumed in a country (in energy units, e.g., TJ). The Tier 2 method relies on determining the actual use of paraffin waxes and applying a country-specific ODU factor to activity data, while the Tier 1 method relies on applying default emission factors to activity data (see decision tree, Figure 5.3).
Tier 1: CO_2 emissions are calculated according to Equation 5.4 with aggregated default data for the limited parameters available:

$$\mathbf{CO_2\ Emissions = PW \cdot CCWax \cdot ODUWax \cdot 44/12}$$

Where:
CO_2 Emissions = CO2 emissions from waxes, tonne CO_2
PW = total wax consumption, TJ
CCWax = carbon content of paraffin wax (default), tonne C/TJ (= kg C/GJ)
ODUWax = ODU factor for paraffin wax, fraction
44/12 = mass ratio of CO_2/C

4.5.2.4 Emission factors

For Tier 1 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

4.5.2.4.1 Activity data

Data on the use of paraffin waxes are required to estimate emissions, with activity data expressed in energy units(TJ). To convert consumption data in physical units, e.g., in tonnes, into common energy units, e.g., in TJ (on a Lower Heating Value basis), calorific values are required (for specific guidance see Section 1.4.1.2 of Chapter 1 of Volume 2 on Energy). Basic data on non-energy products used in a country may be available from production, import and export data and on the energy/non-energy use split in national energy statistics

The activity data for estimation of emissions in subcategory 2.D.2 Paraffin wax use are provided by the NSI in format, obtained by Eurostat Balance.

Table 136: Paraffin wax use and CO2 emissions – CRF 2.D.2 [kt/1000]

CRF 2.D.2 - PARAFFIN WAX USE		
Year	Paraffin wax [kt/year]	CO_2 Emissions [kt/year]
1988	0.5	0.22
1990	0.5	0.22
1995	1	0.44
2000	2	0.88
2005	5	2.20
2010	0.5	0.22
2015	0.5	0.22
2016	0.5	0.22
2017	1.1	0.48

4.5.2.5 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in the following table.

Table 130 Uncertainty of subcategory 2.D.2 – Paraffin wax use, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2	No	CO_2	10	30	31.62

4.5.2.6 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Plausibility checks of the results (due to the national statistic and national VOC register);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);
- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.5.2.7 Source specific recalculation

No source specific recalculation.

4.5.2.8 Source specific planned improvements

No source specific improvements are planned.

4.5.3 OTHER - UREA USE IN SCR CATALYSTS OF DIESEL ENGINES (CRF 2D3D)

4.5.3.1 Source category description

This source category encompasses CO_2 emissions from the use of urea containing AdBlue in diesel engines with SCR-catalysts in road transportation (Euro V/VI).

4.5.3.2 Trend description

The trend of CO2 emissions is presented in the following figure.

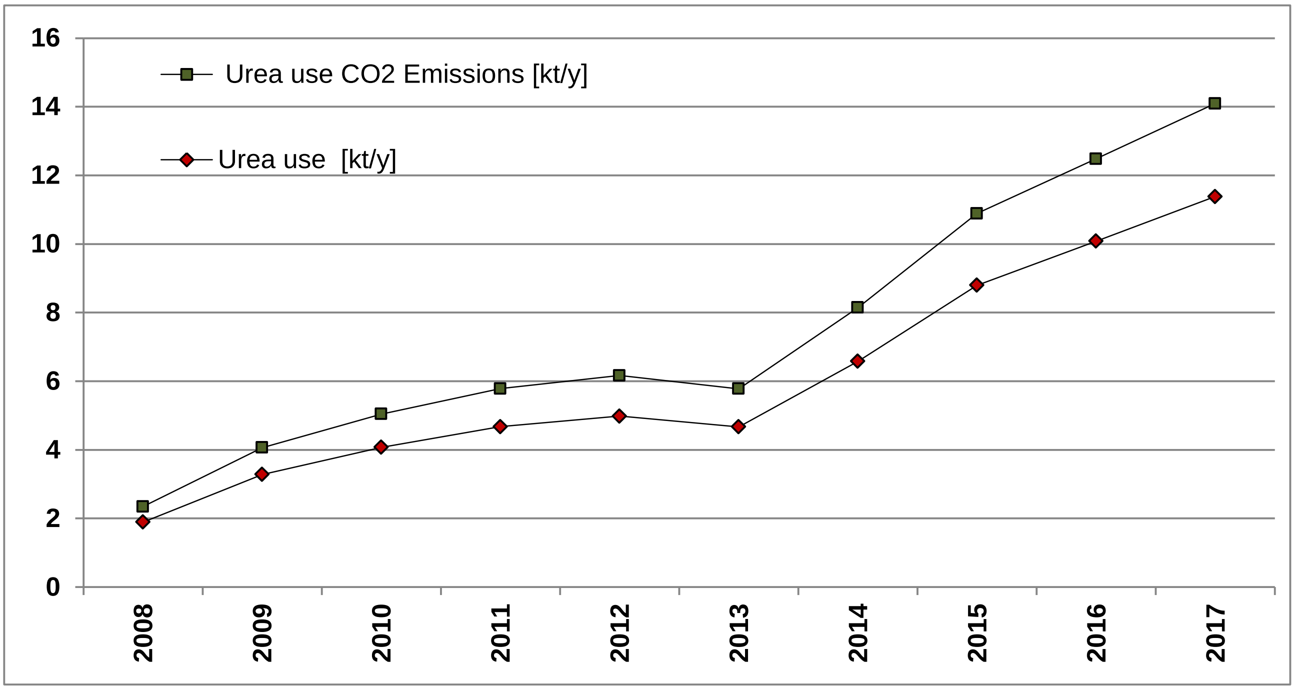

Figure 74 Urea use and CO2 emissions in CRF 2.D.3.d.

4.5.3.3 Methodological issues.

4.5.3.3.1 Methods

For the first time and in accordance with the new 2006 IPCC guidelines the consumption of Ad Blue is reported in this submission following a methodology suggested in the EMEP/EEA guidebook 2013 (EMEP/EEA 2013; part B, chap. 1.A.3.b.i-iv, page 48). A specific percentage of the fuel consumption of SCR-vehicles in road transportation according to their Euro class is applied for Ad Blue consumption estimates. Emissions are calculated according to following formula:

CO_2 Emissions = EF • FC • Share of SCR vehicles mileage • Specific urea share

"FC" - relates to the fuel consumption in [t] of the entire vehicle category
"Share of SCR vehicles mileage" - implies the mileage share of SCR-vehicles in the entire vehicle category

"Specific urea share" - comprises the percentage of fuel consumption which relates to AdBlue (urea solution) consumption.

4.5.3.3.2 Emission factors

The emission factor for CO_2 emissions from urea use in SCR-catalysts in vehicles is a default value (EMEP/EEA 2013) considering the molecular mass conversion of urea into CO_2 during the reaction with water and the content of 32.5% of the aqueous AdBlue urea solution. The EF amounts to 0.238 t per ton of AdBlue.

4.5.3.3.3 Activity Data

The activity data in subcategory 2.D.3.d. are based on the input data in COPERT model used in the road transportation. Please see subcategory Road transport – CRF 1.A.3.b.

Table 131 Urea use and CO2 emissions in CRF 2.D.3.d.

2D3D - UREA USE IN SCR CATALYSTS OF DIESEL ENGINES		
Year	Urea use [kt]	CO_2 Emissions [kt/year]
2008	1.896	0.451
2009	3.283	0.781
2010	4.072	0.969
2011	4.673	1.112
2012	4.981	1.185
2013	4.669	1.111
2014	6.578	1.566
2015	8.796	2.093
2016	10.084	2.400
2017	11.382	2.709

1.1.1.2 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in the following table.

Table 132 Uncertainty of subcategory 2D3d – Urea use, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2	No	CO_2	10	30	31.62

4.5.3.4 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Plausibility checks of the results (due to the national statistic and national VOC register);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);
- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.5.3.5 Source specific recalculation

The urea consumption has been recalculated due to the revision of the fuel consumption data and the implementation of an updated COPERT 5.2.2 model, which corrected some errors.

4.5.3.6 Source specific planned improvements

No source specific improvements are planned.

4.5.4 OTHER - SOLVENT USE (CRF 2.D.3.B)

4.5.4.1 Source category description

This chapter describes the methodology used for calculating greenhouse gas emissions from solvent use in Bulgaria. Solvents are chemical compounds, which are used to dissolve substances as paint or for used also for cleaning purposes (degreasing of metals and dry cleaning). Most of the solvents are released into air after application of these substances or other processing. Solvents consist mainly of NMVOC, it is the cause their use is a major source for anthropogenic NMVOC emissions. Once released into the atmosphere NMVOCs react with air molecules (mainly HO-radicals) or high energetic light and generated emission of CO_2.

Sub-category Solvent use 2D3b include paint application, Degreasing and Dry cleaning and Chemical products.

4.5.4.2 Trend description

The trend of the Solvent use and CO2 emissions is presented in following figure.

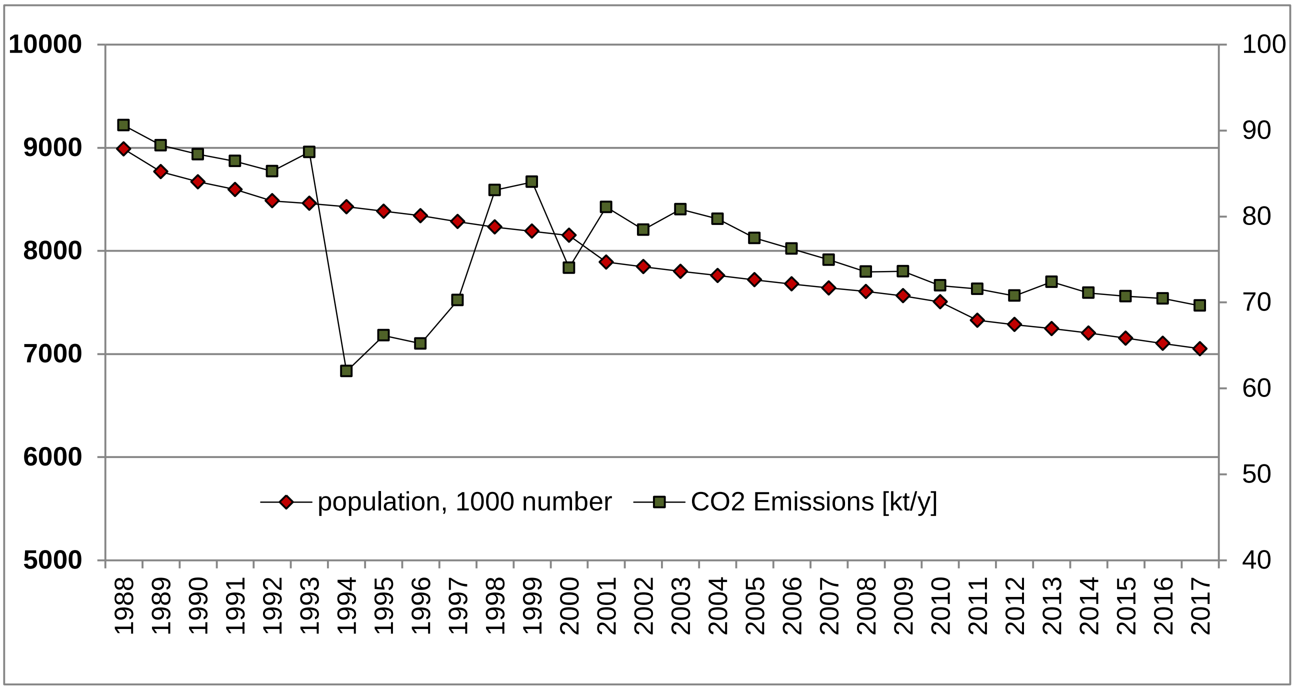

Figure 75 Population and CO2 emissions.

This category covers emissions from following activities.

Paint application

This activity deals with the use of paints within the industrial and domestic sectors.

Decorative coating application, which includes:

- Paint application: construction and buildings (SNAP 060103)
- Paint application: domestic use (SNAP 060104)

Industrial coating application, which includes:

- Paint application: manufacture of automobiles (SNAP 060101)
- Paint application: car repairing (SNAP 060102)
- Paint application: coil coating (SNAP 060105)
- Paint application: boat building (SNAP 060106)
- Paint application: wood (SNAP 060107)
- Other industrial paint application (SNAP 060108)

Other coating application, which includes:

- Other non-industrial paint application (SNAP 060109)

Degreasing and Dry cleaning

This category deals with the following activities:

- Degreasing - process for cleaning products from water-insoluble substances such as grease, fats, oils, waxes, carbon deposits, fluxes and tars. In most cases the process is applied to metal products, but also plastic, fibreglass, printed circuit boards and other products are treated by the same process.
- Dry cleaning - refers to any process to remove contamination from furs, leather, down leathers, textiles or other objects made of fibres using organic solvents.

Chemical products, manufacture and processing

- Chemical products
  This sector covers the emissions from the use of chemical products, use of lacquers and solvents, manufacture and processing (polyester processing, polyvinylchloride processing, polyurethane foam processing, rubber processing, pharmaceutical products manufacturing, paints manufacturing, inks manufacturing, glues manufacturing, asphalt blowing).

The decrease of solvent emissions is due to the positive impact of the enforced regulations in Bulgaria:

- Regulation №7/2003 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, which replaced a Council Directive 1999/13/EC into national legislation;
- Regulation on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products from 23/02/2007, which replace the Council Directive 2004/42/CE of the European Parliament and of the Council of 21 April 2004.

4.5.4.3 Methodological issues.

4.5.4.3.1 Methods

The method used is the Tier 1 using population on average emission fastor specified below. Thus obtained CO_2 emissions are subtracted emission category 2G4.

<u>CO_2 emissions:</u>

$$\boldsymbol{All\ Emission_{CO2} = AR_{\text{population}} \times IEF_{Averdge}}$$

Where:

All EmissionCO_2 = the emission of CO_2

AR population = population of the country)

IEF CO_2 = average CO_2 emission from solvent use per capita value (0.013286 ktCO_2/ population-1000 number).

This equation is applied at national level, using annual national total figures for the activity data.

$$\boldsymbol{2D3b\ Emission_{CO2} = All\ Emission_{CO2} - 2G4\ Emission_{CO2}}$$

<u>NMVOC emissions:</u>

Emissions calculation NMVOC is back interlocking system of proportions of calculating CO_2 emissions aan described in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO_2 from NMVOC:

$$\boldsymbol{2D3b\ Emissions_{NMVOC} = \left(2D3b\ Emission_{CO2} \times \frac{12}{44}\right)/C}$$

Where C is the fraction carbon in NMVOC by mass (default = 0.6)

Reference for default: conversion- factor NMVOC – CO_2, the 2006 IPCC Guidelines, Volume 3, Chapter 5: Industrial Processes and Product Use, page 5.17, 2006 IPCC Guidelines s, Volume 1, Chapter 7: Precursors and Indirect Emissions, page 7.6

4.5.4.3.2 Emission Factor

Used so-called implied emission factor for CO_2 which is based on a simple approach using per capita ratios from a group of 9 Member States (Romania, Hungary, Slovakian republic, Czech republic, Poland, Austria, Italy, Croatia and Bulgaria).

This factor is calculated on the 0.013286 ktCO_2/ population-1000 number (average CO_2 emission from solvent use per capita value),

4.5.4.3.3 Activity Data

The activity data for estimation of emissions in subcategory 2D3b Solvent use are provided by the NSI - it's the country's population.

Table 133 Solvent use and CO2 emissions in CRF 2.D.3.b

2D3b – Other solvent used		
Year	Population [1000 number]	CO_2 Emissions [kt CO_2]
1988	8986.636	90.604
1990	8669.269	87.226
1995	8384.715	66.148
2000	8149.468	74.020
2005	7718.750	77.483
2010	7504.868	71.960
2015	7153.784	70.719
2016	7101.859	70.450
2017	7050.034	69.622

4.5.4.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in the following table.

Table 134 Uncertainty of subcategory 2D3b -Solvents use, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2	No	CO_2	10	30	31.62

4.5.4.5 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.

The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Plausibility checks of the results (due to the national statistic and national VOC register);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);
- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.5.4.6 Source specific recalculation

The change in emissions in this sector is due to recalculations made in the sector 2G4.

4.5.4.7 Source specific planned improvements

No source specific improvements are planned.

4.6 ELECTRONICS INDUSTRY (CRF 2.E)

Research showed that this activity is not applicable for Bulgaria and emissions are not ocurring.

4.7 PRODUCT USES AS SUBSTITUTES FOR ODS– SECTOR OVERVIEW (CRF 2.F)

The following table and figure summarize the results for CRF Sector 2.F for 2017:

Table 135 Summary of the results for 2017

Sector	Actual emission 2017	Actual share
	Gg CO_2-eq.	%
Solvents	0.00	0.00%
Aerosols	13.26	0.74%
Foams	8.47	0.47%
Domestic refrigeration	9.12	0.51%
Commercial and industrial refrigeration	104.00	5.77%
Transport refrigeration	2.45	0.14%
Domestic AC	1146.66	63.59%
Commercial and industrial AC	48.01	2.66%
Mobile AC	464.00	25.73%
Fire protection	7.20	0.40%
Total	1803.19	100.00%

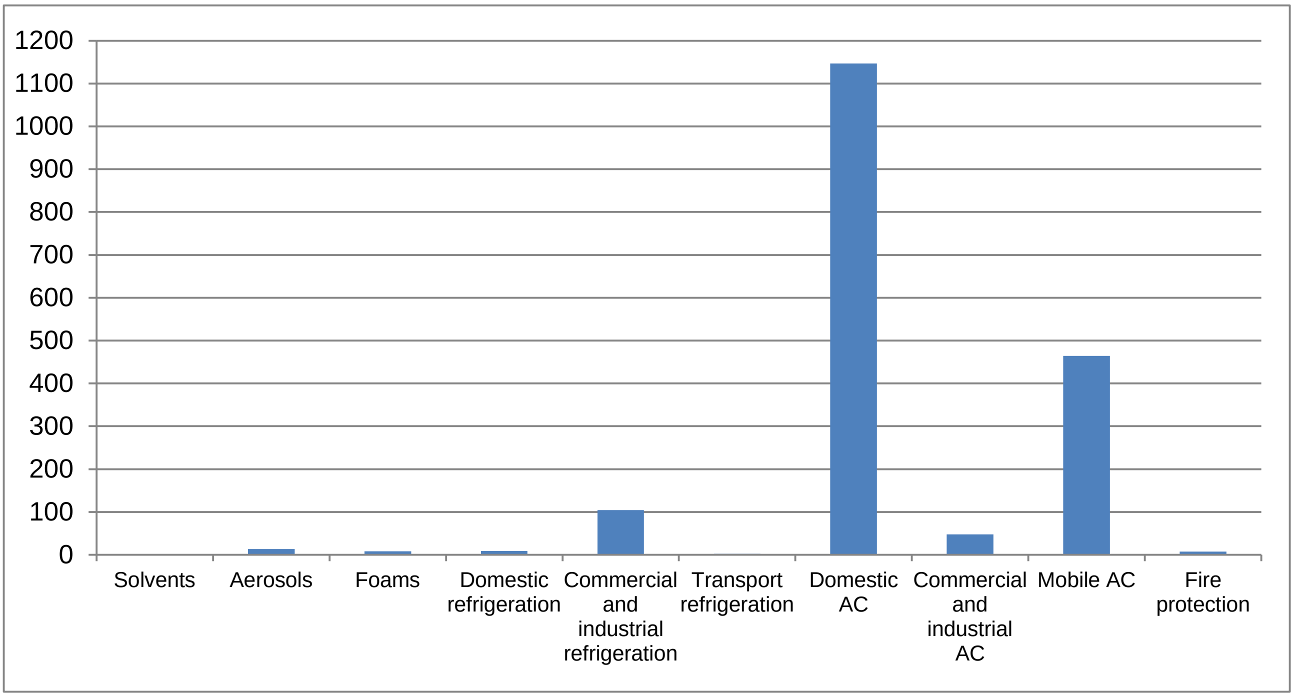

Figure 76 Actual emissions for 2017 [Gg CO2-eq.]

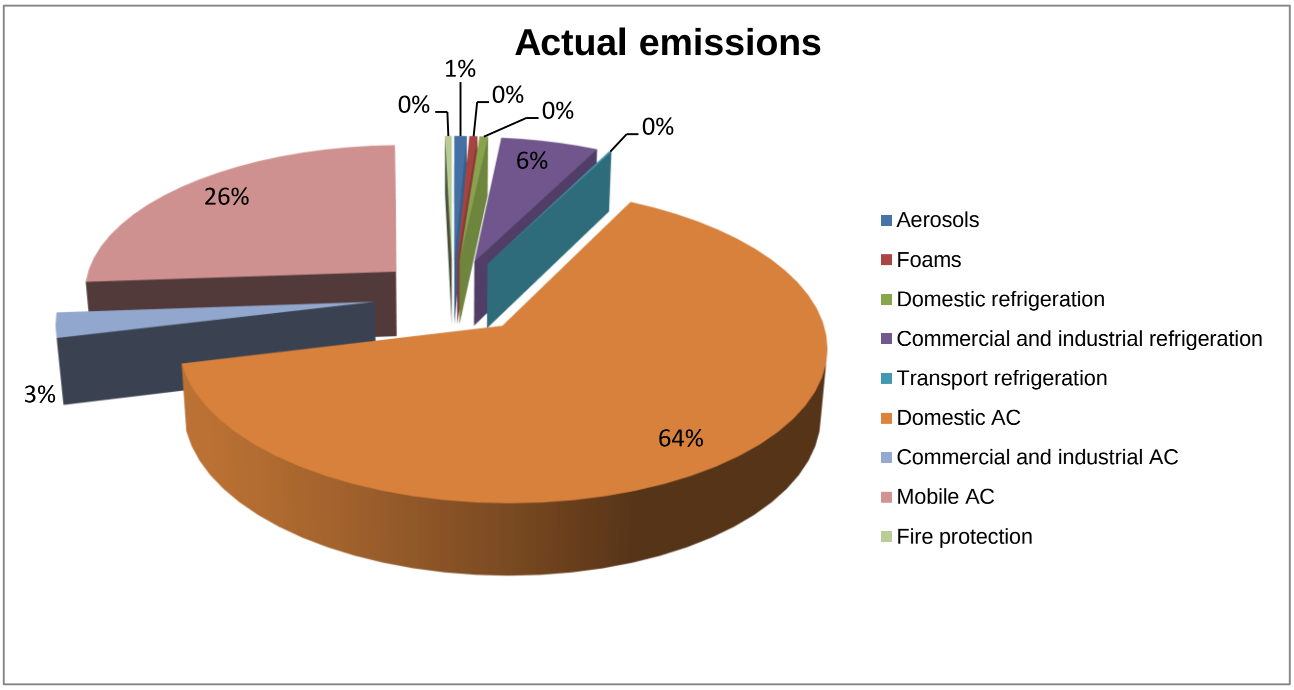

Figure 77 Actual emissions for 2017 [Gg CO2-eq.]

The following table and figure represent the actual emissions for the whole time series:

Table 136 Actual emissions [Gg CO2-eq.]

Year	Solvents	Aerosols	Foams	Domestic Ref	Commercial and Industrial Ref	Transport Ref	Domestic AC	Commercial and industrial AC	Mobil AC	Fire protecion
1988	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1989	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	0.00	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	0.01	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	0.02	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	0.04	NO	NO	NO	NO	1.06	NO
1995	NO	NO	NO	0.06	NO	NO	NO	NO	3.26	NO
1996	NO	NO	NO	0.08	NO	0.05	NO	NO	5.71	NO
1997	NO	NO	NO	0.12	NO	0.09	NO	NO	9.08	NO
1998	NO	1.11	NO	0.17	NO	0.14	NO	NO	13.65	NO
1999	NO	1.78	NO	0.23	NO	0.20	NO	NO	19.39	NO
2000	NO	0.76	NO	0.27	5.35	0.33	NO	1.51	24.69	NO
2001	NO	0.33	NO	0.30	9.89	0.50	0.92	2.88	30.34	0.52
2002	NO	0.81	NO	0.33	14.42	0.72	3.30	4.25	36.81	0.65
2003	NO	1.30	NO	0.36	18.96	1.05	10.06	5.62	45.60	0.81
2004	NO	1.88	NO	0.38	23.50	1.41	19.79	6.99	64.96	1.01
2005	NO	2.60	2.93	0.39	28.04	2.33	32.45	8.36	110.19	1.26
2006	NO	7.17	8.53	1.40	32.58	2.84	54.55	9.73	159.43	1.56
2007	NO	9.89	11.55	2.82	37.12	3.10	107.81	11.10	174.31	1.95
2008	NO	10.31	96.67	4.36	41.66	3.28	192.51	12.46	238.18	2.43
2009	NO	11.91	22.35	4.98	46.20	2.87	219.52	13.83	282.61	3.42

Year	Solvents	Aerosols	Foams	Domestic Ref	Commercial and Industrial Ref	Transport Ref	Domestic AC	Commercial and industrial AC	Mobil AC	Fire protecion
2010	NO	10.89	11.98	7.56	50.74	2.53	247.82	15.20	290.54	3.42
2011	NO	10.35	10.33	8.38	72.16	2.37	289.83	19.61	316.34	4.65
2012	NO	9.98	8.71	10.22	77.71	2.32	346.50	24.98	323.00	4.67
2013	NO	10.54	7.41	17.07	88.97	2.34	436.01	30.99	357.47	5.42
2014	NO	9.52	7.55	20.20	96.95	2.57	504.74	36.21	412.07	5.63
2015	NO	11.31	8.35	12.81	100.67	2.44	570.98	42.91	451.87	6.39
2016	NO	14.64	8.17	10.89	100.17	2.37	725.43	42.96	474.58	6.78
2017	NO	13.26	8.47	9.12	104.00	2.45	1146.66	48.01	464.00	7.20

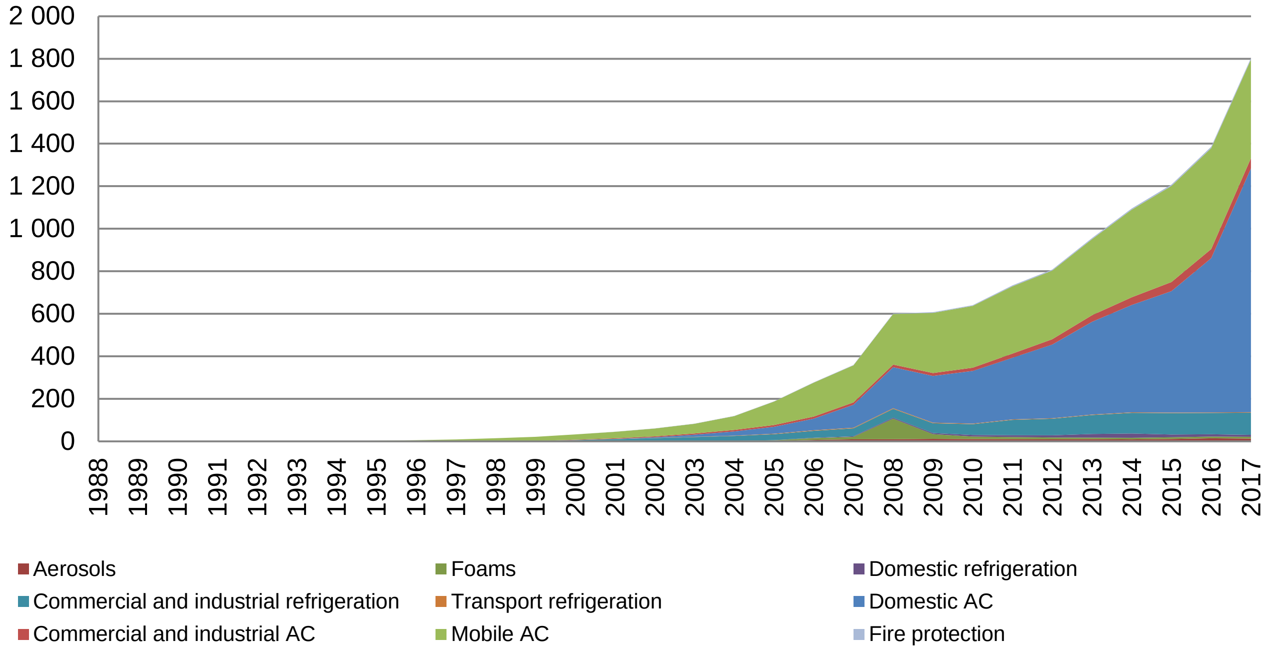

Figure 78 Actual emissions [Gg CO2-eq.]

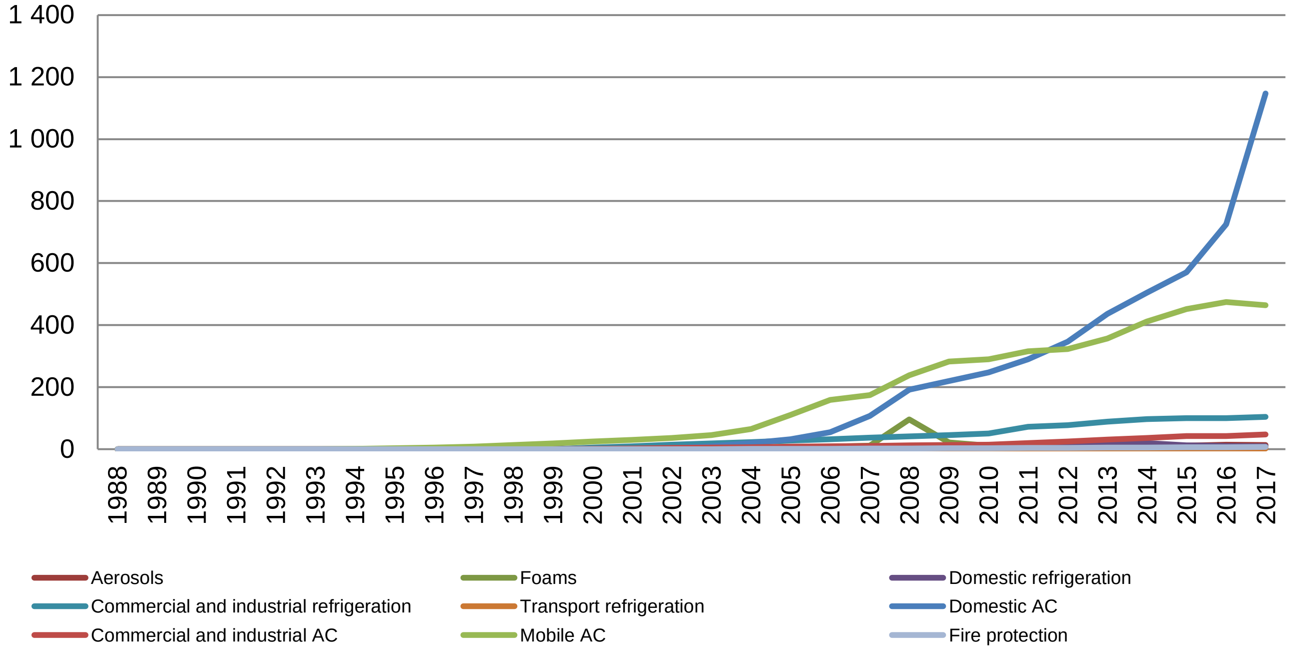

Figure 79 Actual emissions [Gg CO2-eq.]

4.7.1 REFRIGERATION AND AIR CONDITIONING

4.7.1.1 Source Category Description

Depending on the purpose and specifics of the country, the refrigeration and air conditioning equipment can be divided into six major subcategories listed below. It should be noted that according to a recent study, subsector Refrigeration and Air Conditioning employs over 1000 certified technicians and over 70 licensed service companies in the country.

4.7.1.1.1 Commercial and industrial refrigeration (2.F.1.a and 2.F.1.c)

In this subsector emissions from the production of refrigerators, emissions from refrigeration of goods in a supermarket for example, as in other retail outlets are included. The task to determine 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 addition to supermarkets, there is also a wide range of equipment for other types of applications - slaughterhouses, gastronomy, agriculture and others. 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.

Today the most commonly used blend of HFC is R-404A, which becomes even more important than HFC-134a. R-407C also plays an important role. Currently, there are still banked amounts of HCFC-22.

Since the available data does not permit a separate calculation of the banked quantities used in commercial and industrial refrigeration equipment and since the emission factors as recommended by the IPCC Guidelines, are in similar margins, it was decided the two subcategories - commercial and industrial refrigeration - to be grouped and evaluated together.

Even before the entry into force of the Montreal Protocol bans for the use of CFCs and HCFCs (which were subsequently implemented in the European and national legislation), industrial refrigeration equipment was the only sector using alternative cooling agents in significant quantities (mainly ammonia). However, after the ban on the CFC-12 use, imposed by the Montreal Protocol, the main substitute on the market became different types of HFCs. It is also difficult to determine the annual inflow of new refrigerant for this sector due to the its heterogeneity.

The following figure shows the total emissions of HFC (by type) from the sub-sector:

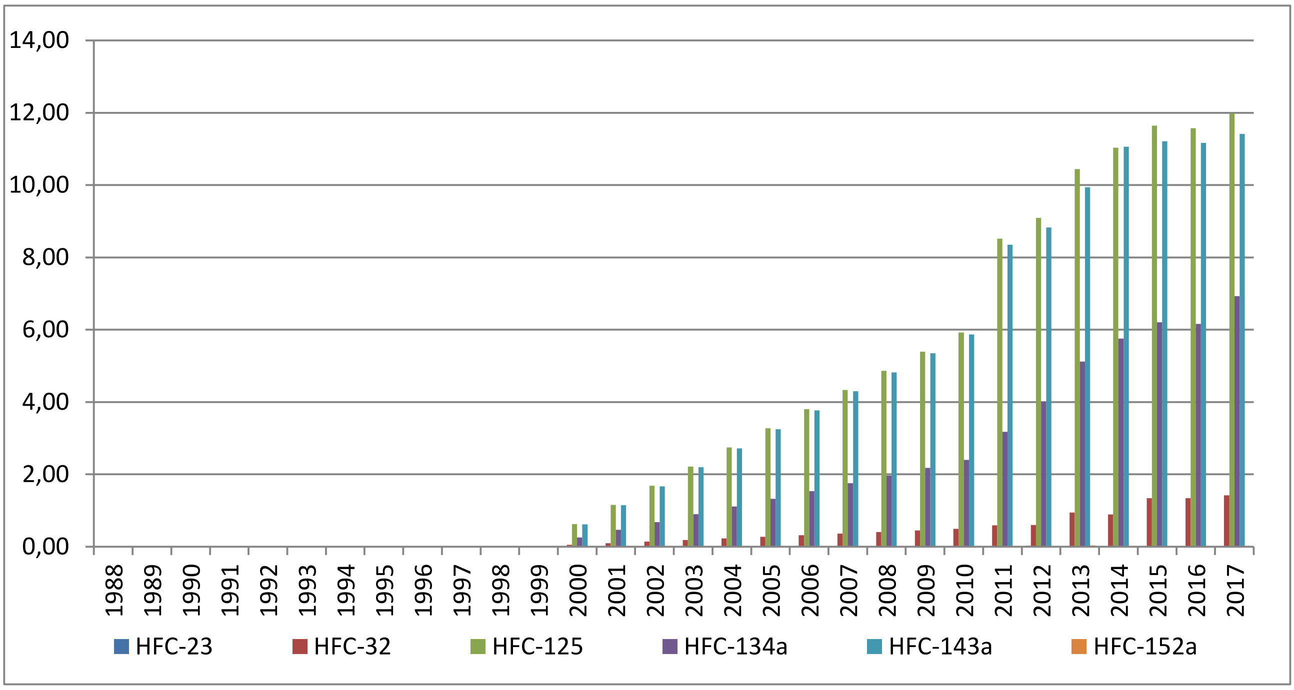

Figure 80 Total emissions by gasses of Commercial and industrial refrigeration in CRF 2.F.1.a and 2.F.1.c

4.7.1.1.2 Domestic refrigeration (2.F.1.b)

There is no production of domestic refrigeration using HFCs in Bulgaria. The producers have switched from CFCs, HFCs, HCFCs and ammonia to other alternatives as i-butane, for example. Therefore, the calculations on this subsector are based on data for imports. The following figure shows the total emissions of HFC (by type) from the sub-sector:

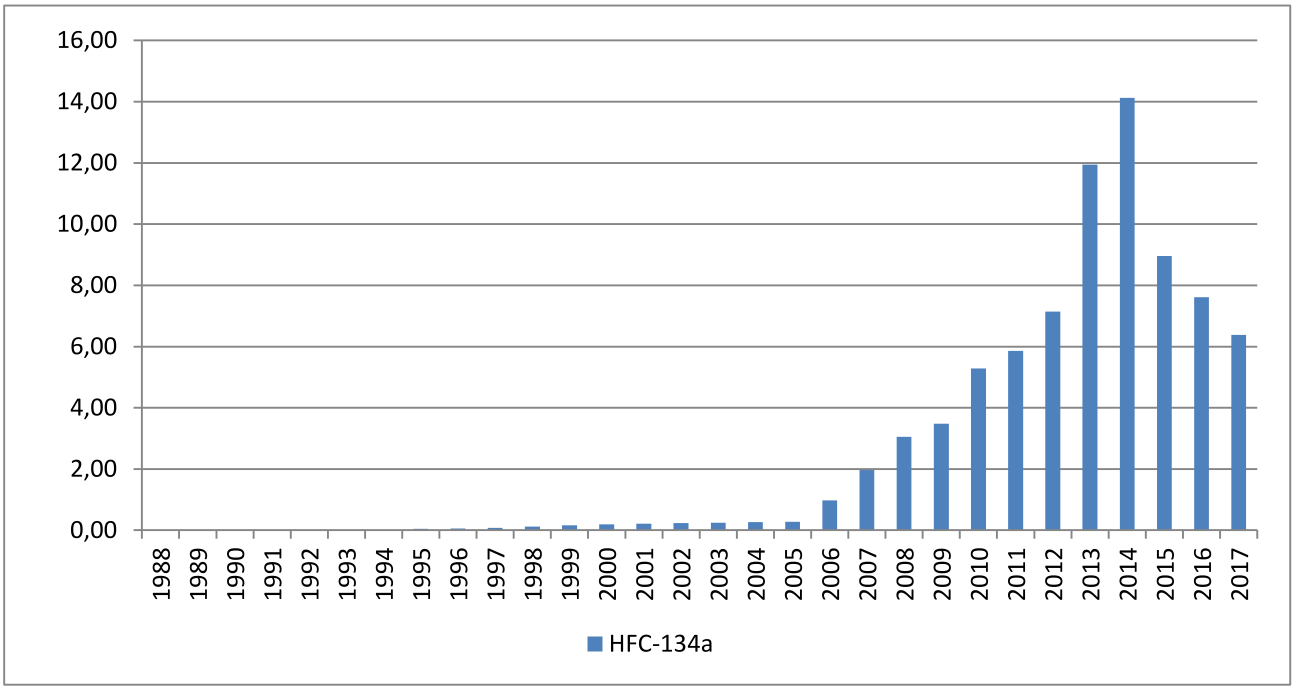

Figure 81 Total emissions by gasses of Domestic refrigeration in CRF 2.F.1.b

4.7.1.1.3 Transport refrigeration (2.F.1.d)

Since the reporting of refrigeration vehicles is not obligated by the legislation, as it is for stationary equipment above 3 kg, there are not many companies, which have submited any data in their annual reports to the RIEW. It is observed that the reports are missing data for years before 2007, and the available for 2007-2013 is scarce, probably inaccurate and it is registered only on the territories of the inspectorates in Sofia, Plovdiv, Varna and Burgas.
Therefore, it was attempted to contact and obtain information directly from some large transport companies, including ones operating outside Bulgaria. Attempt was unsuccessful. As it was not possible to compel the operators to report the data, but apparently, there is data lack in the annual reports of RIEW, estimates are made using one of the largest websites for vehicle resales in Bulgaria. According to statistic extract from the website database, the average number of refrigerated vehicles is taken and after they are classified based on expert judgement and foreign studies' verification and experience (F-gases, Germany, 2005).
The following figure shows the total emissions of HFC (by type) from the sub-sector:

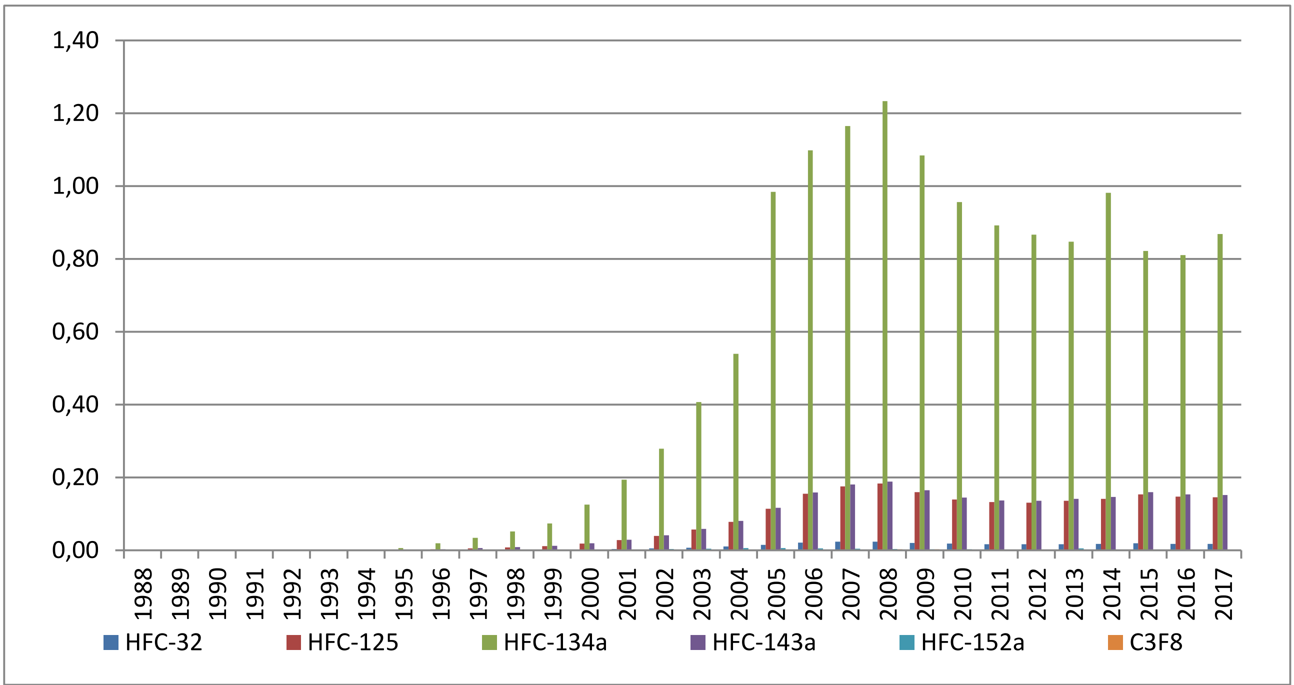

Figure 82 Total emissions by gasses of Transport refrigeration in CRF 2.F.1.d

4.7.1.1.4 Mobile air conditioning (2.F.1.e)

Emissions from mobile air conditioners are summarized in the IPCC manual under the chapter "3.7.5. Mobile air-conditioning sub-source category". There are no special comments, guidelines and methodologies for the separation of air conditioners into different subcategories. However, in this report, mobile air conditioners are divided into four subcategories - for cars, trucks, buses and railway carriages - as each of them has its own specifics that need to be addressed. Production of air conditioners for railway carriages started in 2011.
The following figure shows the total emissions of HFC (by type) from the sub-sector:

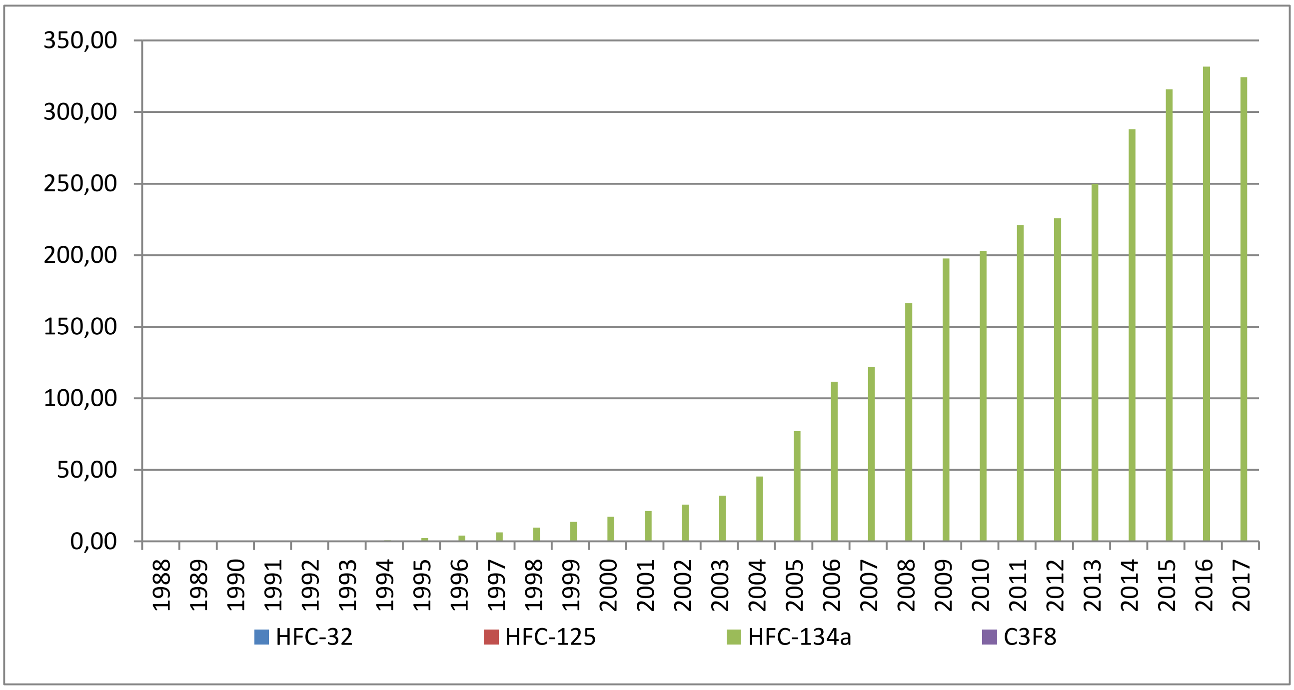

Figure 83 Total emissions by gasses of Mobile air conditioning in CRF 2.F.1.e

4.7.1.1.5 Stationary air conditioning (2.F.1.f)

Stationary air conditioning is divided on domestic and commercial air conditioning systems, respectively divided into more than 20 kW and 20 kW of power. Commercial systems have capacity that is able to provide a comfortable temperature in the whole buildings (central air conditioning systems) or large rooms. In both types of systems, a wide range of HFC is used. Emissions may occur during installation, charging and disposal. Emissions from domestic and commercial air conditioning systems are calculated separately. The following figure shows the total emissions of HFC (by type) from the sub-sector:

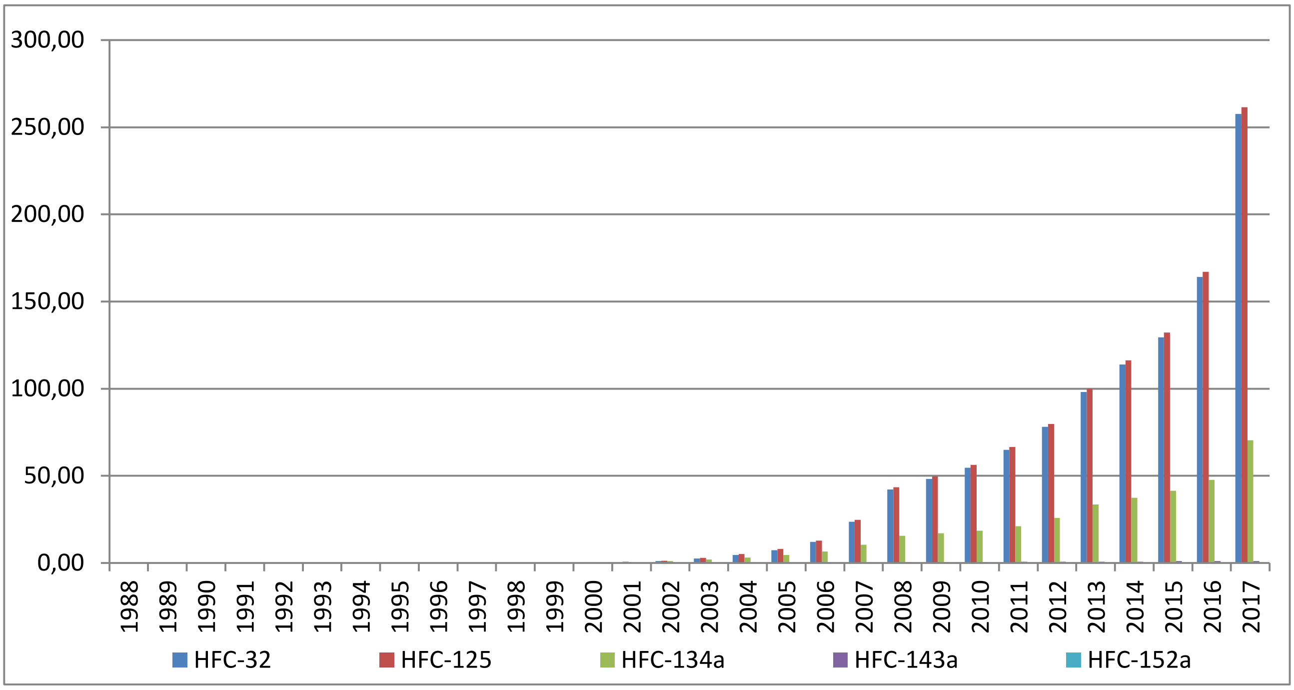

Figure 84 Total emissions by gasses of Stationary air conditioning in CRF 2.F.1.f

4.7.1.2 Methodological Issues

4.7.1.2.1 Commercial and industrial refrigeration (2.F.1.a and 2.F.1.c)

Emission factor of 1.75% was used for the first year and 10% emission factor for emissions from operation (IPCC, 2006). Emissions from disposal of equipment are accounted only if this is explicitly written in the reports of any of the 16 RIEWs, from which the data is taken. The calculations are based on Tier 2a method.

4.7.1.2.2 Domestic refrigeration (2.F.1.b)

A default emission factor of 0.3% per year and average amount of refrigerant in a number of equipment - 0,1 kg was used (IPCC, 2006). In this subsector, emissions from disposal are estimated with lifetime of the equipment set to 15 years (which falls within the boundaries set by IPCC Guidelines, 1996 and 2006).

4.7.1.2.3 Transport refrigeration (2.F.1.d)

The only data that was obtained is used for the amount of refrigerant in the railways from 1998 to 2017. Therefore, their emissions are calculated, even the small amounts of HFC used. Railway carriages were filled with R-12 which is being gradually replaced by HFC-134a, R-401A and R-413A. Tier 2a method, default emission factor for emissions from operation of 20% were used, which fully coincide with the given limits of the Guidelines (IPCC, 2006). This equipment has not been used since 2008 and is kept on storage, but not decommissioned i.e. the equipment is not removed and the cooling agent is not drawn and therefore is being reported.

Concerning the use of refrigeration equipment and cooling agents respectively within the motoring transport, the data concerning the import of heavy and light trucks for the period observed is extracted from statistical databases (NSI, 2017), as well as online database of the one of the biggest websites for vehicle resells in Bulgaria. The statistical processing of the data lets to the calculation of the share of heavy and light trucks imported related to the number of those, equipped with refrigeration system. This share after related to the number of the vehicles imported in the country based on data from NSI, gives us the number of vehicles with refrigeration equipment, divided by categories.

A default EF of 20% (average for Europe) for operation emissions is used, which falls within the boundaries set by the Guidelines (IPCC, 2006). There is no production of mobile refrigeration equipment in the country. It is assumed that 5% in 1995 of the refrigerated trucks used HFCs, reaching 75% in 2010 (IPCC, Working group III). Here, as well as in other categories because of lack of enough stable data for the country, the data concerning the average quantity and type of agent within the different categories of equipment is taken from different European studies (F-gases Germany, 2005). The emissions from disposal are calculated based on lifetime of 9 years.

4.7.1.2.4 Mobile air conditioning (2.F.1.e)

The Guidelines does not take into account the quantities of refrigerant over 1.5 kg and therefore offers no default emission factors for such systems. Only quantities over 1.5 kg for bus air-conditioners are used for the calculations.

Due to the specifics of the Bulgarian car market, a detailed model for the emissions calculation from Car AC subsector had to be created. As regards the fact that in Bulgaria there is no production of trucks or buses, data about import from NSI was used (data from the Association of Automobile manufacturers and their authorized representatives in Bulgaria, which have data from 1991 to today is used for verification). For the proper assessment of the Bulgarian fleet, a detailed statistics of the Road Control Department and the largest website in the country for trade of new and used cars, including the year of manufacture of the vehicle, the presence of air-conditioning system and year of import in Bulgaria was obtained. From 2011, there is production of cars in Bulgaria and data for F-gases (HFC-134A) has been provided by the producer. The results obtained are based on Tier 2a method.

For the selection of appropriate EF, a number of foreign researches have been reviewed. The most 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, declining to 0,8 kg in 2000. Expectations of this study is the amount to decrease up to 0,6 kg in 2010 on the annual level of losses (which include losses from normal use and losses in accidents), the data show that losses in 1995 is amounted to 15%, reducing to 10% in 2000 and projections are for about 6% in 2010. Disposal emissions are not calculated as average lifetime for the country is very high (over 20 years). Overall emissions are overestimated due to the fact that it is assumed that after the refrigerant has been leaked, it has been recharged in 100% of the cases.

According to various international studies (F-gases Germany, 2005; AEAT, 2003), the average quantity of refrigerant in air conditioning systems in the cabins of trucks varies around 1,00-1,20 kg. Similar studies are an appropriate source of information for this report, since Bulgaria does not produce trucks, as well as studies in this field.

According to the classification of NSI (NSI, 2011) whose data were used, mainly trucks are divided by weight - less than 5 t, 5-20 t and over 20 t. In the lowest grade trend over the years is the amount of refrigerant to decrease from 1 to 0,85 kg, while in the other two classes, it remains constant - 1,20 kg. However, for the purposes of this project, a constant quantity of 1 kg for the lower class was chosen, because of lack of accurate data on truck fleet in Bulgaria and the assumption that the car park is older than the average age for Western Europe. The amount of coolant in the three classes vary in small range, since it considers that the magnitude of the cabin and the corresponding volume to be cooled remain almost identical regardless of the increasing weight of the vehicle.

The refrigerant used is mainly HFC-134a. It enters mass market after 1993-1995, as a substitute of CFC-12. At the end of 1993 in Germany, half of all new trucks used cooling agent based on HFCs. Admittedly, in Bulgaria this share was lower. Studies show that from 1994 to 2002, the percentage of trucks with air conditioners has increased from 5 to 32% and this share continues to grow today, especially for heavy trucks (Schwarz, 2007a).

Operating losses of coolant here are much higher than in vehicle AC for number of reasons such as long time driving, larger loads, the greater length of piping and more. No evidence of studies on the loss of agent in trucks over 1,5 t was observed. Additional 5% on 10% emissions during operation are considered acceptable because of the possibility of higher losses in trucks compared to cars and light trucks. The results obtained are based on Tier 2a.

It is assumed that all coaches manufactured after 1999 are equipped with air-conditioning system, and since 1995 their percentage is growing slowly from 20% (AEAT, 2003). As with other mobile air conditioning systems, here the most used cooling agent is HFC-134a. Its average quantity contained in one air conditioner is assumed to be 12 kg. The length of piping may exceed 30 m in order to reach the cooled air to all passengers. Due to this great length, emissions from leakage are increased. Emissions of refrigerant in use are accepted as 15% annually. Here, as in trucks, to 10% emission factor adopted for passenger cars a further 5% were added due to longer pipelines and more frequent bus exploitation. Equipment lifetime is assumed to be 15 years. Emissions from disposal are also included. Calculations were conducted according to Tier 2a methodology.

Since this year the data from the railways is divided to refirgaration and air conditioning(before that all were reported as refrigeration). The quantities of imported carriages for passenger transport are included in this category. To calculate the emissions from this sub-category an EF of 15% is used. Production of air conditioners for railway carriages started in 2011 and all of it is exported. The data is acquired from the manufacturer's report, where it is said also that the used cooling agents are HFC-134a and R-407C. An EF of 0.35% is used for emission estimation.

4.7.1.2.5 Stationary air conditioning (2.F.1.f)

Data about domestic AC was received from NSI. The most commonly used refrigerants are R-407C and R-410A (in ratio of approximately 2:3). The calculation of emissions from domestic systems was made after the following assumptions: EF of 5 % (Preparatory study for a review of Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases, Germany, 2011) was used and the average quantity of agent is 1,5 kg per unit equipment. Emission lifetime is set to 10 years. The results are calculated based on Tier 2a.

Data on F-gas quantities used in the commercial air conditioning equipment were obtained from RIEW reports that importers, operators and service companies are required to report each year.

Emission factor of 1.0% was used for the first year and 10% emission factor for emissions from operation (IPCC, 2006). Emissions from disposal of equipment are accounted only if this is explicitly written in the reports of any of the 16 RIEWs, from which the data is taken. The results are based on Tier 2a.

4.7.1.3 Uncertainties and time-series consistency

4.7.1.3.1 Commercial and industrial refrigeration (2.F.1.a and 2.F.1.c)

Since the beginning of 2009 in Bulgaria a new legal instrument (Ordinance establishing measures for the implementation of Regulation (EC) № 842/2006 on certain fluorinated greenhouse gases, called The Ordinance for short) is in effect, that fulfils the Regulation (EC) № 842/2006 requirements. According to the Ordinance, operators of equipment containing more than 3 kg refrigerant must report annually their relevant quantities to RIEWs, which then send a summary report of all reported to MOEW. Prior to 2008, the reports have been prepared under the legislation for the control and management of ODS. In order to assess emissions from this sector, reports from all 16 RIEW in Bulgaria for the period 1996-2012 were analysed. After summarizing the information it was concluded that in the years before 2009 a significant number of companies were not aware of the new reporting obligations. Therefore, to make an accurate assessment of this sector data from 2010 was used and then linearly extrapolated back in time

4.7.1.3.2 Domestic refrigeration (2.F.1.b)

The share of domestic refrigeration equipment using HFCs in Bulgaria has been allocated approximately from 0% in 1990 to a maximum of 90% in 1998. A drop follows to 40% in 2002 and 5% in 2005. These numbers show the change of Bulgarian producers and importers to use a hydrocarbon refrigerant, replacing HFCs. It is believed that the level of equipment containing HFCs after 2005 remains within 5%. According to a relevant British study (AEAT, 2003) the only agent to be used in this sector is HFC-134a, which has GWP of 1300. Data about the calculation of emission was extracted from the import of refrigeration and air conditioning of the NSI from 2000 to 2010. Data for the years 1988-1999 was extrapolated as a function of data about the total amount of imports of goods and services in Bulgaria (NSI, 2011). An uncertainty in the rage of 20-100% is applied.

. Uncertainty is assumed to be around 50%.

4.7.1.3.3 Transport refrigeration (2.F.1.d)

It is a high uncertainty (80%) that emissions from this subsector are calculated based on many assumptions extracted from foreign studies and do not reflect in the best way the Bulgarian case.

4.7.1.3.4 Mobile air conditioning (2.F.1.e)

Data for passenger cars are provided by Ministry of Interior - General Directorate National Police for the period 2005-2017. The data for the years between 1990 and 2004 were extrapolated from the data as a function of the total imports of new and second hand cars in Bulgaria.

NSI data for imports of trucks provides information only on the years 2000-2017 and therefore it was necessary here on the basis of imports of goods and services (World Bank, 2011) to extrapolate the input data back to 1988.

Data on the number of buses imported into the country were taken from NSI, but only for the years 2000 to 2017. For the years before 2000, data were based on extrapolation of the imports of goods and services for the period 1988-1999 (World Bank, 2011).The subsector is assumed to have approx. 80% uncertainty

4.7.1.3.5 Stationary air conditioning (2.F.1.f)

Data for actual numbers of AC units is available for the period 2000-2005. For the period after 2006 the NSI provides data only for the total money spent on AC equipment. To estimate the number of units after 2006, first the average price of an AC unit calculated for 2005 and the the total numbers for the next period were divided into in. The average price for 2005 was taken insted of average price for

2000-2005 because throught the period the price of a single AC unit drops with a stready trend. Admission was made that before 1999 the majority of equipment was using CFCs and therefore, the calculations do not include the years before 2000. After 2007, legislative modifications have forced the import of equipment with HFCs. Despite that 35% of the refrigerant used in this sector is assumed still to be a CFC (AEAT, 2003).

It is believed that the data concerning commercial AC and reported for the years before 2009 from RIEW reports are not reliable enough. Therefore, to calculate the emissions, data for 2017 were used by 1% emission factor for the first year and 10% in operating emission factor (IPCC, 2006) and then linearly extrapolated back to 1999. Uncertainty is assumed to be around 15%.

4.7.1.4 Source-Specific QA/QA and Verification

In general, the whole Refrigeration and air conditioning subsector (CRF 2.F.1) is verified by an external expert from the MOEW. The expert was introduced with all activity data collection and assumptions, methodological issues and calculation approaches. After a discussion, some measures and improvements, concerning assumptions of the overall subsector were decided to be implemented.

4.7.1.5 Source-Specific recalculations

4.7.1.5.1 Commercial and industrial refrigeration (2.F.1.a and 2.F.1.c)

There are no source specific recalculations for this category.

4.7.1.5.2 Domestic refrigeration (2.F.1.b)

There are no source specific recalculations for this category.

4.7.1.5.3 Transport refrigeration (2.F.1.d)

There are no source specific recalculations for this category.

4.7.1.5.4 Mobile air conditioning (2.F.1.e)

There are no source specific recalculations for this category.

4.7.1.5.5 Stationary air conditioning (2.F.1.f)

There are no source specific recalculations for this category.

4.7.1.6 Source-Specific planned improvements

If new information is available for changes and trends in the category, improvements will be made in the relevant field including AD, EF etc.

4.7.2 FOAM BLOWING(CRF 2.F.2)

4.7.2.1 Source category description

Only two types of HFCs are used in the manufacture of extruded polystyrene insulation foams (XPS), solid polyurethane foams and one component foams (OCF). In Bulgaria, there are several larger companies in the production of foams. The largest of them, using as a blowing agent HFCs, imports raw materials from abroad. Others are using CO_2 and/or water as a substitute for HCFCs.
A large manufacturers of XPS, using HFCs is on the Bulgarian market since 2005. Quantity of imported and used HFCs is reported annually. These quantities (reported to RIEW/MoEW) are used to calculate emissions in this category, by assuming the entire quantity of produced foams stays in the country (although more than 50% is exported). There is no data available for the quantities of foams containing HFCs that were imported in the country.

The following two tables represent the activity date for the subsector:

Table 137 Activity data for Foam blowing – HFC-134a [t]

Activity Data	Filled in new manufactured products	In operating systems	Remained in products at decommissioning	Actual emissions from manufacturing	Actual emissions from stocks	Actual emissions from disposal
1988	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO
2008	C	C	NO	60.18	NO	NO
2009	C	C	NO	4.55	1.35	NO
2010	NO	C	NO	NO	1.45	NO
2011	NO	C	NO	NO	1.44	NO
2012	NO	C	NO	NO	1.42	NO
2013	NO	C	NO	NO	1.41	NO
2014	NO	C	NO	NO	1.40	NO
2015	NO	C	NO	NO	1.39	NO
2016	NO	C	NO	NO	1.38	NO
2017	NO	C	NO	NO	1.37	NO

Table 138 Activity data for Foam blowing – HFC-152a [t]

Activity Data	Filled in new manufactured products	In operating systems	Remained in products at decommissioning	Actual emissions from manufacturing	Actual emissions from stocks	Actual emissions from disposal
1988	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO
2005	C	C	NO	77.01	NO	NO
2006	C	C	NO	205.28	19.25	NO
2010	C	C	NO	107.20	153.65	NO
2015	C	C	NO	86.52	80.84	NO
2016	C	C	NO	80.75	82.26	NO
2017	C	C	NO	89.49	81.88	NO

4.7.2.2 Methodological issues

The data about quantities of HFCs were obtained from questionnaires and annual reports of RIEWs. Market research in Bulgaria showed that only HFC-134a and HFC-152a are used, where foam blowing is carried out with HFCs. For the purposes of the calculations, default emission factors were used as follows - for HFC-134a 25% loss in the first year and 0.75% annual loss, for HFC-152a - 50% EF for the first year and 25% per annum thereafter (IPCC, 2006). Global warming potential of the two gases are respectively 1430 and 38 for HFC-134a and HFC-152a.

Activity data for Foam blowing – HFC-152a, HFC-134a could not be reported, because there is only one producer and data is confidential.

4.7.2.3 Uncertainties and time-series consistency

It is assumed that import and export balance each other, but could also be 40/60 or 60/40 (20% uncertainty).

4.7.2.4 Source-Specific QA/QA and Verification

No source-specific QA/QC and verification is obtained.

4.7.2.5 Source-Specific recalculations

There are no source specific recalculations for this category.

4.7.2.6 Source-Specific planned improvements

There are no planned improvements in this category.

4.7.3 FIRE PROTECTION (CRF 2.F.3)

4.7.3.1 Source category description

According to experts from the industry, who have been asked, fire protections activities with the use of HFC in Bulgaria are implemented in very rare cases - mainly in fire protection systems installed in the server and computer rooms. At the same time in Bulgaria filling of fire fighting equipment is not practiced. It is all imported, as there are no Bulgarian manufacturers of fire protection equipment, using HFC.
The following two tables represent the activity date for the subsector:

Table 139 Activity data for Fire Protection – HFC-125 [t]

Activity Data	Filled in new manufactured products	In operating systems	Remained in products at decommissioning	Actual emissions from manufacturing	Actual emissions from stocks	Actual emissions from disposal
1988	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO
2000	NO	NO	NO	NO	NO	NO
2001	0.148	0.148	NO	NO	0.007	NO
2005	0.071	0.359	NO	NO	0.018	NO
2010	0.000	3.407	NO	NO	0.170	NO
2015	4.345	11.506	NO	NO	0.575	NO
2016	1.406	12.911	NO	NO	0.646	NO
2017	2.224	15.135	NO	NO	0.757	NO

Table 140 Activity data for Fire Protection – HFC-227a [t]

Activity Data	Filled in new manufactured products	In operating systems	Remained in products at decommissioning	Actual emissions from manufacturing	Actual emissions from stocks	Actual emissions from disposal
1988	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO
2000	NO	NO	NO	NO	NO	NO
2001	3.065	3.065	NO	NO	0.153	NO
2005	1.466	7.406	NO	NO	0.370	NO
2010	0.000	17.514	NO	NO	0.876	NO
2015	0.000	27.206	NO	NO	1.360	NO
2016	0.872	28.078	NO	NO	1.404	NO
2017	0.206	28.284	NO	NO	1.414	NO

4.7.3.2 Methodological Issues

Data about banked HFC quantities in firefighting equipment were used (mainly FM-200 and NAFS-125 type), according to which the mainly used HFC is HFC-227ea (80%) and to a lesser extent - HFC-125. This data is provided by "National Fire Safety and Protection of Population Service" in Ministry of Interior. Using default EF of 5% of the IPCC Guidelines, 1996.

4.7.3.3 Uncertainties and time-series consistency

Analysis of data obtained by the questionnaires from operators and importers determined that there is no use of F-gases in fire protection equipment before 2005, while reports of RIEW have reported small amounts of HFC-227ea imports since 2001. Therefore, it is assumed that the starting year of HFC usage in fire protection equipment is 2001. To calculate emissions for the years before 2008, an assumption for linear growth of about 25% in fire fighting equipment was made. Uncertainty is considered to be in range of 60-100% of the original value.

4.7.3.4 Source-Specific QA/QA and Verification

No source-specific QA/QC and verification is obtained.

4.7.3.5 Source-Specific recalculations

There are no source specific recalculations for this category.

4.7.3.6 Source-Specific planned improvements

No source-specific planned improvements are to be performed.

4.7.4 AEROSOLS (CRF 2.F.4)

4.7.4.1 Source category description

The used HFCs as propellants currently are HFC-134a, HFC-227ea and HFC-152a. Data on their use as medical and technical aerosols were obtained directly from industry by telephone calls and questionnaires. After direct contact with experts from the industry, the researched showed that in Bulgaria there is only one producer, which uses HFC-134a in the production of aerosols. There are several companies working in this field, but they do not use any F-gases.

Concerning the import and usage of meter dose inhalers (MDIs) in the medicine, according to an official letter of the Executive Drug Agency in Bulgaria HFC-134a is the only F-gas used in MDIs. The Agency provided a full list of operators and importers of MDIs, containing HFC-134a. A profound research on those companies and contacting them helped in collecting data for the use of such equipment since 2005. Therefore, the results are based on real numbers, reported by the companies.

The following table represents the activity date for the subsector:

Table 141 Activity data for Aerosols/Meter dose inhalers – HFC-134a [t]

Activity Data	Filled in new manufactured products	In operating systems	Remained in products at decommissioning	Actual emissions from manufacturing	Actual emissions from stocks	Actual emissions from disposal
1988	NO	NO	NO	NO	NO	NO
1990	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO
1998	1.559	NO	NO	0.779	NO	NO
2000	0.134	0.462	NO	0.067	0.462	NO
2005	1.990	0.820	NO	0.995	0.820	NO
2010	7.194	4.017	NO	3.597	4.017	NO
2015	10.567	2.623	NO	5.283	2.623	NO
2016	9.915	5.283	NO	4.957	5.283	NO
2017	8.628	4.957	NO	4.314	4.957	NO

4.7.4.2 Methodological Issues

According to the 2006 IPCC Guidelines, aerosol emissions are considered to be immediate, occurring during the first year of production. Using data on quantities of HFC-134a consumed by the company for the period 1988-2017, the default EF of 50% for the first year and 100% for the next year (IPCC, 2006). The EFs selected are default because of the absence of specific empirical data on the territory of Bulgaria. Results are obtained according to Tier 2a method.

4.7.4.3 Uncertainties and time-series consistency

Uncertainty is assumed to be around 30% for the whole subsector.

4.7.4.4 Source-Specific QA/QA and Verification

Data is verified by MOEW expert.

4.7.4.5 Source-Specific recalculations

There are no source specific recalculations for this category.

4.7.4.6 Source-Specific planned improvements

No source-specific planned improvements are to be performed.

4.7.5 SOLVENTS (2.F.5)

Research showed that this activity is not applicable for Bulgaria and emissions are not ocurring.

4.7.6 OTHER APPLICATION USING ODS SUBSTITUTES (2.F.6 CRF SOURCE CATEGORY NUMBER)

Research showed that this activity is not applicable for Bulgaria and emissions are not ocurring.

4.7.7 SEMICONDUCTOR MANUFACTURING (CRF SOURCE CATEGORY NUMBER)

Research showed that this activity is not applicable for Bulgaria and emissions are not ocurring.

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4.8 OTHER PRODUCT MANUFACTURE AND USE (CRF 2.G)

4.8.1 ELECTRICAL EQUIPMENT (CRF 2.G.1)

4.8.1.1 Source category description

In electrical engineering, sulfur hexafluoride is used as a gaseous dielectric for high voltage (usually from 52 kV to 800 kV) equipment - circuit breakers, disconnectors, bushing systems and whole substations and increasingly in medium voltage (6 - 52 kV) networks. It is not flammable. It serves as an arc-extinguishing and insulation medium (in the latter function, in place of air). It has 3 times better electrical insulation properties than air, which allows a substantial reduction in the size of the equipment. To improve the electrical insulation properties, these devices maintain an increased pressure (from 5 to 10 bar due to its wide application in high voltage electrical equipment is often referred to as electric (electric) gas).
It breaks into an electric arc but quickly recovers its insulating properties as the products of the disintegration re-form SF6.
In 2009, the ExEA has conducted a study concerning the determination of banked quantities of SF_6 in the country. The survey on the banked quantities of SF6 is performed on an annual basis - detailed questionnaires to 30 companies were sent, including importers and operators of equipment. The purpose of the survey was to gather additional historical data, with the desire to apply a higher tier to calculate the emissions and in view of the fact that reported data for imports of SF_6 and equipment containing SF_6 is incomplete.
Under Bulgarian law, companies using SF6-containing equipment are required to report annually data on their available equipment. Additionally, companies are sent reminders to provide information about used equipment containing SF6.
In Bulgaria there is no production of SF6 and switchgear containing SF6, it is only imported . The main share (85-90%) of the use of SF6 in switching equipment belongs to a state-owned company for electricity generation and transmission (Bulgarian Energy Holding with four subsidiaries), three electricity distribution companies and the National Company "National Railway Infrastructure Company", the rest SF6 equipment is serviced by thermal power plants and companies with their own substations.

The following table represents the activity date for the subsector:

Table 142 Activity data for Eclectrical Equipment – SF6 [t]

Activity Data	Filled in new manufactured products	In operating systems	Remained in products at decommissioning	Actual emissions from manufacturing	Actual emissions from stocks	Actual emissions from disposal
1988	0.47	5.96	NO	0.033	0.112	NO
1990	0.53	6.67	NO	0.037	0.125	NO
1995	0.70	8.84	NO	0.049	0.166	NO
2000	0.93	11.72	NO	0.064	0.220	NO
2005	0.93	15.26	NO	0.066	0.292	NO
2010	8.06	25.02	NO	0.469	0.354	NO
2015	2.00	34.14	NO	0.132	0.660	NO
2016	2.09	35.41	NO	0.141	0.681	NO
2017	0.77	35.41	NO	0.064	0.704	NO

4.8.1.2 Methodological Issues

Emission data is based on annual reports from companies on available equipment in the relevant year.
The data obtained were used to assess emission using Tier 2a and default EF, according to the IPCC Guidelines, 2006.
Due to the long life of the equipment and the lack of sufficient research data, it is not possible to calculate country-specific EF.Default EF given by the IPCC Guidelines for the equipment containing SF_6, are 0.002 (0.2%) (for Sealed-for-life Equipment) and 0.026 (2.6%) (for Closed Pressure Systems) (IPCC, 2006).
Extremely small amounts were reported as installation emissions. No amounts of SF_6 were reported as used in servicing of equipment or quantities contained in retiring equipment.
According to the IPCC Guidelines 2006, equipment is divided into two main types - with and without the possibility of topping up. Systems without the possibility of additional charging (Sealed-for-life Equipment) usually have a capacity of less than 5 kg per functional unit and they are used at a voltage below 52 kV. They do not require any maintenance during the period of operation; their respective emission factor is much lower. Systems capable of charge (Closed Pressure Systems) are used in more than 52 kV voltage and may contain amounts of 5 to several hundred kg.
Since it is not possible to do a detailed disaggregation between the equipment with or without possibility of charge, it was assumed that the equipment of the high-voltage grid owned by "Electricity System Operator" PLC is close-pressured (about 97% of equipment is with a capacity of over 5 kg and is part of 110, 220 or 400 kV grid). It was assumed that 25% of the quantities of equipment could be initially charged, according to data from the annual reports about the newly installed equipment. and the quantities used for initial charging.

4.8.1.3 Uncertainties and time-series consistency

Although the study was designed to cover the years from 1988 to 2015, almost no company that can report on data from the years before 2003, but most of them reported only data from the last 2-3 years. Therefore, the calculations for previous years were made by extrapolation of the reported amounts for 2009 under the assumption for annual growth rate of newly installed equipment by 5.8% for the period 1995-2003 and 3.9% for the period 2004-2015 (Ecofys, 2005).
Activity data in last years is assumed to be uncertain by +/-10%, in 1988 much less information is available (+/-50%). Furthermore, based on the default EF used, also default uncertainty of the EF (+/-30%) is applied.

4.8.1.4 Source-Specific QA/QA and Verification

No source-specific QA/QC and verification is performed.

4.8.1.5 Source-Specific recalculations

There are no source specific recalculations for this category.

4.8.1.6 Source-Specific planned improvements

No source-specific planned improvements are to be performed.

4.8.2 SF_6 AND PFCS FROM OTHER PRODUCT USE (CRF 2.G.2)

Research showed that this activity is not applicable for Bulgaria and emissions are not ocurring.

4.8.3 N_2O FROM PRODUCT USES - MEDICAL APPLICATION (CRF 2.G.3A)

4.8.3.1 Source category description

N_2O emissions are caused by medical uses of N_2O (for anaesthesia).
Calculation of N_2O emission from subcategory *2G3a Other product manufacture and use, medical application* are based on emission factor in accordance with the 2006 IPCC Guidelines.

4.8.3.2 Trend description

Trend for N_2O emissions from subcategory 2G3 N_2O from product use (2G3a - Medical application).
The N_2O emissions from 2G3a - Medical application are calculated for the entire time series 1988 – 2017.
The trend of N_2O emissions is presented in the following figure.

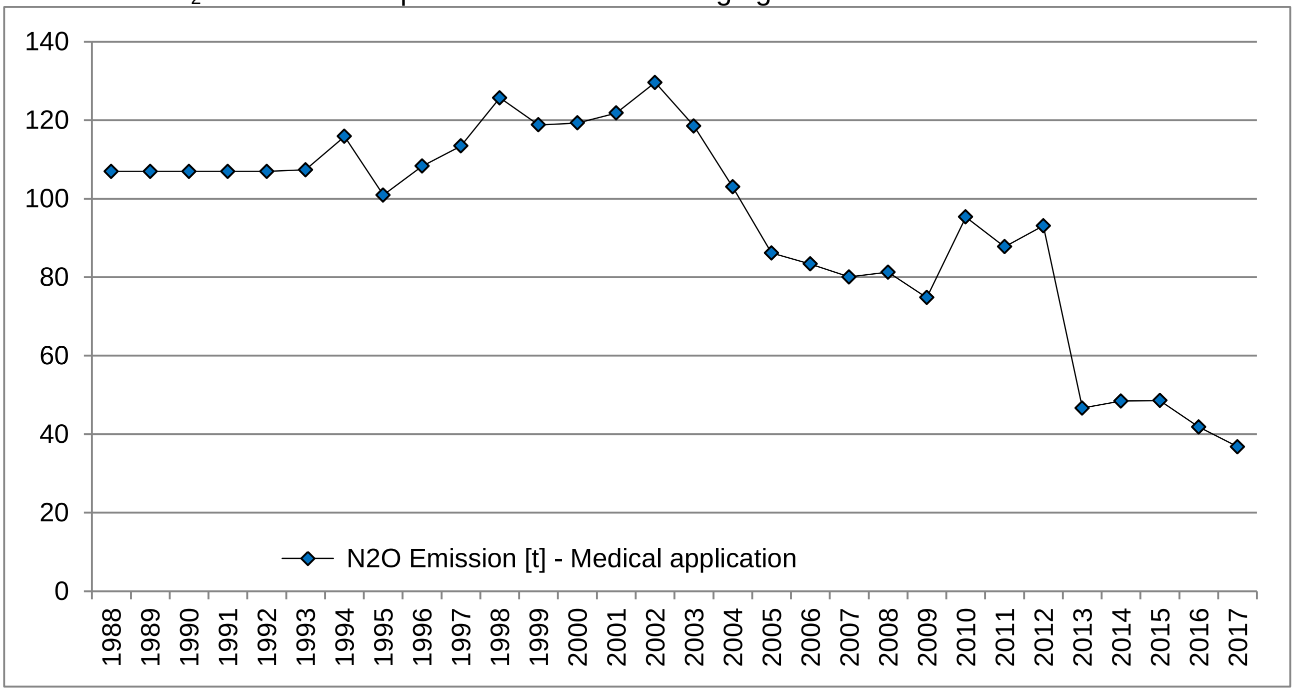

Figure 85 Medical application (Anaesthesia) – N2O emissions.

4.8.3.3 Methodological issues.

4.8.3.3.1 Method

The N_2O emissions from 2G3a Medical application are estimated based on methodological issues set in the 2006 IPCC Guideline (Volume 3: Industrial Processes and Product Use, Chapter 8). Equation 8.24 for estimation of N_2O emissions from other product use is implemented. 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.

4.8.3.3.2 Emission Factor

The default emission factors used for assessment of emissions of N_2O from 2G3a Medical application are presented inTable 143.

Table 143 Emission factor N2O for 2G3a is 1.0.

2G3 N_2O from product uses (Medical application)				
SNAP activity	Name of activity	Emission factor	Unit	Reference
2G3a	Medical application	1.0	Mg/Mg	CORINAIR

4.8.3.3.3 Activity Data

For the period 1988 – 2012 data are obtained by the single manufacturer of N2O in the country. Since 2012 the company has not possessed a license for this activity and stops to work as it is not able to meet the additional requirements to the quality of the production, which are related to unreasonably high capital costs for restructuring of the installation.
A letter to the Drug Agency has been sent in order to obtain the list of the companies which are licensed to import and trade with this product. Letters are sent to those companies which have submitted data for the imported quantities of N_2O in the country.
Due to lack of data, the activity data for the period 1988 – 1991 are taken the same as first available year.

Table 144 AD for N2O emissions from 2G3 N2O from product use (2G3a - Medical application), Mg

2G3a - N_2O from product uses (Medical application)	
Year	N2O Emissions [t N2O]
1988	106.95
1990	106.95
1995	100.95
2000	119.30
2005	86.17
2010	95.36
2015	48.56
2016	41.83
2017	36.77

4.8.3.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 145 .

Table 145 Uncertainty of subcategory 2G3 N2O emissions from product uses (2G3a Medical application), %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2	No	N_2O	10	1	10,05

4.8.3.5 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);

- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.8.3.6 Source specific recalculation

There are no source specific recalculations for this category.

4.8.3.7 Source specific planned improvements

No source specific improvements are planned.

4.8.4 N_2O FROM PRODUCT USES - PROPELLANT FOR PRESSURE AND AEROSOL PRODUCT (CRF 2.G.3.B)

4.8.4.1 Source category description

N_2O emissions are caused by uses of Propellant for pressure and aerosol product (aerosol cans). Calculation of N_2O emission from subcategory *2G3b* N_2O from product uses (2G3b - Propellant for pressure and aerosol product), are based on emission factor in accordance with the 2006 IPCC Guidelines.

4.8.4.2 Trend description

Trend for N_2O emissions from subcategory 2G3b N_2O from product use (2G3b Propellant for pressure and aerosol product).The N_2O emissions from 2G3b - Propellant for pressure and aerosol product are calculated for the entire time series 1988 – 2017.

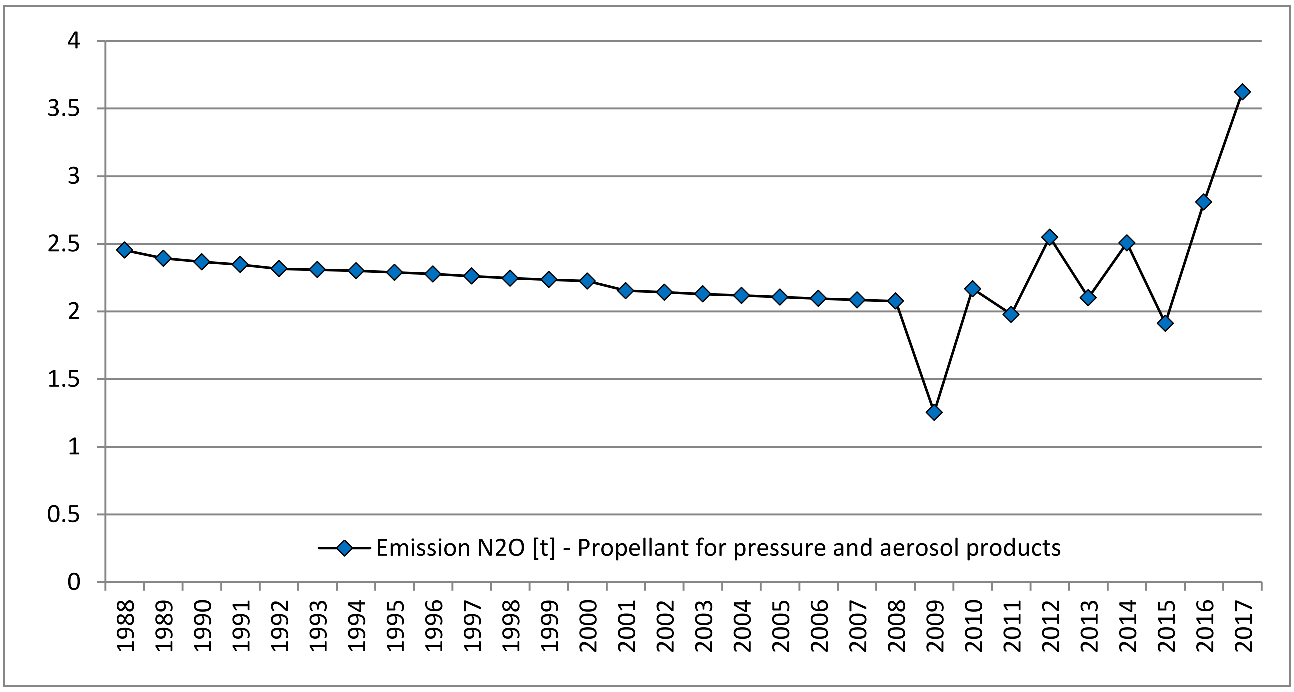

Figure 86 Propellants for pressure and aerosol product - N2O emissions.

4.8.4.3 Methodological issues.

4.8.4.3.1 Method

The data are provided from the importing companies in the cream spray. Available data on the amount of cream sprayed are for the period 2009-2017 and the nitric oxide content in cans. On the basis of the data on the population of the country (provided by the NSI), an average emission factor was calculated which was applied for the period 1988-2008.

4.8.4.3.2 Emission Factor

The default emission factors used for assessment of emissions of N_2O from 2G3b – 100% of the quantity of N_2O contained in the cans of cream spray imported to the country.

4.8.4.3.3 Activity Data

Data on the amount of N_2O imported in the country was obtained by sending letters to the importing companies to which these imports were authorized by the Bulgarian Food Safety Agency.

Table 146 AD for N2O emissions from 2G3 N2O from product use (2G3b - Propellant for pressure and aerosol product), Mg

2G3b **- N_2O from product uses (Propellant for pressure and aerosol product)**		
Year	**N_2O Emissions [t N_2O]**	**Population [1000 number]**
1988	2.4528	8986.636
1990	2.3662	8669.269
1995	2.2886	8384.715
2000	2.2244	8149.468
2005	2.1068	7718.750
2010	2.1678	7504.868
2015	1.9123	7153.784
2016	2.8088	7101.859
2017	3.6236	7050.034

4.8.4.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 147

Table 147 Uncertainty of subcategory 2G3 N_2O emissions from product uses (2G3b Propellant for pressure and aerosol products), %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2G3b	No	N_2O	10	1	10,05

4.8.4.5 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);
- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.8.4.6 Source specific recalculation

Recalculations are made on the basis of new data.

4.8.4.7 Source specific planned improvements

No source specific improvements are planned.

4.8.5 DOMESTIC SOLVENT USE (CRF 2G4I)

4.8.5.1 Source category description

This category deals with the following activities:

- Domestic solvent use (other than paint application) (SNAP activity 060408)
- Domestic use of pharmaceutical products (SNAP activity 060411)

It comprises mainly the application of cleaning agents and solvents in private households for building and furniture cleaning and personal hygiene. The cleaning agents contain solvents which evaporate during use or after the application.

4.8.5.2 Trend description

The trend of emissions for sector 2.G.4.i Domestic solvent use is presented in the following chart.

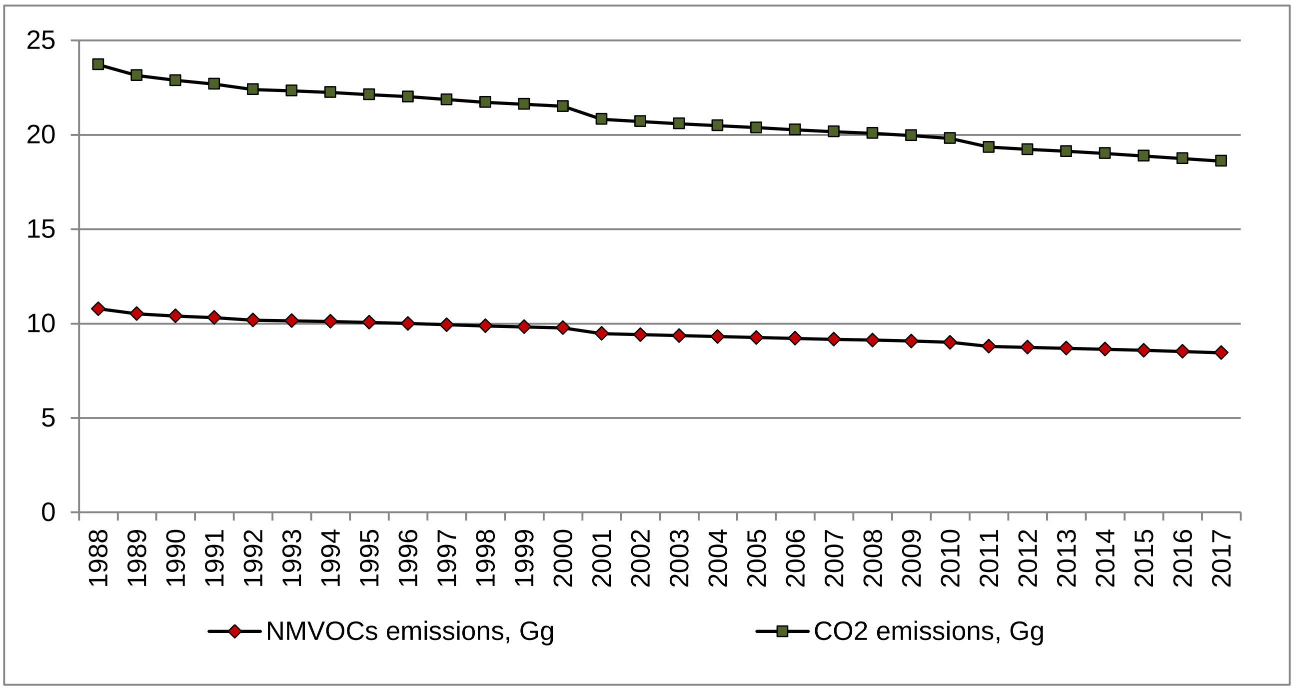

Figure 87 Trend of CO2 and NMVOC emissions in sector 2.G.4.i Domestic solvent.

4.8.5.3 Methodological issues.

4.8.5.3.1 Emission Factor

The emission factor has been derived from an assessment of the emission factors presented in GAINS model developed by IIASA. So, for Bulgaria we assume to use the EF of 1.2 kt/M people.
Converting of NMVOC into CO_2 with conversion factor is provided in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO_2.
From NMVOC:

$$\boldsymbol{Inputs_{CO_2} = Emissions_{NMVOC} \times C \times \frac{44}{12}}$$

Where C is the fraction carbon in NMVOC by mass (default = 0.6)
Reference for default: conversion- factor NMVOC – CO_2, the 2006 IPCC Guidelines , Volume 3, Chapter 5: Industrial Processes and Product Use, page 5.17, 2006 IPCC Guidelines s, Volume 1, Chapter 7: Precursors and Indirect Emissions, page 7.6
Time-series have been created due to application of EMEP/EEA Guidebook 2013.

4.8.5.3.2 Activity Data

All emissions related to domestic use of solvents and pharmaceuticals are calculated proportional to the Bulgarian population.

Table 148 Activity data of 2G4i Domestic solvent use in 1990-2017

Years	Inhabitants, 1000 person	NMVOCs emissions, Gg	CO_2 emissions, Gg
1988	8986.6	10.78	23.72
1990	8669.3	10.40	22.89
1995	8384.7	10.06	22.14
2000	8149.5	9.78	21.51
2005	7718.8	9.26	20.38
2010	7504.9	9.01	19.81
2015	7153.8	8.58	18.89
2016	7101.9	8.52	18.75
2017	7050.0	8.46	18.61

4.8.5.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 147

Table 149 Uncertainty of subcategory 2G4i Domestic solvent use, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2G4i	No	CO_2	10	30	31.62

4.8.5.5 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);
- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.8.5.6 Source specific recalculation

There are no source specific recalculations for this category.

4.8.5.7 Source specific planned improvements

No source specific improvements are planned.

4.8.6 OTHER PRODUCT USE (CRF 2G4I)

4.8.6.1 Source category description

This category deals with the following activities:

- Fat, edible and non-edible oil extraction (SNAP activity 060404)
- Application of glues and adhesives (SNAP activity 060405)

- Preservation of wood (SNAP activity 060406)
- Printing (SNAP activity 060403)

4.8.6.2 Trend description

The trend of emissions for sector 2.G.4.I Other product use is visualized in the following chart.

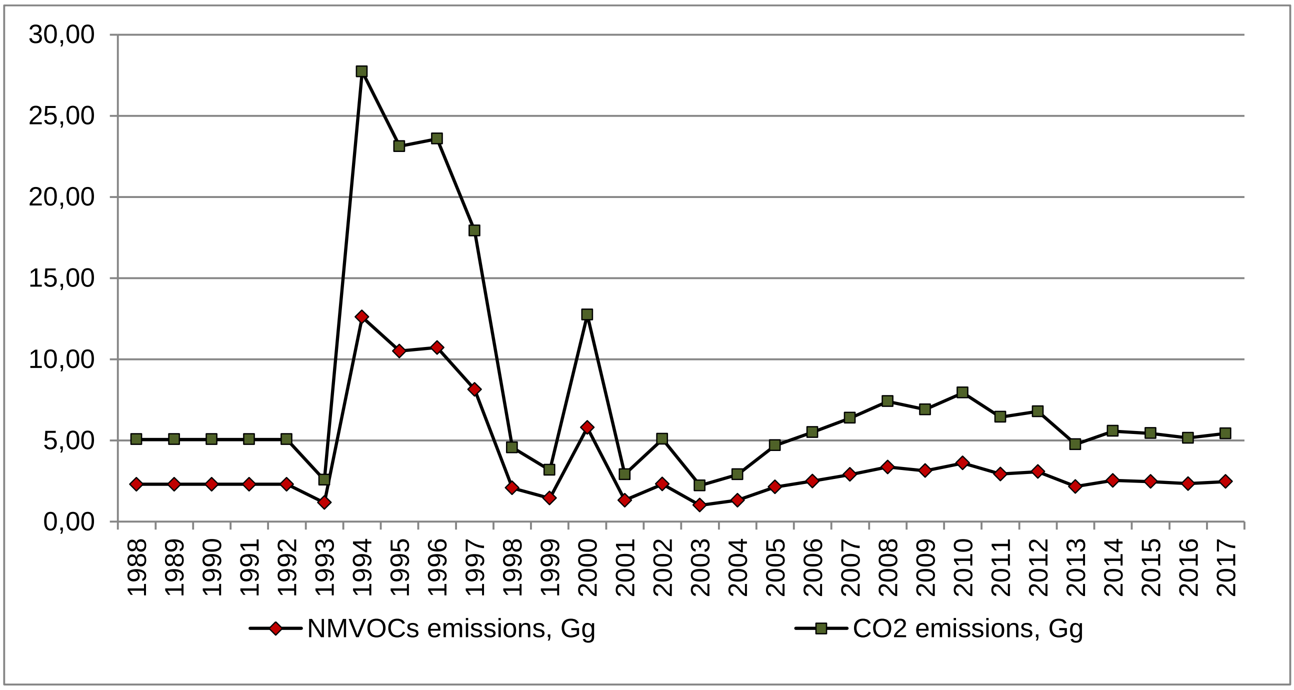

Figure 88 Trend of NMVOC and CO2 emissions in sector 2.G.4.I Other product use.

4.8.6.3 Methodological issues.

4.8.6.3.1 Emission Factor

The Tier 1 default approach has been implemented. The general equation is:

E pollutant = AR production × EF pollutant

where:
E pollutant = the emission of the specified pollutant,
AR production = the activity rate (consumption of paint, chemical production data, solvent consumption)
EF pollutant = the emission factor for this pollutant.
This equation is applied at the national level, using annual national total figures for the activity data.
TIER1 EFs provided in the EMEP/EEA 2013 Guidebook are used for NMVOC.

Table 150 Emission factors used for Other product use (CRF 2G4I)

SNAP activity	Name of activity	Emission factor	Unit	Reference
Other product use*				
060404	Fat, edible and non-edible oil extraction	1.57	g/kg seed	EMEP/EEA guidebook 2016
060405	Application of glues and adhesives	522	g/kg adhesives	EMEP/EEA guidebook 2016
060406	Preservation of wood: Creosote preservative type	945 105	g/kg preservative	EMEP/EEA guidebook

SNAP activity	Name of activity	Emission factor	Unit	Reference
	Waterborne preservative	0,5		2016
060403	Printing	730	g/kg ink	EMEP/EEA guidebook 2016

** The other SNAP activities under CRF 2G4I Other product use are not estimated due to lack of activity data.*

Converting of NMVOC into CO_2 with conversion factor is provided in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO_2.

From NMVOC:

$$Inputs_{CO_2} = Emissions_{NMVOC} \times C \times \frac{44}{12}$$

Where C is the fraction carbon in NMVOC by mass (default = 0.6)

Reference for default: conversion- factor NMVOC – CO_2, the2006 IPCC Guidelines , Volume 3, Chapter 5: Industrial Processes and Product Use, page 5.17, 2006 IPCC Guidelines s, Volume 1, Chapter 7: Precursors and Indirect Emissions, page 7.6

4.8.6.3.2 Activity Data

Activity data for sector 2.G.4.I Other product use are provided by PROTPROM for the activity "Fat, edible and non-edible oil extraction" and by NSI for the following activities: "Application of glues and adhesives" (SNAP activity 060405), "Preservation of wood" (SNAP activity 060406) and "Printing" (SNAP activity 060403).

Data on used quantities of substances used to protect wood in the manufacture of railway sleepers was obtained from the only one factory in the country. Information on the amount of creosote used in the production for the period 2005-2017 was provided, and in 2009 the company started to buy creosote with less solvent. The company also provides data on the water-soluble wood preservative used. For the period before 2005 an extrapolation of the data used by the NSI was made. In Bulgaria there are other smaller woodworking companies for the purpose of preservation, which only use a water solution preparations based on metal salts.

The activity data for sector 2.G.4.I Other product use are presented in the following table.

Table 151 Activity data for sector 2.G.4.i – Other product use

2.G.4.i – Other product use			
Year	*Other product use [kt]*	*NMVOC Emissions [kt NMVOC] [kt]*	*CO2 Emissions [kt CO2] [kt]*
1988	11.14	2.30	5.07
1990	11.14	2.30	5.07
1995	20.91	10.51	23.12
2000	121.36	5.79	12.74
2005	53.95	2.13	4.69
2010	355.48	3.61	7.94
2015	767.48	2.47	5.44
2016	740.71	2.34	5.16
2017	813.57	2.47	5.43

4.8.6.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 147

Table 152 Uncertainty of subcategory 2G4i Other product use, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2G4i	No	CO_2	10	30	31.62

4.8.6.5 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken in CRF sector Other product use.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors (time series)
- Time series consistency
- Plausibility checks of dips and jumps
- Documentation and archiving of all information required in NIR,
- Background documentation and archive.

4.8.6.6 Source specific recalculation

The recalculations are made on the basis of the quantities of used creosote and water soluble wood preservatives and the respective EF taken from the EMEP/EEA guidebook 2016.

4.8.6.7 Source specific planned improvements

No source specific improvements are planned.

4.9 OTHER: (CRF 2.H.3)

4.9.1 VEGETABLE OIL PRODUCTION (CRF 2.H.3.I)

4.9.1.1 Source category description

This chapter describes the methodology used for calculating greenhouse gas emissions from vegetable oil production in Bulgaria. Solvents are used also in vegetable oil production.

4.9.1.2 Trend description

Trend for NMVOC and CO_2 emissions from subcategory – 2H3i Other (vegetable oil production)
NMVOC emissions in Vegetable oil production 2H3i have been calculated for the period 1988 - 2017. The emission factor are in accordance with the EMEP/EEA air pollutant emission inventory guidebook –2006 and 2013[27]. The activity data are provided mainly by the National Statistics Institute – NSI.
The trend of NMVOC and CO_2 emissions is presented in the following figure.

[27] In the following referred as EMEP/EEA Guidebook (2013)

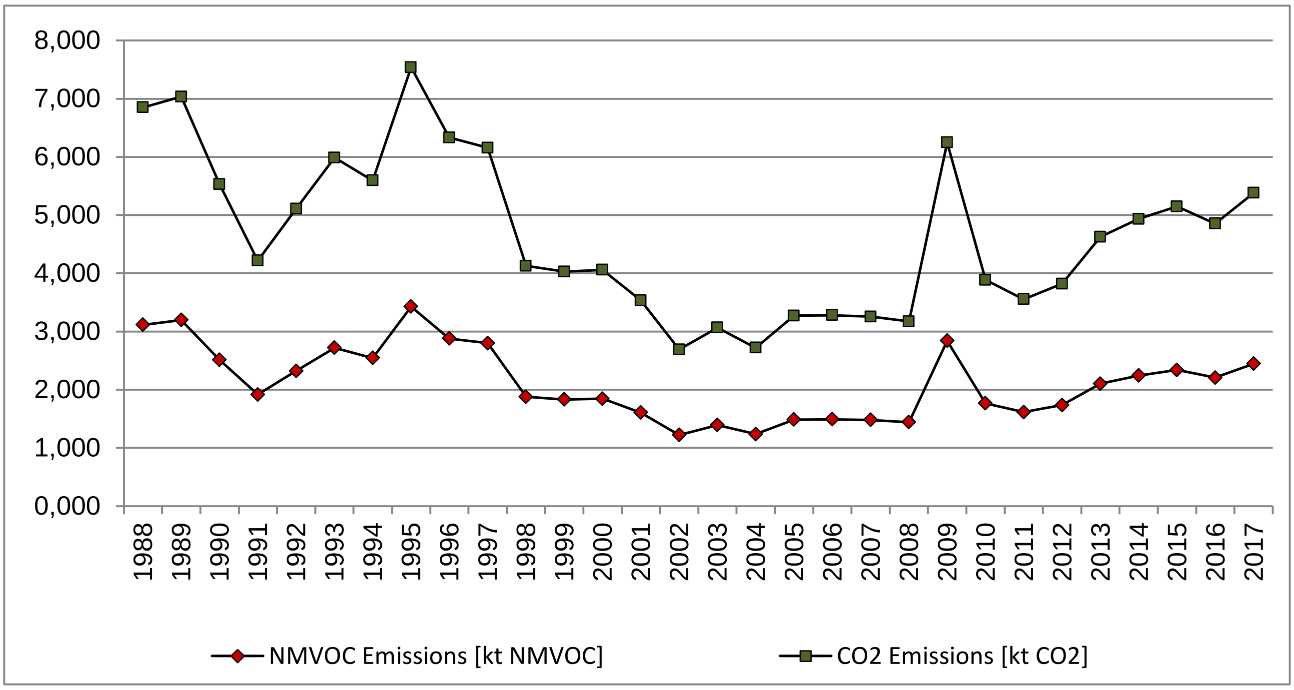

Figure 89 NMVOC and CO2 emissions in Vegateble oil production.

4.9.1.3 Methodological issues

4.9.1.3.1 Methods

The emissions of NMVOC from *2H3* Other (Vegetable oil production), are estimated based on the emission factor are in accordance with the EMEP/EEA air pollutant emission inventory guidebook – 2006 and 2013[i]. The activity data are provided mainly by the National Statistics Institute – NSI.
CO_2 emissions from *2H3* Other (Vegetable oil production)
Converting of NMVOC into CO_2 with conversion factor is provided in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO_2.
From NMVOC:

$$\boldsymbol{Inputs_{CO_2} = Emissions_{NMVOC} \times C \times \frac{44}{12}}$$

Where C is the fraction carbon in NMVOC by mass (default = 0.6)
Reference for default: conversion- factor NMVOC – CO_2, 2006 IPCC Guidelines , Volume 3, Chapter 5: Industrial Processes and Product Use, page 5.17, 2006 IPCC Guidelines s, Volume 1, Chapter 7: Precursors and Indirect Emissions, page 7.6

4.9.1.3.2 Emission Factor

The default emission factors used for assessment of emissions of NMVOC from 2H3 are presented in Table 153.

Table 153 Emission factor used for estimation of NMVOC emissions from 2H3 Other (Vegetable oil production)

SNAP activity	Name of activity	Emission factor	Unit	Reference
2H3	Vegetable oil production	18	kg/t	CORINAIR

4.9.1.3.3 Activity Data

The activity data for estimation of emissions in 2H3, are provided by the NSI.

Table 154 AD for NMVOC and CO2 emissions from 2H3 - Other (Vegetable oil production), Gg.

2H3 Other - Vegetable Oil Production		
Year	NMVOC Emissions [kt NMVOC]	CO_2 Emissions [kt CO_2]
1988	3.115	6.852
1990	2.512	5.527
1995	3.428	7.541
2000	1.845	4.059
2005	1.487	3.271
2010	1.766	3.885
2015	2.339	5.146
2016	2.207	4.854
2017	2.446	5.381

4.9.1.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented inTable 155 .

Table 155 Uncertainty of subcategory 2H3 Vegetable oil production, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
2.H.3.I	NO	CO_2	10	30	31.62

4.9.1.5 Source specific QA/QC verification

All activities regarding QC as described in QA/QC System have been undertaken.
The following sector specific QA/QC procedures have been carried out:

- Check of methodology, emissions, emission factors and IEF (time series);
- Time series consistency;
- Plausibility checks of the results (due to the national statistic);
- Documentation and archiving of all information required in NIR, background documentation and archive;
- QA procedures have been performed by the Sector expert in the MOEW (Order № RD-218/05.03.2010 by the Minister of Environment and Water).

4.9.1.6 Source specific recalculation

No source specific recalculation.

4.9.1.7 Source specific planned improvements

No source specific improvements are planned.

5 AGRICULTURE (CRF SECTOR 3)

5.1 OVERVIEW OF SECTOR

This chapter gives information about the estimation of greenhouse gas emissions from Sector Agriculture in correspondence to the data reported under the Sector 3 in the Common Reporting Format. The following sources exist in Bulgaria:

- domestic livestock activities with enteric fermentation and manure management,
- rice cultivation,
- agricultural soils,
- agricultural residue burning, and
- urea fertilisation.

5.2 EMISSION TRENDS

In the year 2017 the sector agriculture contributed 10,69% to the total of Bulgaria's greenhouse gas emissions (without LULUCF). The trend of GHG emissions from 1988 to 2017 shows a decrease of 52% for this sector due to decrease in activity data. (Figure 90)

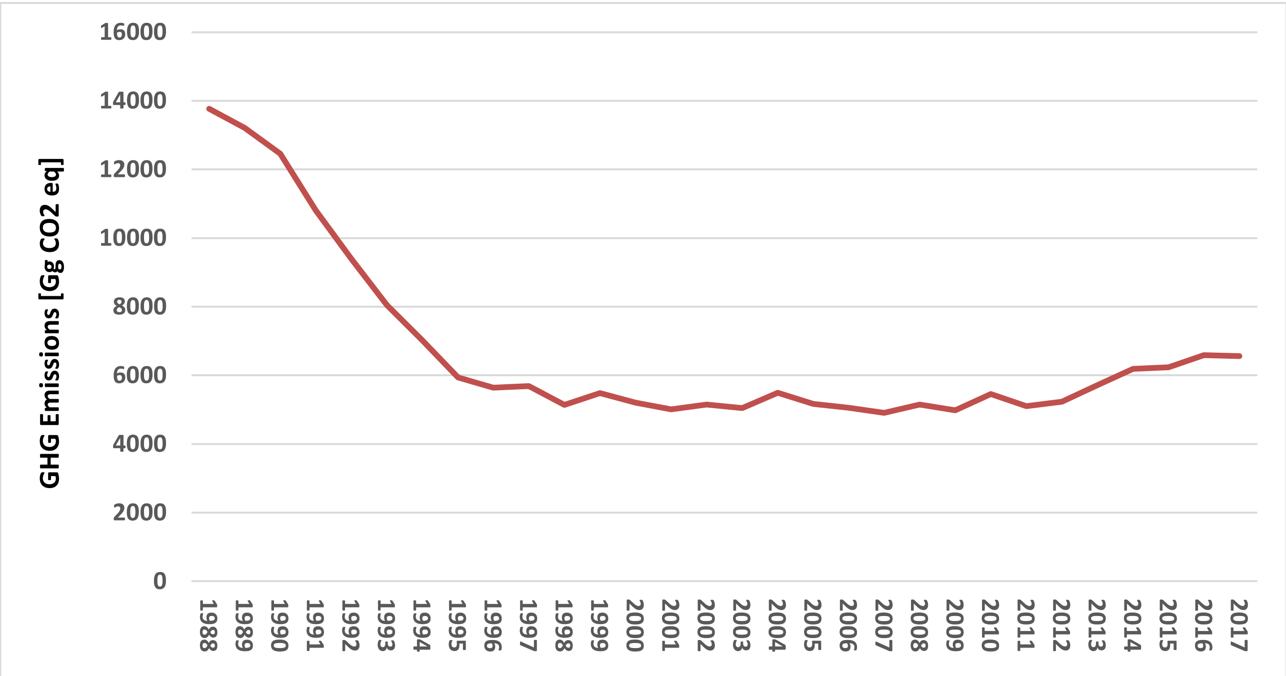

Figure 90 Trend of GHG Emissions from agriculture

5.3 EMISSION TRENDS PER GAS

CH_4 emissions are 27% from of the total emissions in the sector in CO_2-eq in 2017. A steady trend of emissions decrease is observed after 2004 due to reduction in animal numbers.

N_2O emissions from the sector are also significant. The share of N_2O emissions is 73% for the year 2017. The biggest share in these emissions has the Agricultural soils category with 89,8%. N_2O emissions from manure management and field burning of agricultural residues are of an order of magnitude smaller.

Since 1988 the CH_4 emissions from agriculture decreased by 70% and N_2O emissions by 39%. The trend is presented in Table 156.

CH_4 emissions were 70,16 Gg in the year 2017. The decrease for the year 2017 is 1,2% compared to 2016. N_2O emissions decrease from 16.022Gg in 2016 to 16.017Gg in 2017 year.

Table 156 Emissions of greenhouse gases from agriculture 1988 – 2017.

Year	GHG emissions [Gg]		
	CH_4	N_2O	CO_2
1988	237,14	26,10	62,17
1990	225,78	22,72	45,49
1995	105,95	10,97	14,88
2000	91,99	9,69	16,65
2005	82,92	10,33	18,32
2010	73,21	12,10	18,05
2015	71,53	14,82	31,27
2016	71,01	16,02	35,93
2017	70.16	16,02	33,42

5.3.1 EMISSION TRENDS PER SUB CATEGORY

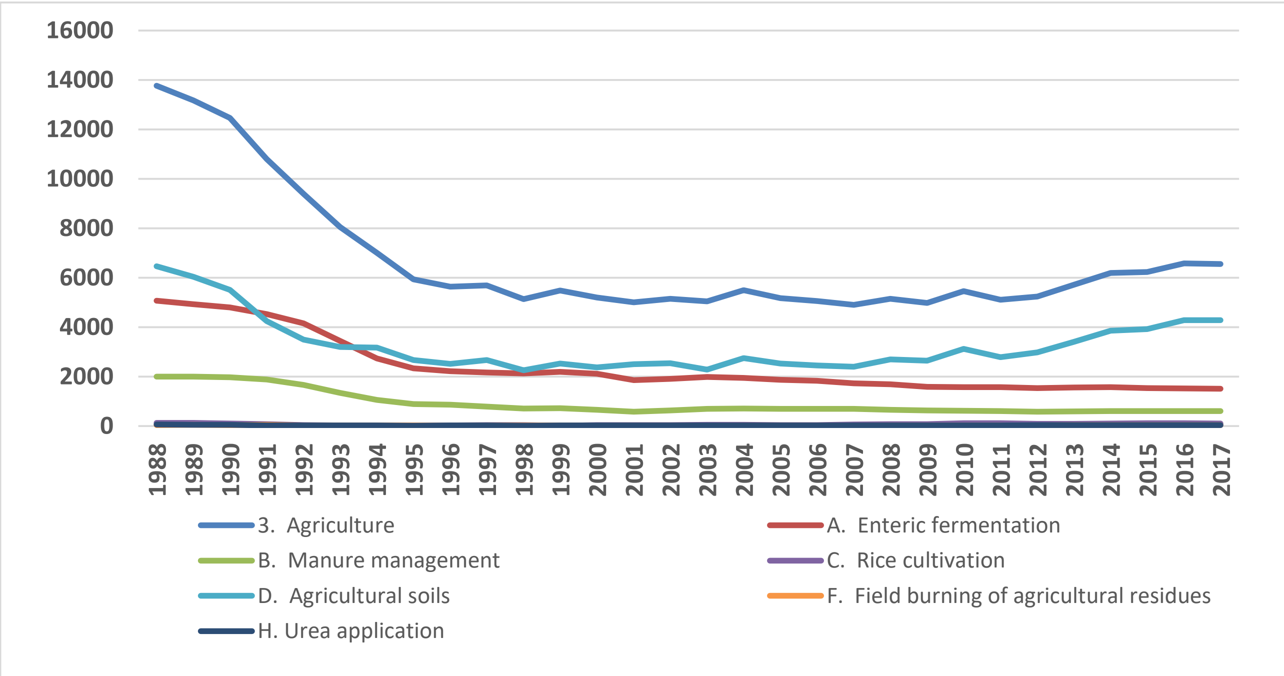

Figure 91 GHG emission trends 1988–2016 of agriculture by categories (Gg CO2-eq)

Table 157 and Figure 91 present total GHG emissions and trend 1988–2017 from agriculture by sub-categories as well as the contribution to the overall inventory emissions. Important categories are 3.D Agricultural soils (65%) and 3.A Enteric Fermentation (23%) followed by 5.B Manure management (9%).

Table 157 GHG emissions 1988–2016 of agriculture by categories.

Year	GHG emissions [Gg CO_2 equivalent] by categories						
	3	3.A	3.B	3.C	3.D	3.F	3.H
1988	13767,95	5071,20	2000,60	126,99	6469,60	37,40	62,17
1990	12461,57	4804,54	1974,49	95,37	5504,10	37,57	45,49
1995	5933,28	2329,68	889,46	12,43	2663,21	23,62	14,88
2000	5205,33	2113,83	651,98	32,16	2375,37	15,34	16,65

Year	GHG emissions [Gg CO_2 equivalent] by categories						
	3	3.A	3.B	3.C	3.D	3.F	3.H
2005	5170,04	1869,65	688,32	40,53	2532,89	20,33	18,32
2010	5454,64	1566,57	610,19	107,87	3125,78	26,17	18,05
2015	6236,25	1535,49	606,12	111,77	3919,58	32,02	31,27
2016	6585,68	1521,87	604,38	107,97	4282,63	32,91	35,93
2017	6560,44	1512,39	601,73	93,97	4284,10	34,82	33,42
Share in Total 2017	-	23,05%	9,17%	1,43%	65,30%	0,53%	0,51%

As can be seen in Figure 2 and Table 2, the overall trend for emissions in the most categories is decreasing. The reasons for the decrease are structural changes in agricultural holdings which lead to reduction in farm animal populations and decrease in arable land area.

5.3.2 KEY CATEGORIES

Table 158 Key sources of agriculture.

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment*
3.D.1	Direct N_2O emissions from Agricultural soils	N_2O	Yes
3.A.1	Enteric Fermentation - cattle	CH_4	Yes
3.B2	Manure Management	N_2O	Yes
3.D.2	Indirect N_2O from Nitrogen used in Agriculture	N_2O	Yes

5.3.3 COMPLETENESS

Table 159 gives an overview of the IPCC categories included in this chapter and provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this sub-category have been estimated.

Table 159 Overview of sub-categories of agriculture.

IPCC Category		CH_4		N_2O	CO_2
3.A	**ENTERIC FERMENTATION**	**ENTERIC FERMENTATION**	✓	**NA**	**NO**
3.A.1	Cattle	–	✓	NA	**NO**
3.A.1.	Dairy Cattle	Dairy cows	✓	NA	**NO**
3.A.1.	Non-Dairy Cattle	Other cattle	✓	NA	**NO**
3.A.1.	Young cattle	Calves and heifers	✓	NA	**NO**
3.A.2	Sheep	Sheep	✓	NA	**NO**
3.A.3	Swine	Swine	✓	NA	**NO**
3.A.4	Other livestock				**NO**
3.A.4	Buffalo	Buffalos	✓	NO	**NO**
3.A.4	Goats	Goats	✓	NA	**NO**
3.A.4	Camels and Lamas	Camels	NO	NO	**NO**
3.A.4	Horses	Horses	✓	NA	**NO**
3.A.4	Mules and Asses	Mules and asses	✓	NA	**NO**
3.A.4	Poultry	Laying hens, broilers, other poultry	NA	NA	**NO**
3.B.	**MANURE MANAGEMENT**	**MANURE MANAGEMENT REGARDING ORGANIC COMPOUNDS**	✓	**NO**	**NO**
		MANURE MANAGEMENT REGARDING NITROGEN COMPOUNDS	**NO**	✓	
3.B.1.1 +	Cattle	–	✓	✓	**NO**

IPCC Category		CH_4		N_2O	CO_2
3.B.2.1					
3.B.1.1 + 3.B.2.1	Dairy Cattle	Dairy cows	✓	✓	**NO**
3.B.1.1 + 3.B.2.1	Non-Dairy Cattle	Other cattle	✓	✓	**NO**
3.B.1.1 + 3.B.2.1	Young cattle	Calves and heifers	✓	✓	**NO**
3.B.1.4 + 3.B.2.4	Buffalo	Buffalos	✓	✓	**NO**
3.B.1.2 + 3.B.2.2	Sheep	Sheep	✓	✓	**NO**
3.B.1.4 + 3.B.2.4	Goats	Goats	✓	✓	**NO**
3.B.1.4 + 3.B.2.4	Horses	Horses	✓	✓	**NO**
3.B.1.4 + 3.B.2.4	Mules and Asses	Mules and asses	✓	✓	**NO**
3.B.1.3 + 3.B.2.3	Swine	Swine	✓	✓	**NO**
3.B.1.4 + 3.B.2.4	Poultry	Laying hens, broilers, Other poultry (ducks, gooses,…)	✓	✓	**NO**
3.B.2.5	Emissions per MMS	Emissions per MMS		✓	**NO**
3.C	**RICE CULTIVATION**	**Rice Field (with fertilizers) Rice Field (without fertilizers)**	✓	**NO**	**NO**
3.D	**AGRICULTURAL SOILS**	**CULTURES WITH FERTILIZERS CULTURES WITHOUT FERTIZERS**	**NO**	✓	**NO**
3.D.1	Direct Soil Emissions	Cultures with and without fertilizers	NO	✓	**NO**
3.D.1.3	Pasture, Range and Paddock Manure	Cultures without fertilizers	NO	✓	**NO**
3.D.3	Indirect Emissions	Cultures with and without fertilizers	NO	✓	**NO**
3.E	**PRESCRIBED BURNING OF SAVANNAS**	**–**	**NO**	**NO**	**NO**
3.F	**FIELD BURNING OF AGRICULTURAL RESIDUES**	**ON-FIELD BURNING OF STUBBLE, STRAW, …**	✓	✓	**NO**
3.F.1	Cereals	Cereals	✓	✓	**NO**
3.F.2	Pulses	Pulse	✓	✓	**NO**
3.F.3	Tubers and Roots	Tuber and Root	✓	✓	**NO**
3.F.4	Sugar Cane	Sugar Cane	✓	✓	**NO**
3.G	**LIMING**	**NO**	**NO**	**NO**	**NO**
3.H	**UREA FERTILIZATION**	**NO**	**NO**	**NO**	✓

5.3.4 QA/QC ACTIVITIES

- Sector specific QA/QC procedures are to be intensified;
- Comparison of emissions using alternative approaches;
- Food and Agriculture Organization of the United Nations (FAO);
- Documentation and archiving of all information required in NIR, background documentation and archive.

5.3.5 RECALCULATIONS AND TIME-SERIES CONSISTENCY

In the submission 2019, emissions from the Agriculture sector have been recalculated for year 2016. With the recalculations emissions of the sector is 6585.68 CO_2-eq for 2016 and 6560.44 CO_2-eq for 2017.

Recalculations are due to corrections of some technical mistakes and implementation of the recommendations from the ESD review 2018:

- The recalculation have been made for 2016 due to revised AD-population of Sheep (please see chapter Enteric Fermentation).

5.4 ENTERIC FERMENTATION (CRF SECTOR 3A)

Emissions from this key source are result from fermentation in ruminant animals' digestive system (e.g., cattle, sheep, goats). Non – ruminant livestock (horses, mules and asses) and monogastric livestock (swine) produce lower methane emissions. The amount of methane that is released depends on age, weight of the animal, and the quality and quantity of the feed consumed. All domestic animals indicated in 2006 IPCC GL except for llamas and camels are bred in Bulgaria.

In 2017, this source category was responsible for 23% of the total GHG emissions from the agriculture sector.

5.4.1 SOURCE CATEGORY DESCRIPTION

CH_4 emissions in CO_2-eq. were 1512,39 Gg in the year 2017. Compared to base year a decrease of 70% is observed.

CH_4 emissions from the enteric fermentation of domestic livestock are given in Table 160**.**

Table 160 Greenhouse gas emissions from enteric fermentation 1988–2017.

Year	CH_4 emissions [Gg] per Livestock Category								
	3.A	3.A.1	3.A.1	3.A.1	3.A.4	3.A.2	3.A.4	3.A.4	3.A.3
	Total	Mature Dairy	Mature Non-Dairy	Young	Buffalo	Sheep	Goats	Horses, Mules & asses	Swine
1988	202,85	66,18	12,11	44,71	1,66	64,13	2,17	5,82	6,06
1990	192,18	64,80	11,40	42,10	1,53	58,16	2,17	5,68	6,34
1995	93,19	38,69	3,63	13,39	1,02	24,46	3,68	5,27	3,04
2000	84,55	42,36	2,86	11,85	0,64	15,69	4,47	4,77	1,91
2005	74,79	38,27	3,24	12,99	0,53	11,59	3,32	3,45	1,41
2010	62,66	32,74	3,51	10,13	0,58	9,89	1,79	2,98	1,05
2015	61,42	30,50	6,86	9,71	0,67	9,82	1,42	1,57	0,86
2016	60,87	29,66	8,15	8,88	0,76	9,92	1,29	1,31	0,91
2017	60,50	28,29	8,94	9,20	0,82	9,86	1,24	1,23	0,91
Share 2017	-	48%	15%	15%	1%	16%	2%	2%	1%
Trend 1988–2017	-70%	-57%	-26%	-79%	-50%	-85%	-43%	-79%	-85%

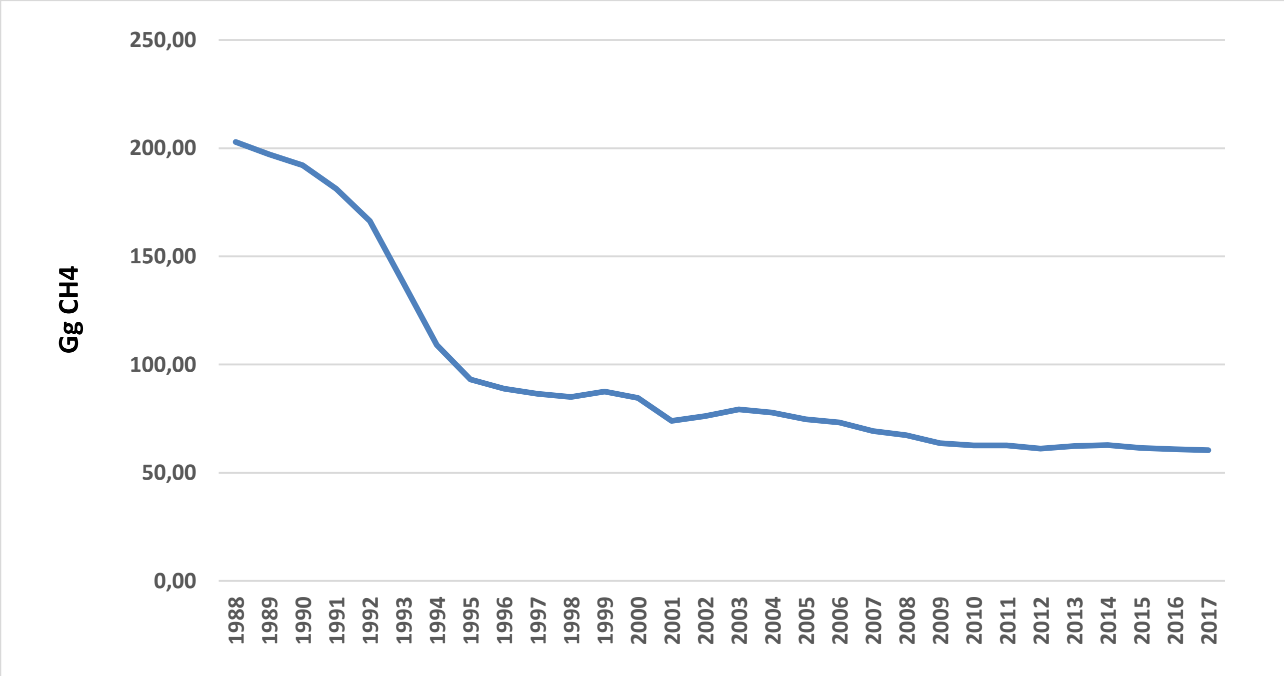

Figure 92 CH_4 emissions from enteric fermentation

Figure 92 shows steady decrease in CH_4 emissions after 2002. The rapid decrease in the period 1991-1995 is consequence of a reform in agricultural holdings during this period. The overall reduction is caused by a decrease in total numbers of animals.

5.4.2 METHODOLOGICAL ISSUES

5.4.2.1 Methods

The IPCC Tier 1 method has been used to estimate the emissions from all farm animal categories with the exception of cattle (IPCC Sub-category 3A1) and sheep (IPCC Sub-category 3A2) for which Tier 2 method is used and option B for cattle.

5.4.2.2 Emission factors

Country specific emission factors are used for cattle and sheep. They are calculated from the specific gross energy intake and the methane conversion rate.

$$\mathbf{EF_i = [GE_i \bullet Ym_i \bullet 365] / 55.65}$$

With *i = each livestock category*

EF_i expressed in kg CH_4/head/year

Y_m Methane conversion rate

Ge =Gross energy intake

The factor 55.65 expressed in MJ/kg of CH_4

➔ See equation 10.21 in the 2006 IPCC GL.

For the Tier 1 method, default GE is usually provided in the 2006 IPCC GL. For the Tier 2 method, GE is the combination of various feed intake – or net energy – estimates relating to maintenance, activity, growth, etc. of the animals.

The methane conversion rate (Y_m) is taken from the 2006 IPCC GL.

Tier 2 method – cattle and sheep

The IEF for cattle and sheep are representing in Table 164.

For **dairy cattle**, the EF has been calculated by combining activity data, coefficients and parameters shown in Table 161. Bulgarian specific values for dairy cows were derived from feed intake data and energy content of food in dependency of annual milk yields.

DE% has been update in submission 2017 with value equal to 71%.

Information have been based on the article "Effect of sunflower expeller supplementation on intake and digestibility of pasture grass with low protein content"[28] published in *Bulgarian Journal of Agricultural Science, 15 (No 2) 2009, 168-176, Agricultural Academy.*

Table 161 Activity data and parameters used for IPCC Sub-category 3A1 – Cattle – Mature Dairy Cattle

Parameter	Unit	Source
Livestock (# of animals)	#	Ministry of Agriculture, Food and Forestry (see Table 167**)**
Live Weight	kg	Executive Agency for Selection and Reproduction in Animal Breeding (see Table 171)
Calf Birth weight	kg	Ministry of Agriculture, Food and Forestry
Daily Weight Gain	kg/day	NA
Annual Milk Yield	kg/cow/year	Ministry of Agriculture, Food and Forestry (see . Table 169)
Daily Milk Yield	kg/cow/day	Calculated using division by 365 days/yr
Fat Content of Milk	%	Ministry of Agriculture, Food and Forestry(see . Table 169)
Digestible Energy	%	Country-specific value equal to 71 %;
Net Energy for Maintenance	MJ/day	Eq. 10.3 & Table 10.4 - 2006 IPCC GL
Net Energy for Activity	MJ/day	Eq. 10.5 & Table 10.5 - 2006 IPCC GL
Net Energy for Growth	MJ/day	Eq. 10.6 - 2006 IPCC GL
Net Energy for Lactation	MJ/day	Eq. 10.8 - 2006 IPCC GL
Net Energy for Work	MJ/day	Eq. 10.11 - 2006 IPCC GL
Net Energy for Pregnancy	MJ/day	Eq. 10.13 & Table 10.7 - 2006 IPCC GL
Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed		Eq. 10.14 - 2006 IPCC GL
Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed		Eq. 10.15 - 2006 IPCC GL
Gross Energy Intake (average)	MJ/day	Eq. 10.16 - 2006 IPCC GL
CH4 conversion rate (average)	%	Table 10.12 - 2006 IPCC GL
Implied Emission Factor - CH4	kg CH_4/head/ year	Eq. 10.21 - 2006 IPCC GL

For the **other cattle** categories, IEF's are obtained by combining slightly different parameters which are listed in Table 162.

[28] N. A. TODOROV (Thracian University, Faculty of Agriculture, BG-6000 Stara Zagora, Bulgaria) and H. S. ALI (Research Institute of Mountain Stockbreeding and Agriculture, BG-5600 Troyan, Bulgaria)

Table 162 Activity data and parameters used for IPCC Sub-category 3A1 – Cattle – Non-Dairy Cattle

Parameter	Unit	Source
Livestock	#	Ministry of Agriculture,Food and Forestry (see Table 167)
Live weight	kg	Executive Agency for Selection and Reproduction in Animal Breeding (see Table 171)
Live body weight	kg	Agrostatistics bulletins
Daily weight gain	kg/day	- mature non-dairy cattle: NA - young cattle: Default
Digestible energy	%	- 60%, Table 10.2 IPCC 2006
Net energy for maintenance	MJ/day	equation 10.3 & table 10.4 – 2006 IPCC GL
Net energy for activity	MJ/day	equation 10.5 & table 10.5 – 2006 IPCC GL
Net energy for growth	MJ/day	equation 10.6 – 2006 IPCC GL
Net energy for lactation	MJ/day	Equation 10.8 – 2006 IPCC GL
Net energy for work	MJ/day	equation 10.11 – 2006 IPCC GL
Net energy for pregnancy	MJ/day	Equation 10.13& table 10.7 – 2006 IPCC GL
Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed	#	equation 10.14 – 2006 IPCC GL
Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed	#	equation 10.15 – 2006 IPCC GL
Gross Energy Intake (average)	MJ/day	equation 10.16 – 2006 IPCC GL
CH4 Conversion Rate (average)	%	table 10.12 – 2006 IPCC GL

For the **Sheep,** EF has been calculated by combining activity data, coefficients and parameters shown in table below.

For more accurate estimations, sheep have been divided into follow sub-categories:

- Mature sheep for meat or wool production or both;
- Mature sheep for commercial milk production;
- Other (males);
- Young sheep – intact males, castrates & females;

All estimations are based on the equations listed in IPCC 2006 and activity data provided from Miniry of Agriculture, Food and Forestry (please see table below).

Table 163 Activity data and parameters used for IPCC Sub-category 3A2 – Sheep:

Parameter	Unit	Source
Livestock (# of animals)	#	Ministry of Agriculture, Food and Forestry (see Table 168)
Live Weight	kg	Ministry of Agriculture, Food and Forestry (see Table 171)
Weight at weaning	kg	Ministry of Agriculture, Food and Forestry
Daily Weight Gain	kg/day	NA
Annual Milk Yield	kg/sheep/year	Ministry of Agriculture, Food and Forestry
Daily Milk Yield	kg/sheep/day	Calculated using division by 365 days/yr
Fat Content of Milk	%	Ministry of Agriculture, Food and Forestry– 6.5 % for the whole time series
Digestible Energy	%	Table 10.2 - 2006 IPCC GL
Net Energy for Maintenance	MJ/day	Eq. 10.3 & Table 10.4 - 2006 IPCC GL
Net Energy for Activity	MJ/day	Eq. 10.5 & Table 10.5 - 2006 IPCC GL

Parameter	Unit	Source
Net Energy for Growth	MJ/day	Eq. 10.7 - 2006 IPCC GL
Net Energy for Lactation	MJ/day	Eq. 10.9 - 2006 IPCC GL
Net Energy for Pregnancy	MJ/day	Eq. 10.13 & Table 10.7 - 2006 IPCC GL
Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed		Eq. 10.14 - 2006 IPCC GL
Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed		Eq. 10.15 - 2006 IPCC GL
Gross Energy Intake (average)	MJ/day	Eq. 10.16 - 2006 IPCC GL
CH4 conversion rate (average)	%	Table 10.13 - 2006 IPCC GL
Implied Emission Factor - CH4	kg CH_4/head/year	Eq. 10.21 - 2006 IPCC GL

Table 164 Enteric fermentation emission factors for cattle and sheep:

	Emission Factor [kg CH_4/head*yr]			
Year	**Mature Diary Cattle**	**Mature Non-Diary Cattle**	**Young Cattle**	**Sheep**
1988	105,28	78,94	50,72	6,95
1989	104,70	78,94	50,69	6,93
1990	104,67	78,94	50,69	6,95
1991	99,61	78,94	50,69	6,88
1992	97,30	78,94	50,69	6,87
1993	95,26	78,94	50,69	6,88
1994	96,53	78,94	50,69	6,90
1995	100,73	78,94	50,69	6,83
1996	102,92	78,94	50,69	6,85
1997	103,56	78,94	50,69	6,81
1998	106,54	78,94	50,69	6,86
1999	105,10	78,94	50,66	6,86
2000	108,07	78,55	51,77	7,04
2001	104,68	78,25	49,01	7,10
2002	107,38	78,77	49,62	7,04
2003	107,29	78,98	51,04	7,01
2004	107,79	79,14	48,76	6,98
2005	106,83	79,35	52,44	7,03
2006	107,96	79,17	53,21	7,03
2007	104,03	78,69	47,63	7,05
2008	105,73	78,75	51,02	7,14
2009	105,69	79,28	49,85	7,17
2010	108,25	78,64	52,06	7,14
2011	107,64	78,08	52,72	7,09
2012	107,84	78,01	51,72	7,12
2013	109,86	78,04	53,49	7,26
2014	108,06	77,74	52,83	7,36
2015	106,73	77,27	54,85	7,37
2016	108,34	76,95	50,93	7,37
2017	108,11	76,90	53,79	7,37

For mature dairy cattle, over the period 1988-2017, the milk yield has increased by 7% (see Table 169). At the same time the dairy cattle population decline. As these two parameters are the main drivers for the calculation of the EF under the Tier 2 method, it is the reason to have slight fluctuations in the EF expressed in CH_4/head/year for mature dairy cattle.

The slight fluctuations in EFs for mature non-dairy cattle are because those are weight average EF between several categories (mature males and females).

The main driver for the calculation of the EF for young cattle is the live-weight, and for them this weight is not constant (see Table 172), so this is the reason for the differences in EF.

The slight fluctuations in EFs for sheep are because those are weight average EF between several categories.

Tier 1 method – all farm animal categories except cattle and sheep

For farm animals, other than cattle and sheep, the IEFs are the default enteric fermentation EFs for developed countries represent in Table 166. More details are provided in Table 165.

Table 165 Activity data, coefficients and parameters used for goats, horses, mules and asses, swine:

Parameter name	Unit	Parameter source
Livestock	#	-Miniry of Agriculture, Food and Forestry– Agrostatistics department -Bulgarian Foodsafety Agency, Animal Health and Welfare Directorate (see Table 168)
Live Weight	kg	- Miniry of Agriculture, Food and Forestry– Agrostatistics department (see Table 171) - Executive Agency for Selection and Reproduction in Animal Breeding

Table 166 Enteric fermentation emission factors for farm animals, other than cattle and sheep (buffalo, goats, horses, mules and asses, swine):

Livestock category	Emission factor [kg CH_4 $HEAD^{-1}$ YR^{-1}]	Reference
Buffalo	66*	Table 10.10 - 2006 IPCC GL
Goats	5	Table 10.10 - 2006 IPCC GL
Horses	18	Table 10.10 - 2006 IPCC GL
Mules and Asses	10	Table 10.10 -2006 IPCC GL
Swine	1,5	Table 10.10 - 2006 IPCC GL

*Emission factor for buffalo have been recalculated, according ERT recommendation (BG NIR 2017)

- The ERT recommended Bulgaria scale the EF used for estimating CH4 emissions from Enteric fermentation for buffalo following the recommendations in the 2006 IPCC guidelines by multiplying the default EF factor of reference by (380/300)0.75 (see Table 10.10 in the Guidelines).

5.4.2.3 Activity data

5.4.2.3.1 Livestock populations

The average number of animals per year is shown in Table 167**;** Table 168.

Data is collected from the Agricultural Statistics Department of the Ministry of Agriculture, Food and Forestry, Bulgarian Food Safety Agency, FAO Database and National Statistics Institutes' yearbooks 1990-2000.

The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data. In the case of Bulgaria, this data comes from the national statistical system. FAOSTAT data are seemingly based on the official data but there is an annual attribution error (according FAO's requirements numbers of animal should be presented from 1 October to 30 September. In Bulgaria agriculture statistics is collected by 1 November, so the official data from the year before are the data for the present year in FAO).

For the period 1988-2000 the main data source is National statistics Institute's yearbooks.

For the period 2000-present there is agreement with the Agrostatistics Department at the Ministry of Agriculture, Food and Forestry (MAFF), to provide activity data for the preparation of the NGHGI, and this is the official source of agricultural statistics.

MAFF collect agricultural statistics in Bulgaria with surveys. There are large legal basis with Regulations and Ordinances which determinate the methods and conduct of statistical surveys.

The livestock statistics is based on Regulation (EC) No 1165/2008 of the European Parliament and of the Council concerning livestock and meat statistics and repealing Council Directives 93/23/EEC, 93/24/EEC and 93/25/EEC.

According to the Statistical National program, the results of the statistical surveys, carried out by the Agrostatistics Department, are published on the website of the MAFF.

Every year there are agrostatistics bulletins with information on livestock (number of agricultural animals, milk production, meat production, live weight) and crops productions.

(see http://www.mzh.government.bg/MZH/bg/ShortLinks/SelskaPolitika/Agrostatistics.aspx).

According Ordinance on the terms and procedure for organizing the national inventories of emissions of harmful substances and greenhouse gases into the ambient air, there is an agreement whit the Bulgarian Food Safety Agency, which presented information on numbers of horses, mules and asses after 2010 year to present. Before 2010, activity data are provided as follow – 1988 - 2001: National statistics Institute's yearbooks; 2002 - 2009: FAO data base.

Table 167 Domestic livestock populations 1988–2017 (1000 number) (I).

	Dairy cattle	Non-dairy cattle-females	Non-dairy cattle - bulls	Young cattle - <1yr	Young cattle 1-2yrs	Goats	Buffalo
1988	628,64	134,37	18,97	688,06	193,45	434,78	25,31
1989	628,78	130,11	18,37	666,28	187,32	431,98	23,89
1990	619,14	126,59	17,87	648,25	182,25	434,28	23,27
1991	601,25	118,77	16,77	608,21	171,00	465,51	24,28
1992	585,30	103,66	14,64	530,84	149,24	525,41	25,34
1993	530,33	79,43	11,21	406,75	114,36	581,98	23,64
1994	452,79	53,14	7,50	272,12	76,51	643,83	19,68
1995	384,11	40,28	5,69	206,25	57,99	735,93	15,46
1996	359,52	35,77	5,05	183,15	51,49	814,38	13,69
1997	363,21	31,64	4,47	162,03	45,55	841,03	12,57
1998	371,85	29,22	4,13	149,63	42,07	907,43	11,00
1999	404,24	30,81	4,35	157,78	44,36	1006,86	10,46
2000	392,02	32,40	3,97	183,50	45,42	893,82	9,67
2001	360,63	30,01	3,27	206,41	38,52	707,66	7,76
2002	358,41	35,22	4,68	219,26	45,26	714,88	7,01
2003	360,01	42,72	6,11	237,08	63,86	739,89	7,68
2004	365,28	38,76	5,83	224,58	65,50	721,71	7,92
2005	358,24	35,15	5,66	190,67	56,97	663,27	8,09
2006	348,95	35,81	5,44	180,61	54,23	578,75	8,22
2007	343,02	38,12	4,91	174,20	54,91	522,28	8,61
2008	325,28	39,32	5,18	160,90	52,80	462,66	9,10
2009	305,71	38,56	6,07	148,90	52,99	395,33	8,77
2010	302,46	39,58	5,02	141,36	53,22	358,58	8,78

	Dairy cattle	Non-dairy cattle-females	Non-dairy cattle - bulls	Young cattle - <1yr	Young cattle 1-2yrs	Goats	Buffalo
2011	307,50	44,42	4,49	139,75	54,88	348,85	9,56
2012	297,80	48,96	4,82	129,78	60,52	317,50	9,55
2013	297,92	51,59	5,13	133,91	62,29	291,47	9,59
2014	301,24	60,68	5,24	133,53	63,51	290,98	9,76
2015	285,77	83,21	5,51	113,18	63,83	284,78	10,20
2016	273,74	100,54	5,36	112,42	61,97	257,23	11,56
2017	261,69	110,59	5,66	112,55	58,56	247,26	12,54

Table 168 Domestic livestock populations 1988–2017 (1000 number) (II).

	Mature sheep			Young sheep	Horses	Swine	Mules & Asses	Poultry	
	For meat or wool production or both	commercial milk production	Other (males)	Intact males, castrates & Females				Chicken (1)	ducks, geese, etc.(2)
1988	590,22	6 838,09	217,21	1 579,05	122,13	4 042,18	362,20	35 856,16	4 723,47
1989	559,69	6 484,38	205,97	1 497,37	122,41	4 076,47	355,27	36 770,38	4 843,90
1990	535,52	6 204,34	197,08	1 432,71	120,45	4 225,23	351,51	34 523,50	4 547,91
1991	514,06	5 955,66	189,18	1 375,28	117,16	4 259,10	349,19	28 423,85	3 744,38
1992	468,41	5 426,78	172,38	1 253,15	114,85	3 663,99	347,42	21 959,95	2 892,87
1993	368,47	4 268,97	135,60	985,79	113,99	2 910,56	335,32	18 369,90	2 419,94
1994	274,41	3 179,21	100,99	734,14	113,44	2 375,53	322,03	16 825,50	2 216,49
1995	229,09	2 654,12	84,31	612,89	123,11	2 028,76	305,86	16 495,86	2 173,06
1996	216,93	2 513,21	79,83	580,35	141,78	2 063,10	294,69	16 671,62	2 196,22
1997	204,83	2 373,11	75,38	548,00	160,50	1 820,23	301,10	15 390,86	2 027,50
1998	187,70	2 174,62	69,08	502,16	148,34	1 490,09	273,06	13 692,69	1 803,79
1999	179,04	2 074,24	65,89	478,98	129,79	1 600,62	239,41	13 453,35	1 772,26
2000	142,63	1 652,50	52,49	381,60	137,20	1 276,43	230,12	13 540,63	1 783,76
2001	106,45	1 233,33	36,37	264,40	140,67	809,90	216,38	13 233,72	1 743,33
2002	106,54	1 234,38	37,36	271,60	145,50	892,46	185,77	14 636,46	1 928,12
2003	105,59	1 223,32	42,21	292,34	142,85	1 014,39	151,50	17 673,16	1 849,54
2004	104,48	1 210,50	39,47	291,08	130,66	981,85	130,75	18 239,40	1 970,25
2005	99,63	1 233,17	36,14	278,44	130,66	937,20	110,00	17 182,20	2 331,35
2006	97,55	1 207,74	36,87	276,68	141,50	977,82	94,00	17 582,00	2 254,00
2007	106,91	1 157,90	36,48	279,61	151,50	950,63	83,00	17 192,50	2 235,00
2008	102,40	1 113,38	35,54	249,31	161,64	836,13	71,90	16 095,50	2 028,00
2009	79,07	1 087,72	33,64	237,11	171,68	756,72	60,90	15 883,50	1 591,50
2010	72,49	1 041,76	27,20	242,67	134,39	696,90	56,52	15 032,50	1 635,00
2011	78,62	1 054,48	27,19	251,01	87,17	636,13	54,19	13 606,00	1 688,50
2012	80,94	1 048,25	30,61	248,28	79,94	569,61	50,51	13 493,00	1 464,50
2013	87,48	1 031,56	30,59	215,93	77,52	558,68	48,44	12 751,50	1 485,50
2014	84,63	1 046,34	31,76	189,69	75,74	569,77	45,05	12 318,00	1 593,50
2015	86,21	1 026,82	32,39	188,18	67,78	576,59	35,33	13 614,00	1 490,50
2016	97,55	1 025,39	31,79	191,26	58,62	608,25	25,53	13 353,00	1 297,00
2017	103,49	1 009,15	32,29	193,51	60,70	604,79	13,89	12 656,00	1 572,00

(1) broiler and layer chickens, roosters, chicks
(2) ducks, geese, turkeys, guinea-fowls, wild poultry

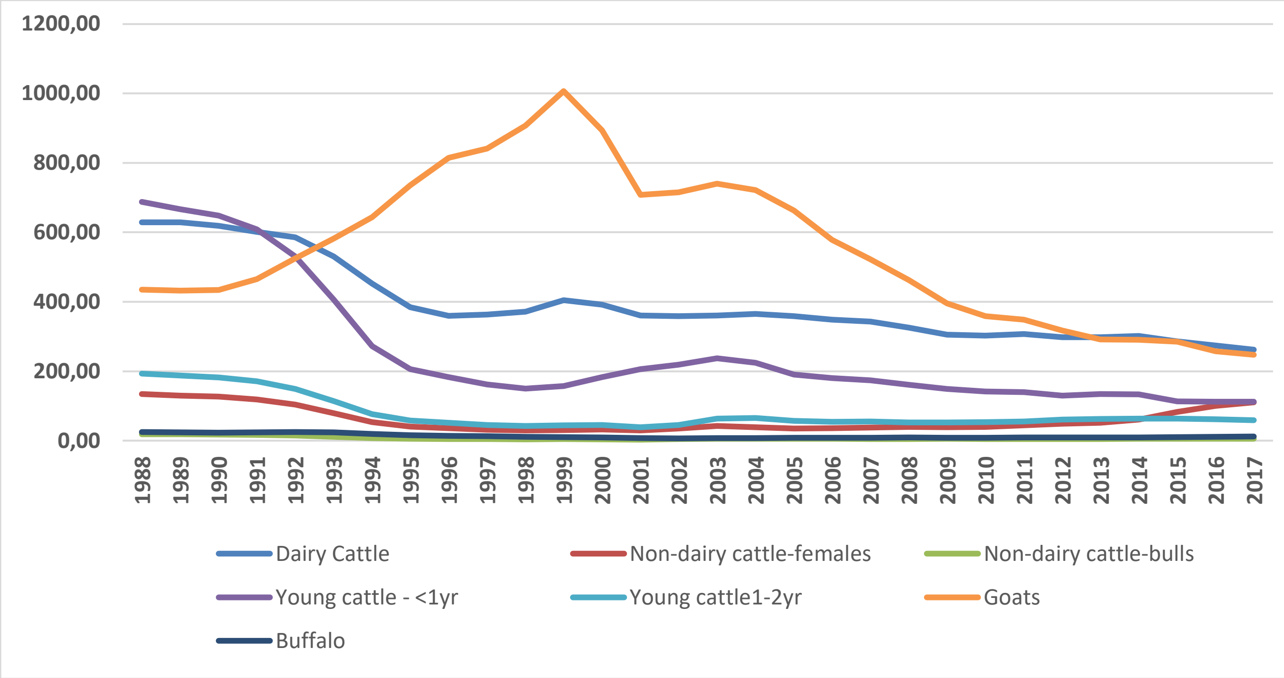

Figure 93 Domestic livestock populations (I)

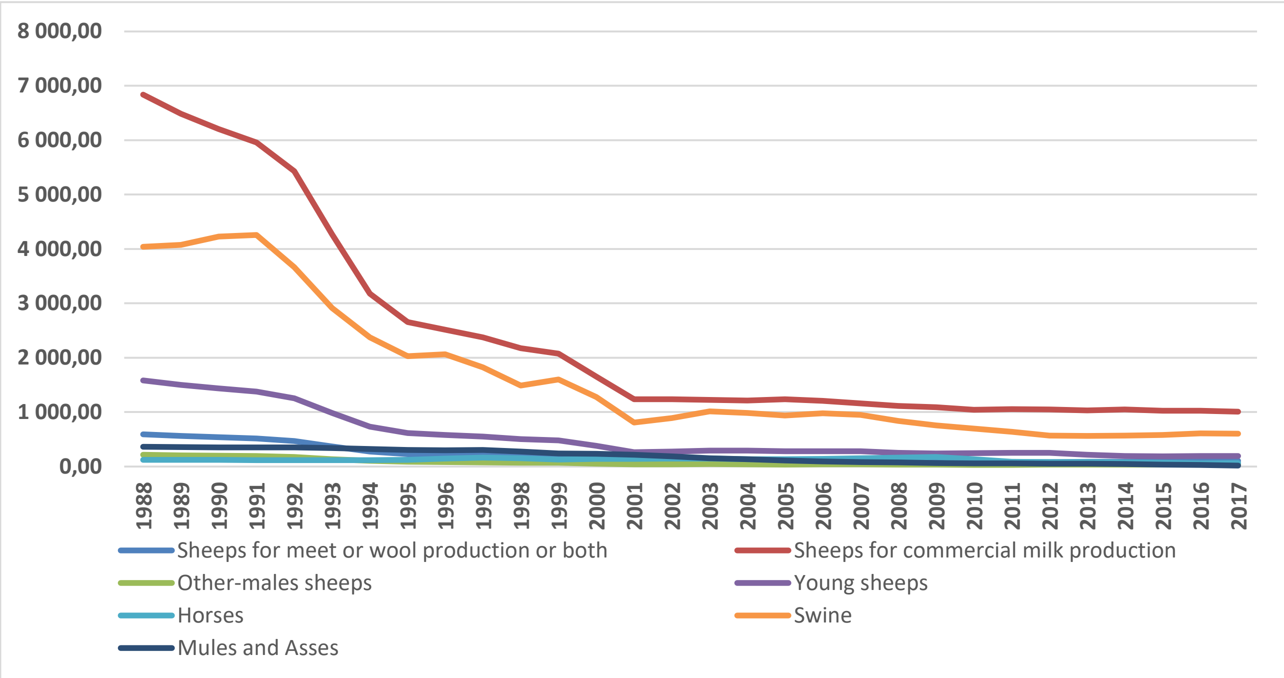

Figure 94 Domestic livestock populations (II)

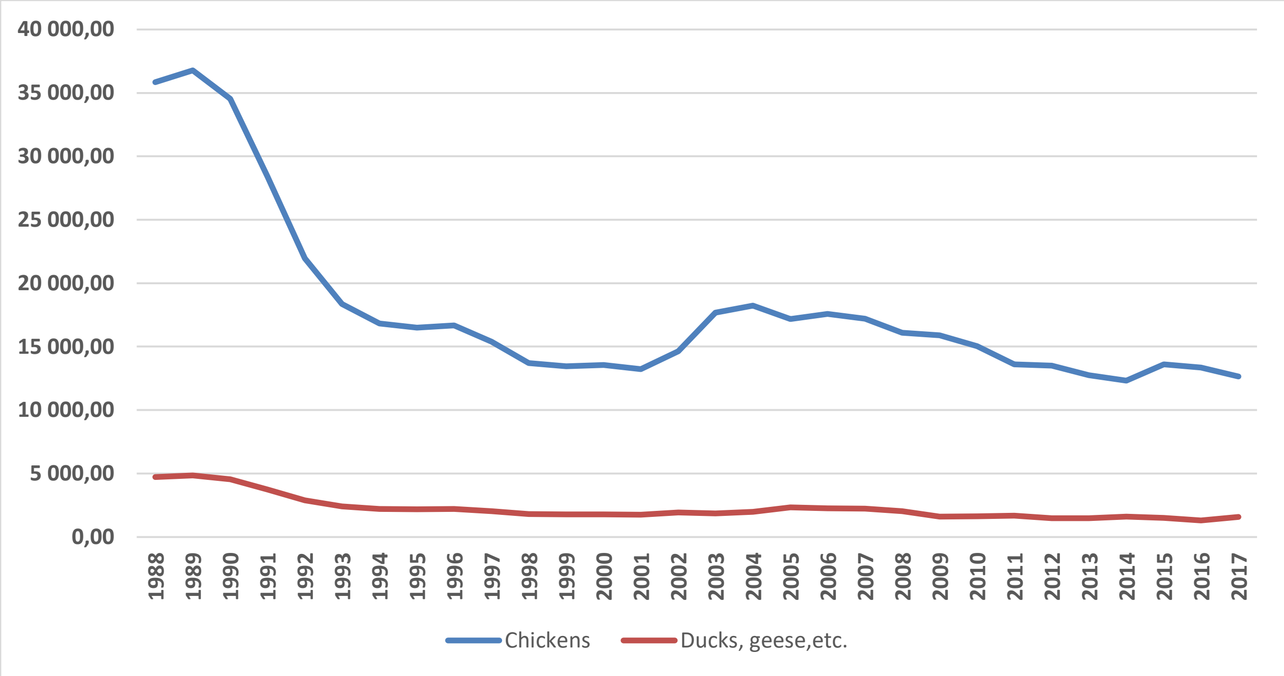

Figure 95 Domestic livestock populations (III)

The rapid decline in cattle, swine and sheep numbers in the period 1992-1994 is due to reforms in agricultural holdings.The main reasons for the declining GHG emission trend in Bulgaria are the structural economic changes due to the radical transition process from a centrally-planned economy to a market-based economy.

5.4.2.3.2 Milk yield and fat content

The milk yield is obtained by dividing the milk production by the number of dairy cows. It is measured in kg per head. The Agrostatistics department at the Ministry of Agriculture, Food and Forestry calculates the milk production by adding up the amount of milk collected by the dairy industry directly from the farmers. All milk production is considered.

Over the period 2000-2015, the milk yield has decreased by 3 %. This is the reason for the slight fluctuations in Gross energy intake expressed in MJ/head/day.

The fat content of milk for 2017 is 3,67 %. Data on the fat content of milk is available in EUROSTAT.

Table 169 Milk yield, gross energy intake for dairy cattle: 1988 – 2017:

Year	Milk Yield [kg/cow*yr]	Gross Energy Intake [MJ/head*day]
1988	4127,43	246,94
1990	4060,55	245,51
1995	3626,27	236,27
2000	4435,56	253,48
2005	4299,03	250,58
2010	4448,66	253,90
2015	4305,16	250,35
2016	4452,84	254,12
2017	4427,48	253,58

Source: Ministry of Agriculture and Food, Agrostatistics Department

For the sheep, milk yield is obtained by dividing the milk production by the number of mature sheep.

It is measured in kg per head. Data is provided by the Agrostatistics department at the Ministry of Agriculture, Food and Forestry. MAFF provided the data on the fat content. It's constant over the time – 6,5 %.

Table 170 Milk yield, gross energy intake for sheep: 1988 – 2017

Year	Milk Yield [kg/sheep*yr]	Gross Energy Intake [MJ/head*day]
1988	80,82	16,64
1990	80,82	16,63
1995	80,82	16,36
2000	80,82	16,84
2005	85,19	16,82
2010	81,59	17,09
2015	72,38	17,55
2016	77,71	17,56
2017	68,7	17,56

5.4.2.3.3 Live weight

Live-weight for most animal categories has been provided by the Agrostatistics department of Ministry of Agriculture, Food and Forestry. These data are not published as such and, therefore, might be considered as expert judgments. However, they rely on measurements and are not purely speculative. These weights are constant over time and are provided in Table 171. For buffalo, goats, horses and mules and asses the live-weight is default from Table 10A-6 and Table 10A-9 - 2006 IPCC GL.

Table 171 Live-weight for farm animals reported in the inventory

<table>
<tr><th>Livestock category</th><th colspan="2">Live-weight in kg used for estimating enteric fermentation emissions</th></tr>
<tr><td>Cattle – Mature Dairy Cattle</td><td colspan="2">588</td></tr>
<tr><td>Cattle – Mature Non-Dairy Cattle – Females</td><td colspan="2">613</td></tr>
<tr><td>Cattle – Mature Non-Dairy Cattle – Males</td><td colspan="2">880</td></tr>
<tr><td>Cattle – Young Cattle – Calves</td><td colspan="2">199</td></tr>
<tr><td>Cattle – Young Cattle – Growing Heifers</td><td colspan="2">390</td></tr>
<tr><td>Sheep-Mature ewes where either meat or wool production or both is the primary purpose</td><td colspan="2">61.00</td></tr>
<tr><td>Sheep-Mature ewes where commercial milk production is the primary purpose</td><td colspan="2">45.20</td></tr>
<tr><td>Mature Sheep-Other(males)</td><td colspan="2">65.00</td></tr>
<tr><td rowspan="2">Young sheep - Intact males, castrates & Females</td><td>Slaughter body weight</td><td>16,00</td></tr>
<tr><td>Weight at weaning</td><td>12.90</td></tr>
<tr><td>Swine</td><td colspan="2">104.00</td></tr>
<tr><td>Poultry – Chickens</td><td colspan="2">2.10</td></tr>
<tr><td>Other – Other Poultry</td><td colspan="2">4,48</td></tr>
<tr><td>Buffalo</td><td colspan="2">380,00</td></tr>
<tr><td>Goats</td><td colspan="2">38,50</td></tr>
<tr><td>Horses</td><td colspan="2">377,00</td></tr>
<tr><td>Mules and asses</td><td colspan="2">130,00</td></tr>
</table>

Source: Ministry of agriculture and Food, Agrostatistics department

Live-weight for young cattle is not constant over the time. The live-weight for calves and growing heifers has been provided by the Agrostatistics department of Ministry of Agriculture, Food and Forestry(see Table 172). Due to lack of data, for the period 1988 – 1999 average value have been used.

Table 172 Live-weight for young cattle 1988 – 2016:

Year	Live-weight Cattle – Young Cattle – Calves	Live-weight Cattle – Young Cattle – Growing Heifers
1988	200,38	369,06
1990	200,38	368,07
1995	200,38	368,07
2000	211,30	361,05
2005	209,75	379,45
2010	200,60	385,15
2015	211,00	389,55
2016	187,68	363,43
2017	207,15	381,55

5.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty from methane emissions from this source is 50%.

Table 173 Uncertainty of sub-sector Enteric Fermentation for 2017, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
3.A.1	Cattle	CH_4	0.64	20	20
3.A.4	Buffalo	CH_4	0.64	50	50
3.A.2	Sheep	CH_4	1.63	20	20
3.A.4	Goats	CH_4	1.65	50	50
3.A.4	Horses	CH_4	2	50	50
3.A.4	Mules and Asses	CH_4	2	50	50
3.A.3	Swine	CH_4	0.51	50	50
3.A.4	Poultry	CH_4	2	50	50

Emission factor's uncertainty is default ones from 2006 IPCC GL.

AD uncertainties have been provided by MAFF.

AD uncertainty is based on the official statistical data in the country. It's country specific and it's based on the Regulation (EC) No 1165/2008 of the European Parliament and of the Council concerning livestock and meat statistics and repealing Council Directives 93/23/EEC, 93/24/EEC and 93/25/EEC.

Statistical samples are representative of level 6 statistical areas (NUTS2).

5.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All activities regarding QC as described in QA/QC System have been undertaken.

Data were checked for transcription errors between input data and calculation sheets. Calculations were examined focusing on units/scale and formulas.

Activity data check

The inventory compiler reviews livestock data collection methods, in particular checking that livestock subspecies data were collected and aggregated correctly. The data is cross-checked with previous years to ensure the data are reasonable and consistent with the expected trend. Inventory compilers documents data collection methods, identifies potential areas of bias, and evaluate the representativeness of the data.

Review of emission factors

- Cross-check country-specific factors against the IPCC defaults;
- Sector specific QA/QC procedures are intensified according to QMS;
- Comparison of emissions using alternative approaches (Tier 1 method);
- Compared national statistics activity data with data from Food and Agriculture Organization of the United Nations (FAO);
- Documentation and archiving of all information required in NIR, national statistic of agriculture and food provided by MAFF, background documentation and archive.

5.4.5 SOURCE-SPECIFIC RECALCULATIONS

The recalculation have been made for 2016 due to revised AD-population of sheep.

5.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

There are no planned improvements for this category.

5.5 MANURE MANAGEMENT (CRF sector 3B)

The section describes the estimation of methane and nitrous oxide emissions produced during the storage and treatment of manure, and from manure deposited on pasture (CH_4), and treatment of manure before it is applied to land (N_2O). In accordance with the IPCC guidelines, the term "manure" is used here collectively to include both dung and urine produced by livestock.

In 2017, this source category was responsible for 9% of the total GHG emissions from the agriculture sector.

5.5.1 SOURCE CATEGORY DESCRIPTION

CH_4 and N_2O emissions from manure management are given in Table 174 and Table 175**.**

Table 174 CH4 emissions from Manure management 1988 –2017, Gg

CH_4 emissions from manure management [Gg]										
Livestock categories										
Year	3.B.1* Total	3.B.1.1 Dairy	3.B.1.1 Non Dairy	3.B.1.1 Young	3.B.1.4 Buffalo	3.B.1.2 Sheep	3.B.1.4 Goats	3.B.1.4 Horses, Mules and asses	3.B.1.3 Swine	3.B.1.4 Poultry
1988	28,05	2,00	0,35	1,28	0,13	1,87	0,06	0,47	20,80	1,11
1990	28,60	1,96	0,33	1,20	0,12	1,70	0,06	0,46	21,74	1,04
1995	11,53	1,21	0,11	0,40	0,08	0,71	0,10	0,42	7,93	0,57
2000	5,66	1,41	0,09	0,37	0,05	0,46	0,12	0,39	2,35	0,43
2005	5,87	1,21	0,10	0,39	0,04	0,34	0,09	0,29	2,92	0,50

CH_4 emissions from manure management [Gg]										
Livestock categories										
Year	3.B.1* Total	3.B.1.1 Dairy	3.B.1.1 Non Dairy	3.B.1.1 Young	3.B.1.4 Buffalo	3.B.1.2 Sheep	3.B.1.4 Goats	3.B.1.4 Horses, Mules and asses	3.B.1.3 Swine	3.B.1.4 Poultry
2010	5,42	0,94	0,10	0,27	0,04	0,29	0,05	0,25	3,08	0,40
2015	4,64	0,83	0,18	0,25	0,05	0,29	0,04	0,13	2,54	0,34
2016	4,79	0,81	0,21	0,23	0,06	0,29	0,03	0,11	2,72	0,33
2017	4,82	0,76	0,23	0,23	0,06	0,29	0,03	0,11	2,78	0,33
Share 2016		15,85%	4,70%	4,84%	1,30%	5,95%	0,67%	2,18%	57,59%	6,92%
Trend 1988–2016	-82,82%	-64,86%	-34,53%	-81,57%	-50,46%	-84,69%	-43,13%	-77,40%	-86,66%	-69,97%

Code 3.B.1 indicates **CH_4 from Manure management*

Table 175 N_2O emissions from Manure management 1988 –2017, Gg

Year	N_2O emissions from manure management (without indirect emissions) [Gg]									
	Livestock categories									
	3.B.2* Total	3.B.2.1 Dairy	3.B.2.1 Non Dairy	3.B.2.1 Young	3.B.2.4 Buffalo	3.B.2.2 Sheep	3.B.2.4 Goats	3.B.2.4 Horses, Mules & Asses	3.B.2.3 Swine	3.B.2.4 Poultry
1988	3,11	1,07	0,17	0,80	0,0008	0,36	0,02	0,03	0,03	0,63
1990	2,99	1,05	0,16	0,75	0,0008	0,32	0,02	0,03	0,03	0,62
1995	1,45	0,58	0,05	0,21	0,0005	0,14	0,04	0,03	0,13	0,27
2000	1,25	0,48	0,03	0,15	0,0003	0,09	0,05	0,03	0,19	0,23
2005	1,36	0,59	0,04	0,22	0,0003	0,06	0,04	0,02	0,08	0,31
2010	1,22	0,58	0,06	0,20	0,0003	0,05	0,02	0,02	0,03	0,26
2015	1,30	0,63	0,13	0,21	0,0003	0,05	0,02	0,01	0,01	0,24
2016	1,28	0,60	0,16	0,21	0,0004	0,05	0,01	0,01	0,01	0,23
2017	1,27	0,58	0,18	0,21	0,0004	0,05	0,01	0,01	0,01	0,22
Share 2017		45,74%	13,74%	16,54%	0,03%	4,05%	1,10%	0,67%	0,52%	17,61%
Trend 1988–2017	-59,03%	-45,33%	0,79%	-73,47%	-50,46%	-85,48%	-43,13%	-73,49%	-78,79%	-64,47%

Code 3.B.2 indicates **N_2O from Manure management*

5.5.2 METHODOLOGICAL ISSUES

5.5.2.1 CH_4 emissions from manure management

Animal numbers are the same as the ones used for calculating emissions from enteric fermentation. Pigs are divided into sub-categories in order to estimate more accurately the nitrogen excretion. Division of pigs is presented in Table 182.

Buffalos, goats, horses, mules, asses are of minor importance in Bulgaria, therefore the CH_4 emissions of these livestock categories are estimated with the Tier 1 approach with default EFs from the 2006 IPCC GL.

The 2006 IPCC GL Tier 2 methodology has been applied to estimate CH_4 emissions from manure management of cattle and swine as these are key sources. This method requires detailed information on animal characteristics and the manner in which manure is managed.

Emissions from sheep and poultry also have been calculated with Tier 2 method.

The following formula has been used (2006 IPCC GL, Equation 10.23):

$$EF_i = VS_i * 365 \ [days\ yr^{-1}] * B_{0i} * 0.67 \ [kg\ m^{-3}] * \Sigma_{jK}\ MCF_{jK} * MS\%_{ijK}$$

EF_i = *annual emission factor (kg) for animal type i (e.g. dairy cows)*

VS_i = *Average daily volatile solids excreted (kg) for animal type i*

B_{0i} = *maximum methane producing capacity (m^3 per kg of VS) for manure produced by animal type I*

MCF_{jK} = *methane conversion factors for each manure management system j by climate region K*

$MS\%_{ijK}$ = *fraction of animal type i`s manure handled using manure systems j in climate region K*

Average daily volatile solids excreted **(VS)** is estimate by using equation 10.24 in 2006 IPCC GL. The estimations are based on digestibility of the feed, gross energy intake and the ash content of manure.

$$\boldsymbol{VS} = [\boldsymbol{GE} * (\boldsymbol{1} - \frac{\boldsymbol{DE}\%}{\boldsymbol{100}}) + (\boldsymbol{UE} * \boldsymbol{GE})] * [(\frac{\boldsymbol{1} - \boldsymbol{ASH}}{\boldsymbol{18.45}})]$$

VS = volatile solid excretion per day on a dry-organic matter basis, kg VS day-1

GE = gross energy intake, MJ day-1(see Table 14)

DE% = digestibility of the feed in present (based on Guidelines IPCC 2006)

(UE•GE) = urinary energy expressed as fraction of GE (0.04GE for ruminants and 0.02GE for swine).

ASH = the ash content of manure calculated as a fraction of the dry matter feed intake

18.45 = conversion factor for dietary GE per kg of dry matter (MJ kg-1)

The values of VS for **cattle** have been determinate from country-specific gross energy intake. Values for DE% and GE are the same as used in Enteric fermentation. Values for UE (0,04) and ASH (8%) are according 2006 IPCC GL.

2006 IPCC GL presented default values for VS for breeding and market **swine** (normally 90% of the pig population is market swine and 10% - breeding). An average default value is 0,32 kg VS kg dry matter/head/day. Bulgaria used country-specific value of 0,23 kg dry matter/head/day. In order to estimate more accurately VS, swine were divided into sub-categories (see Table 182), not only on breeding and market pigs. For each sub-category were determined different country-specific values for the DE% and GE. Data were provided from scientific studies published in Global Journal of Science Frontier Research (volume 14, issue 5).

The ASH contain (ASH = 12,21%) is provided from the same scientific studies. Data about pig excrements, are based on own studies and represent the average values of 6 samples of different origin – pig-fattening farms. Pig dung (without urine) – taken by Ampulla recti for pigs – 110 kg from slaughter-houses – pure (without being in contact with the floor).

Value for UE (0.02) is default from 2006 IPCC GL.

The values of VS (0,35 kg-dm/head/day compared with the default 0,40 kg-dm/head/day in 2006 IPCC GL) for **sheep** have been determinate from country-specific gross energy intake. Values for DE% and GE are the same as used in Enteric fermentation. Values for UE (0,04) and ASH (8%) are according 2006 IPCC GL. Sheep have been divided into sub-categories listed above (chapter Enteric fermentation).

Implied emission factor for **poultry** is weighted average between several categories – layers, broilers, turkeys, and ducks. Values of B_o and VS have been taken from Table 10A-9. AWMS distribution have been calculated as 50% dry lot and 50% solid storage.[29]

Maximum methane producing capacity (**B_0**) values are from 2006 IPCC GL for all farm animals (Table 10A-4 to Table 10A-9).

Methane conversation factors (**MCF**) are default 2006 IPCC GL presented in Table 176, and are based on cool allocation by climate.

Table 176 Methane conversion factors

AWMS	Allocation by climate	MCF
Liquid system	Cool	20%
Solid storage	Cool	2%
Dry lot	Cool	1%
Other	Cool	1%

A survey conducted with the Agricultural University of Plovdiv, provided data about the **distribution of AWMS** for cattle, swine and sheep.

The survey provided data for 5 pillar years – 1995, 2000, 2005, 2010 and 2015. Bulgaria have been recalculated the data between the period 2010 – 2015 year due to new data from the agriculture statistics for year 2015. This data as well as interpolated data is provided in Table 177.

A survey was based on following components:

- Identification of the number of animals per species and categories;
- Determining the quantity fresh manure and nitrogen in animal categories;
- Determining the nitrogen emitted into different parts of the ecosystem.

The data collection methodology is based on the methodologies used by EUROSTAT since the raw data is collected by the Agrostatistics department at the Ministry of Agriculture, Food and Forestry (MAFF). On every 5 years there is a complete survey on all farms.

Finally all of these determinations were used to calculate the animal waste management systems distribution data.

In Bulgaria all farms with more than 50 sows, store the manure in liquid systems, all farms with 10-50 sows store the manure in dry lot and for all farms with up to 10 sows (small private farms) is accepted (conditionally) that manure is collect in solid storage.

The AWMS variation in the period 1988 – 2017 provided in Table 177 shows that 90% of manure is tread in liquid systems for swine, decreasing to 27% in 2000 and increasing back to 83% in 2011.

Reasons for these variations are reforms in agricultural holdings. In the period 1993 – 2000 the agriculture sector is in a crisis. Most of the farms are small and this is the reason for higher per cent for solid storage and dry lot management system in this years.

After 2005 there is stabilization in the sector and the farms with more than 50 sows increase.

[29] D. PENKOV, V. GERZILOV et all, 2012 Data on the chemical content and management of waste from industrial poultry breeding

Table 177 AWMS distribution for cattle, swine, and sheep:

	Cattle			Swine			Sheep	
	Solid storage	Dry lot	Pasture range paddock	Liquid systems	Solid storage	Dry lot	Solid storage	Pasture range paddock
1988	33,50%	47,00%	19,50%	92,00%	8,00%	0,00%	35%	65%
1989	33,50%	47,00%	19,50%	92,00%	8,00%	0,00%	35%	65%
1990	33,50%	47,00%	19,50%	92,00%	8,00%	0,00%	35%	65%
1991	33,50%	47,00%	19,50%	92,00%	8,00%	0,00%	35%	65%
1992	33,50%	47,00%	19,50%	92,00%	8,00%	0,00%	35%	65%
1993	35,20%	44,60%	20,20%	84,00%	12,50%	3,50%	35%	65%
1994	36,70%	42,30%	21,00%	75,70%	17,30%	7,00%	35%	65%
1995	38,40%	40,00%	21,60%	67,80%	22,00%	10,20%	35%	65%
1996	40,00%	37,70%	22,30%	59,70%	26,60%	13,70%	35%	65%
1997	41,60%	35,40%	23,00%	51,60%	31,30%	17,10%	35%	65%
1998	43,20%	33,10%	23,70%	43,50%	36,00%	20,50%	35%	65%
1999	44,80%	30,70%	24,50%	35,40%	40,60%	24,00%	35%	65%
2000	46,40%	28,40%	25,20%	27,40%	45,30%	27,40%	35%	65%
2001	45,00%	31,50%	23,50%	32,60%	42,80%	24,60%	35%	65%
2002	43,60%	34,30%	22,10%	37,90%	40,30%	21,80%	35%	65%
2003	42,20%	37,50%	20,30%	43,20%	37,80%	19,00%	35%	65%
2004	40,70%	40,60%	18,70%	48,40%	35,30%	16,30%	35%	65%
2005	39,30%	43,60%	17,10%	53,60%	32,90%	13,50%	35%	65%
2006	36,80%	46,10%	17,10%	58,70%	29,30%	12,00%	35%	65%
2007	34,30%	48,70%	17,00%	63,60%	25,70%	10,70%	35%	65%
2008	32,80%	51,10%	16,10%	68,60%	22,10%	9,30%	35%	65%
2009	29,20%	53,70%	17,10%	73,50%	18,60%	7,90%	35%	65%
2010	26,70%	56,10%	17,20%	78,60%	15,00%	6,40%	35%	65%
2011	25,40%	58,10%	16,50%	81,23%	13,03%	5,74%	35%	65%
2012	24,00%	60,30%	15,70%	83,86%	11,07%	5,08%	35%	65%
2013	22,70%	62,30%	15,00%	86,48%	9,10%	4,42%	35%	65%
2014	21,30%	64,40%	14,30%	89,11%	7,13%	3,76%	35%	65%
2015	20,00%	66,50%	13,50%	91,74%	5,16%	3,10%	35%	65%
2016	20,00%	66,50%	13,50%	91,74%	5,16%	3,10%	35%	65%
2017	20,00%	66,50%	13,50%	91,74%	5,16%	3,10%	35%	65%

5.5.2.2 Direct N_2O emissions from manure management

Following the guidelines, all emissions of N_2O taking place before the manure is applied to soils are reported under manure management.

For the estimation of N_2O emissions from manure management systems a Tier 1 approach have been used for farm animal other than cattle, swine and poultry.

The 2006 IPCC GL method for estimating N_2O emissions from manure management entails multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems (see formulas below).

N excretion per animal waste management system:

$$\mathbf{Nex_{(AWMS)} = \sum_{(T)}[N_{(T)} \times Nex_{(T)} \times AWMS_{(T)}]}$$

$Nex_{(AWMS)}$ = *N excretion per animal waste management system [kg yr^{-1}]*
$N_{(T)}$ = *number of animals of type T in the country*
$Nex_{(T)}$ = *N excretion of animals of type T in the country [kg N $animal^{-1}$ yr^{-1}]*
$AWMS_{(T)}$ = *fraction of $Nex_{(T)}$ that is managed in one of the different distinguished animal waste management systems for animals of type T in the country*
T = *type of animal category*

N_2O emission per animal waste management system:

$$N_2O_{(AWMS)} = \sum[Nex_{(AWMS)} \times EF_{3(AWMS)}]$$

$N_2O_{(AWMS)}$ = *N_2O emissions from all animal waste management systems in the country [kg N yr^{-1}]*
$Nex_{(AWMS)}$ = *N excretion per animal waste management system [kg yr^{-1}]*
$EF_{3(AWMS)}$ = *N_2O emissions factor for an AWMS [kg N_2O-N per kg of Nex in AWMS]*

AWMS

The animal waste management systems distribution data applied to estimate N_2O emissions from Manure Management is the same as used for the estimation of CH_4 emissions from Manure Management (see Table 177).

5.5.2.2.1 Nitrogen excretion

Bulgaria used country-specific data for nitrogen excretion from cattle, swine and poultry.

Calculations have been made by combining activity data for the feeding situation of these farm animals. The main drivers for the estimations are the daily protein intake by cattle and average protein content in swine feed, amount of nitrogen in protein content, undigested N provided by the experts from the Agricultural University of Plovdiv and Trakia University of Stara Zagora.

- **Cattle:**

In current submission the Nex values for cattle have been recalculated due to implementation of new activity data on the feeding characteristics of cattle. New data have been provided by project prepared by prof. Lazar Kozelov from Institute of animal science (http://www.ias.bg/english/index_en.html).

The values are calculated based on the animal's food intake.

The equation used is:

Daily N intake x amount of non-digested N(%) x 365 = Annual Nex

The daily N intake for the different cattle categories is as follows:

Table 178 Amount of nitrogen per day in cattle food

Animal type	Amount of N per day(g)
Mature dairy cattle	334
Mature non-dairy cattle	192
Fattening claves under 1 year	146
Other calves under 1 year	146
Bovine 1-2 years	164
Heifers	183

The value for the fraction of N which is retained by the animals is taken from table 10.20 from the 2006 IPCC GL and is assumed the rest is excreted.

Table 179 Activity data for estimating nitrogen excretion from cattle

	Mature dairy cattle		Mature non-dairy cattle		Young cattle under 1 year		Bovine and heifers 1-2years	
	Population size	Daily N excretion (g)	Population size	Daily N excretion (g)	Population size	Daily N excretion (g)	Population size	Daily N excretion (g)
1988	628640	267,2	153338	178,6	688059	135,5	193448	165,46
1990	619145		144465		648247		182255	165,46
1995	384111		45965		206253		57988	165,46
2000	392017		36362		183503		45418	165,21
2005	358237		40811		190675		56967	166,03
2010	302461		44607		141362		53215	165,45
2015	285767		88724		113181		63833	165,91
2016	273745		105902		112417		61970	166,12
2017	261693		1162525		112551		58563	166,21

- **Swine:**

Data have been provided by the experts from the Agricultural University of Plovdiv and Trakia University of Stara Zagora.

The values are calculated based on the animal's food intake.

The equation used is:

Daily N intake x Amount of non-digested N(%) x 365 = Annual Nex

This general equation is used for each swine categories and is slightly modified to meet the features of smallest piglet with body weight below 20 kg and also the features of pregnant and lactating sows.

The adjustment for piglets below 20 kg is that 8 grams of N are added to the daily N taken with the fodder. These 8 grams are from the mother's milk.

The adjustment for pregnant and lactating sows is to reflect the fact that each sow goes through pregnancy and the lactates. During these two periods the amount of feed given to the animal is adjusted according to the national swine growing standards.

The equation for piglets below 20 kg is:

(Daily N intake + 8) x Amount of non-digested N(%) x 365 = Annual Nex

The equation for sows is:

Daily N intake (in pregnancy) x Amount of non-digested N (%) x 302 + Daily N intake (when lactating) x Amount of non-digested N (%) x 63 = Annual Nex.

The ratios of undigested N are as follows:

Table 180 Undigested N (swine)

Animal weight/condition	Undigested N(%)
<20 kg	50%
20-50 kg	60%
50-80 kg	60%
80-110 kg	60%
>110 kg and boars	60%

Animal weight/condition	Undigested N(%)
Pregnant	70%
lactating	65%

The amount of N the animals receive with the food is as follows:

Table 181 Amount of nitrogen per day in swine food

Animal weight/condition	Amount of N per day(g)
<20 kg	40,00
20-50 kg	47,60
50-80 kg	54,91
80-110 kg	59,39
>110 kg and boars	73,92
Pregnant	58,24
lactating	184,80

Table 182 Activity data for estimating nitrogen excretion from swine

	Population size					
	Pigs < 20 kg	Pigs 20-50 kg	Pigs 50 -80 kg	Pigs 80 -110 kg	Pigs > 110 kg, and boars	Breeding pigs
1988	760204	740890	663715	848329	612470	416569
1990	794631	774442	693772	886746	640206	435434
1995	381545	371851	333117	425774	307397	209075
2000	240056	233957	209586	267883	193404	131543
2005	176598	175458	177554	190536	121197	95856
2010	127246	141764	107584	142807	108823	68677
2015	135448	145674	100071	111940	26801	56658
2016	125289	153310	122390	119584	26347	61329
2017	127194	146365	128680	124075	15275	63333
Daily N excretion (g)	***20***	***28,56***	***32,95***	***35,64***	***44,35***	***Pregnant- 40,77 Lactating- 120,12***

- **Poultry:**

Poultry calculations are based on the quantities of poultry manure per day and content of nitrogen in the poultry manure (see Table 183). Data have been provided by Agriculture university of Plovdiv.[30]

Table 183 Activity data for estimating nitrogen excretion from poultry

Layer hen		Broilers		Other Poultry	
Kg Manure/day	Kg N in 1000 Kg manure	Kg Manure/day	Kg N in 1000 Kg manure	Kg Manure/day	Kg N in 1000 Kg manure
0,13	14,2	0,15	18,30	0,23	22,30

[30] D. PENKOV, V. GERZILOV et all, 2012 Data on the chemical content and management of waste from industrial poultry breeding

- **Other farm animals:**

For estimation of nitrogen excretion from buffalo, sheep, goats, horses and mules and asses default values for nitrogen excretion rate were used represented in Table 10.19 in the 2006 IPCC GL. Estimations for these farm animals are based to eq. 10.30 (2006 IPCC GL):

$$\mathbf{Nex_{(T)} = Nrate_{(T)} \times TAM/1000 \times 365}$$

$Nex_{(T)}$ = N excretion of animals of type T in the country [kg N animal-1 yr-1]
$N_{rate(T)}$ = default N excretion rate, kg N (1000 kg animal mass) $^{-1}$day^{-1} (table 10.19, IPCC 2006)
TAM = typical animal mass, kg animal -1 (see Table 171, chapter Enteric fermentation)

Values of nitrogen excretion of animal of type are present in Table 184.

Table 184 Nitrogen excretion of the livestock category.

Livestock category	Nitrogen excretion [kg/animal*yr.]
Mature Dairy Cattle	97,53
Mature Non Dairy Cattle	65,17
Young Cattle – Calves under 1 year	49,45
Young Cattle - Growing Heifers 1 – 2 years	60,67
Buffalo	44.38
Sheep	14,02
Goats	17.99
Horses	41.28
Mules & Asses	14.24
Swine(weight average)	11.68
- Pigs <20 kg	7.30
- Pigs20-50 kg	10.42
- Pigs 50-80 kg	12.03
- Pigs 80-110 kg	13.01
- Pigs >110 kg and boars	16.19
- Breeding pigs	19.88
Poultry average	0,93
Poultry Chickens	0,81
Other Poultry	1,87

5.5.2.2.2 Emission factors

N_2O emission factors of the 2006 IPCC GL have been used for all AWMS.

Emission factors applied in the Bulgarian inventory are listed in the following table:

Table 185 Emission factors for N_2O from manure management

Animal Waste Management System	Emission factor [kg N_2O-N per kg N excreted]	Reference
Liquid system	0.00	Table 10.21 - 2006 IPCC GL
Solid storage	0.005	Table 10.21 - 2006 IPCC GL
Dry lot	0.02	Table 10.21 - 2006 IPCC GL
Other	0.001	Table 10.21 - 2006 IPCC GL

5.5.2.3 Indirect N_2O emissions from manure management

Table 186 Indirect N2O emissions from Manure Management

Year	Total N volatilised as NH_3 and NOx (kg N/year)	N_2O emissions (Gg)
1988	79433729	1,25
1990	78412026	1,23
1995	36311696	0,57
2000	29264955	0,46
2005	29325383	0,46
2010	23444134	0,37
2015	21998867	0,35
2016	21880539	0,34
2017	21653712	0,34

Indirect N_2O emissions from manure management are result from diffusion into the surrounding air (volatilisation) and from leaching and runoff. All indirect N_2O emissions from the pasture range and paddock manure management systems are reported under the Agricultural soils category.

The 2006 IPCC GL Tier 1 methodology is used for calculating N_2O emissions resulting from volatilisation:

$$N_2O_{\,G(mm)} = (N_{volatilization\text{-}MMS} \times EF_4) \times \frac{44}{28}$$

$N_2O_{\,G(mm)}$ – indirect N_2O emissions due to volatilization of N from Manure Management, kg N2O/year

EF_4 – emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N2O-N/kg NH3-N + NOx-N volatilised – default value is 0,01 kg N_2O-N/kg NH_3-N + NOx-N volatilised (table 11.3, 2006 IPCC GL);

$$N_{volatilization\text{-}MMS} = \sum_S [\sum_T [(N \times Nex \times MS) \times (\frac{FracGasMS}{100})]]$$

$N_{volatilization\text{-}MMS}$ - amount of manure nitrogen that is lost due to volatilization of NH3 and NOx, kg N/year;

N – number of head of livestock species (see Table 167 and Table 168);

Nex – annual average N excretion per head of species, kg N/animal/year (see Table 184);

MS – fraction of total annual nitrogen excretion for each livestock that is managed in manure management system;

$Frac_{GasMS}$ – present of managed manure nitrogen for livestock category that volatilises as NH3 and NOx in the manure management system, % (see below).

Table 187 2006 IPCC GL values for nitrogen loss due to volatilisation of NH3 and NOx from Manure management (source: Table 10.22, 2006 IPCC GL):

Animal type	Manure Management system	$Frac_{GasMS}$
Swine	Liquid system	48 %
	Solid storage	45 %
Dairy Cow	Dry lot	20 %
	Solid storage	30 %
Poultry	Poultry without litter	55 %
Other cattle	Dry lot	30 %
	Solid storage	45 %
Other	Solid storage	12 %

The 2006 IPCC GL Tier 1 methodology for determining indirect N_2O emissions does not provide values for nitrogen loss due to leaching and run-off. There has been no country-specific emission factors derived for leaching and runoff from manure management systems in Bulgaria. Anyway, the loss fractions in Table 10.23 include also losses of N which are not included in the indirect emissions from volatilizations.

5.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties have been revised due to ERT recommendations.

Table 188 Uncertainty of sub-sector Manure Management for 2017, %

CRF categories	Key Category	GHG	Activity data uncertainty, %	Emission factor uncertainty, %	Combined uncertainty, %
3.B.2.1	Cattle	N_2O	0.64	50	50
3.B.2.4	Buffalo	N_2O	0.64	100	100
3.B.2.2	Sheep	N_2O	1.63	50	50
3.B.2.4	Goats	N_2O	1.65	100	100
3.B.2.4	Horses	N_2O	2	100	100
3.B.2.4	Mules and Asses	N_2O	2	100	100
3.B.2.3	Swine	N_2O	0.51	50	50
3.B.2.4	Poultry	N_2O	2	100	100
3.B.1.1	Cattle	CH_4	0.64	20	20
3.B.1.4	Buffalo	CH_4	0.64	30	30
3.B.1.2	Sheep	CH_4	1.63	20	20
3.B.1.4	Goats	CH_4	1.65	30	30
3.B.1.4	Horses	CH_4	2	30	30
3.B.1.4	Mules and Asses	CH_4	2	30	30
3.B.1.3	Swine	CH_4	0.51	20	20
3.B.1.4	Poultry	CH_4	2	30	30

Default values from the IPCC guidelines for the EF; Ministry of Agriculture, Food and Forestry for the AD

5.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All activities regarding QC as described in QA/QC System have been undertaken.

Activity data check

The inventory compiler reviews livestock data collection methods, in particular checking that livestock subspecies data were collected and aggregated correctly. The data is cross-checked with previous years to ensure it is reasonable and consistent with the expected trend. Inventory compilers document data collection methods, identify potential areas of bias, and evaluate the representativeness of the data. Population modelling can be used to support this approach.

Review of emission factors

If cross-check country-specific factors against the IPCC defaults finds significant differences between country-specific factors and default factors are explained and documented.

5.5.5 SOURCE-SPECIFIC RECALCULATIONS

The recalculation have been made for 2016 due to revised AD-population of sheep.

5.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

There are no planned improvements for this category.

5.6 RICE CULTIVATION (CRF SECTOR 3.C)

5.6.1 SOURCE CATEGORY DESCRIPTION

Rice cultivation is a traditional Bulgarian agricultural activity. During the structural reforms, rice crop areas decreased from 14 100 ha in 1988 to 1417 ha in 1999. There has been a restoration of rice crop areas after 1999, reaching 10 434 ha in 2017.

93,97 Gg CH_4 CO_2-eq. has been emitted in 2017. Emission decrease by 13% compared to the year 2016(107,97 Gg CH_4 CO_2-eq) which is due to the decrease of the areas with rice crops.

In Bulgaria rice is produced under the continuously flooded water regime with season length of 125 days and one harvest per year.

5.6.2 METHODOLOGICAL ISSUES

5.6.2.1 Methods

CH_4 emission calculation is carried out according to the default method from the 2006 IPCC GL for continuously flooded water regime.

$$\mathbf{CH_{4\,Rice} = EF \times t \times A \times 10^{-6}}$$

EF – daily emission factor, kg CH4/ha/day (see 5.6.2.2);

t – cultivation period of rice = 125 days[31];

A – annual harvested area of rice, ha/day;

5.6.2.2 Emission factors

Daily emission factor are estimated according equation 5.2 from the 2006 IPCC GL:

$$\mathbf{EF = EF_c \times SF_w \times SF_p \times SF_o}$$

Table 189 Emissions factors for Rice calculations

Baseline Emission Factor (EF_c)	1,30	Table 5.11 2006 IPCC GL
Scaling factor to account for the difference in water regime during the cultivation period (SF_w)	0,78	Table 5.12 2006 IPCC GL
Scaling factor to account for the difference in water regime before the cultivation period (SF_p)	1,22	Table 5.13 2006 IPCC GL
Scaling factor organic amendments (SF_o)	2,33	Eq. 5.3; Table 5.14 2006 IPCC GL

SFo have been calculated with equation 5.3 from the 2006 IPCC GL.

All parameters except Application rate of organic amendment (ROA) are from IPCC 2006.

ROA have been estimated based on the Good Agricultural practices – "Program of measures to reduce and prevent nitrate pollution from agricultural sources", approved by order of the Ministry of

[31] According NAAS (National Agricultural Advisory Service)

Environment and Water (MoEW). In the program there is a methodology which is used to calculate the application rate of organic amendment (in fresh weight).

5.6.2.3 Activity data

Data comes from the Agricultural Statistics Department of the Ministry of Agriculture, Food and Forestry based on surveys on yields of main crops, and for the years before National Statistics Institutes'' yearbooks and FAO's database.

5.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty of emission factor is 60 % (2006 IPCC GL). Activity data uncertainty is 20 %.

5.6.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All activities regarding QC as described in QA/QC System have been undertaken.

5.6.5 SOURCE-SPECIFIC RECALCULATIONS

There are no recalculations for this category.

5.6.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

There are no planned improvements for this category.

5.7 AGRICULTURAL SOILS (CRF SECTOR 3D)

Microbial processes of nitrification and denitrification in agricultural soils produce nitrous oxide emissions. In 2017 this category generates 65,30% of N_2O emissions from Agricultural sector.

There is a decrease of 33,78 % for this category from 1988 to 2017 (Figure 96). The reasons are structural changes in agricultural holdings and decrease in arable land area.

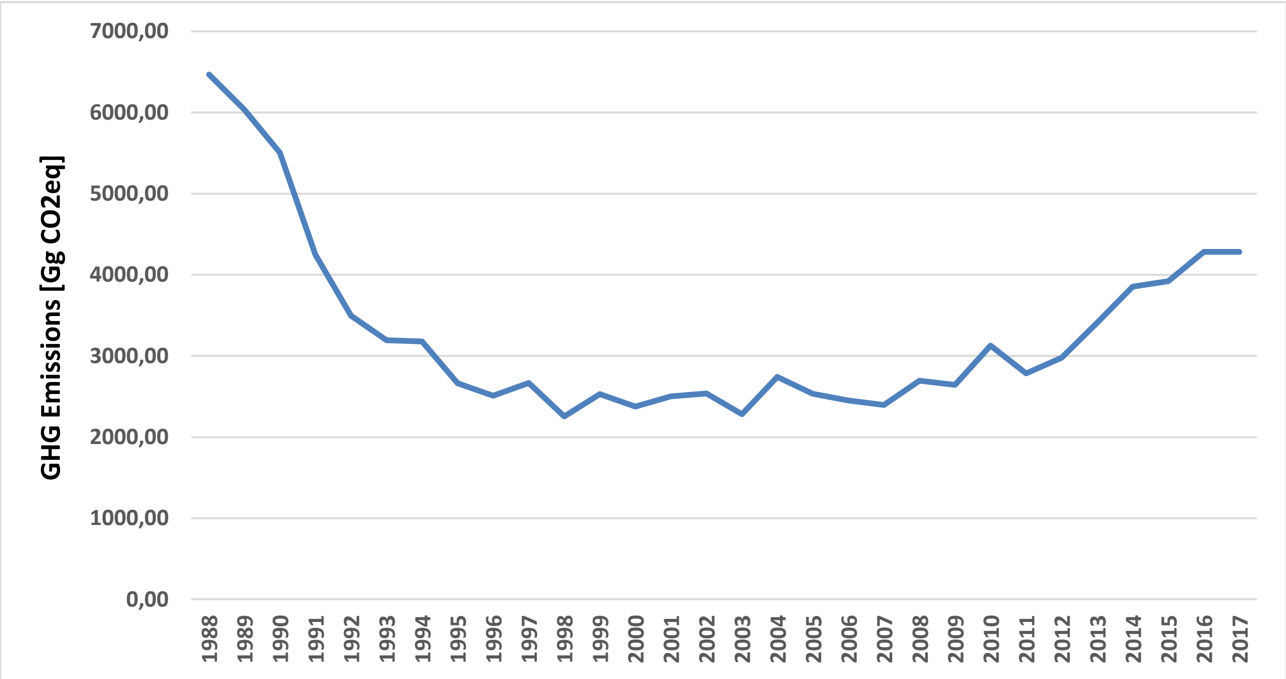

Figure 96 Trend of GHG Emissions from agricultural soils

5.7.1 SOURCE CATEGORY DESCRIPTION

The emissions from this subsector include the two main categories N_2O emissions:

- Direct emissions;
- Indirect emissions.

These two categories above are key sources in the year 2017.

Direct emissions in Bulgaria are results from:

- Soil fertilization with synthetic nitrogenous fertilizers;
- Nitrogen input from manure applied to soils (excluding manure from pasture animals);
- Sewage sludge spreading on agricultural soils;
- Decomposition of vegetable waste from different crops;
- Animal excretion on pasture range and paddock;
- N mineralisation associated with loss of soil organic matter resulting from change of land use;
- Cultivation of organic soils (i.e. Histosols).

Indirect emissions include:

- ammonia and nitrous oxides release in the ambient air after nitrogen fertilization;
- emissions from drawing of water.

Activities described above are differentiated according to the IPCC classification. One has to take into consideration that the existing emissions of methane from soil are considered natural (non-anthropogenic) and is not subject of the inventory.

Direct N_2O emissions are 3394,70Gg CO_2-eq. in 2017 (see

Table 193). Indirect N_2O emissions are 889,40 Gg CO_2-eq. in 2017.

5.7.2 METHODOLOGICAL ISSUES

5.7.2.1 Methods

The IPCC Tier 1 method was applied and IPCC default emission factors were used.

The following formula has been used to estimate Direct emissions (2006 IPCC GL, eq. 11.1).

$$\mathbf{N_2O_{Direct} – N = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1] + (F_{OS,CG,Temp} \times EF_{2CG,Temp}) + (F_{PRP,CPP} \times EF_{3PRP,CPP}) + (F_{PRP,SO} \times EF_{3PRP,SO})}$$

F_{SN} – annual amount of synthetic fertiliser N applied to soil (kg N/yr)

F_{ON} – annual amount of animal manure and sewage sludge applied to soil (kg N/yr)

F_{CR} – annual amount of N in crop residues, returned to soils (kg N/yr)

F_{SOM} – annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use, kg N/yrF_{PRP}

F_{Os} – annual area of managed organic soils, ha

F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, (kg N/yr); The subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals

EF_1, $EF_{2CG,Temp}$, $EF_{3PRP, CPP}$, $EF_{3PRP, SO}$ – default emission factors (kg N_2O-N/kg N), see Table 191

- F_{SN} has been estimated from the total amount of synthetic fertiliser consumed annually (according to 2006 IPCC GL);
- F_{ON} included annual amount of animal manure and sewage sludge applied to soil (equation 11.3 from the 2006 IPCC GL).
  - Annual manure applied to soils has been calculated with equation 10.34 and default values for nitrogen loss from manure management (Frac $_{LossMS}$) given in table 10.23 from the 2006 IPCC GL. In the estimations the amount of nitrogen from bedding is not included due to that information is not available in Bulgaria.
  - Anual amount of sewage sludge applied to soil in Bulgaria have been calculated since 2007 year. Before 2007 that activity did not occur in the country due to available local legalisation.
  - The 2006 IPCC GL included in F_{ON} annual amount of total compost N applied to soils. Composting in Bulgaria is preaty new technology (there are three composting instalation working from 2011 year). The compost is not with high quality and it used mainly for recultivation. There is no data in the country for composting in Agriculture.
- F_{CR} has been calculated with eq. 11.7 A from the 2006 IPCC GL. Default values for all parameters given in 2006 IPCC GL Table 11.2 are used except from dry matter values which are based on national values. Annual harvested area of crops and harvested yield for crops are provided by Ministry of Agriculture and Food; dry matter fractions of crops are provided by University of Agriculture of Plovdiv.

- F_{SOM} has been calculated with eq. 11.8 from the 2006 IPCC GL. Land use type is Annual Cropland converted to Perennial Cropland. Area and net carbon stock change in soils are listed in LULUCF chapter (CRF table 4B). C:N ratio is default from the 2006 IPCC GL.
- F_{OS} – According to the ERT and TERT reccomendations, the area of cultivated organic soils has been included in the current submission. The area have been provided by FAO database.
- F_{PRP} has been calculated with eq. 11.5 from the 2006 IPCC GL.

Conversion of N_2O – N emission to N_2O emission for reporting purposes is performed by using the following equation:

$$N_2O = N_2O - N \times 44/28$$

Indirect emissions including emissions from atmospheric deposition of N volatilised from managed soils and nitrogen leaching (and run-off). Emissions were estimate by using equation 11.9 and 11.10 according the 2006 IPCC GL and default fractions ($Frac_{LEACH-(H)}$) shown in Table 11.3 in the 2006 IPCC GL.

Bulgaria have been used country - specific parameter for $Frac_{GASF}$ to estimate N_2O emissions from ammonia volatilization.

The synthetic fertilizers quantities are provided by the National Service for Plant Protection at the Ministry of Agriculture Food and forestry. According to the EMEP/EEA Guidebook 2016, the NH_3 emission depends on fertiliser type. There is no such information for the consumption of each fertiliser type in the county, so for the estimation of NH3 - N emissions ($Frac_{GASF}$) the sales data from IFA for 2010 were used (Table A1-2, Chapter 3.D, EMEP 2016). Furthermore, the NH_3 emission factor for each fertiliser is given, based on the values from the EMEP/EEA Guidebook 2016. The major part of the Bulgarian emission is related to the use of ammonium nitrate. The Bulgarian $Frac_{GASF}$ is low compared to the IPCC default value. This is due to the small consumption of urea, which has a high emission factor compared to the other fertilisers.

In the 2016 submission, $Frac_{GASF}$ have been recalculated, according new data in the EMEP/EEA Guidebook 2016.

Table 190 Activity data for the estimations of $Frac_{GASF}$.

Fertiliser type	NH_3 Emission factor, kg NH_3-N per kg N	Percent	Consumption, t N	Average NH_3-N emission ($Frac_{GASF}$)
Urea	0,155	31%	105898,5	0,064
Ammonium nitrate (AN)	0,015	55%	187884,4	
CAN	0,008	1%	3416,08	
Ammonium sulphate (AS)	0,09	4%	13664,32	

5.7.2.2 Emission factors

Emission factors are the default ones from the 2006 IPCC GL. So far, there are no assessments of these emission factors, which result from measurements in the country. The factors are represented in Table 191.

Table 191 N_2O emissions factors for agricultural soils.

Category	Emission Factor [kg N_2O-N/kg N]	Source
3.D.1 Direct Soil Emissions		
3.D.1.1 - Synthetic fertilizers (mineral fert.)	0.01	Table 11.1 - 2006 IPCC GL
3.D.1.2.a - Animal waste applied to soils		
3.D.1.2.b - Sewage sludge spreading		
3.D.1.4 - Crop residue return to soil		
3.D.1.3 Pasture, range and paddock manure – weighted average between several animals categories		
- Cattle, poultry and pigs - Sheep and "other animal"	0.02 0.01	Table 11.1 - 2006 IPCC GL
3.D.1.6. Cultivation of organic soils	8 kg N_2O–N ha^{-1}	Table 11.1 - 2006 IPCC GL
3.D.2 Indirect soil emissions		
3.D.2.1 - Atmospheric deposition	0.01/ kg of volatized nitrogen	Table 11.3 -2006 IPCC GL
3.D.2.2 - Nitrogen leaching (and run-off)	0.0075/ kg N-loss by leaching	Table 11.3 - 2006 IPCC GL

5.7.2.3 Activity data

- **The synthetic fertilizers quantities:**

It's provided with official letters by Bulgarian Food Safety agency/ National Service for Plant Protection (see Table 193) (1988-2016).Since 2017 the data is provided with official letter by Ministry of Agriculture, Food and Forestry. Also it is crossed-check with report of The National state of the environment. The report is published every year on the website of the Executive Agency of environment. Every year data have been provided to EUROSTAT

(http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_usefert&lang=en).

Bulgaria has been cross-checked the data with the informations presented by FAO. There are differences due to activity data presented by FAO is not official but the data obtained as a balance.

The main reasons for the declining in the fertiliser's quantity are the structural economic changes due to the radical transition process from a centrally-planned economy to a market-based economy.

- **Manure quantity:**

Its calculated using the prototype parameters for different types of animals in the Eastern Europe region, given in the 2006 IPCC GL and using the data provided by the Agricultural University of Plovdiv.

- **Sewage sludge:**

At the national level the data on the sludge are collecting according several regulations and orders.

Each year waste wastewater treatment plants have provided in the Executive Environment Agency (ExEA) annual reports for the previous year. Also ExEA receive data from Basin Directorates for the new wastewater treatment plants and information about the technology that they use for wastewater treatment.

ExEA summarizing the information and every year published official report on the use of sewage sludge in agriculture - https://eea.government.bg/bg/nsmos/waste/dokladi (available only on Bulgarian).

- **Annual crop production:**

Data have been provided by the Agrostatistics department at the Ministry of Agriculture, Food and Forestry and is cross-checked with the FAO database. For the period 1988-2000 the main data source is National statistics Institute's yearbooks.

MAFF collect agricultural statistics in Bulgaria with surveys. There are large legal basis with Regulations and Ordinances which determinate the methods and conduct of statistical surveys.

The crop statistics is based on Regulation (EC) No 543/2009 of the European Parliament and of the Council concerning crop statistics.

According to the Statistical National program, the results of the statistical surveys are presented to Eurostat and NSI.

Every year MAFF published the information on their website.

- **Area of organic soils**

Data is provided by FAO database (http://www.fao.org/faostat/en/#data/GV)

Table 192 Activity data for Agricultural soils

Category	Data Sources
3.D.1 Direct soil emissions	
Synthetic fertilizers (mineral fert.)	National service for Plant Protection (Table 193)
Animal waste applied to soils	Calculations within source category 3.B and eq. 10.34 and default data in table 10.23 from the 2006 IPCC GL.
Crop residue	Harvested amount of agricultural crops - MAFF
Sewage sludge spreading	Data from wastewater treatment plants
Area of organic soils	FAO
3.D.1.3 Pasture, range and paddock manure	
Grazing Animals	Calculations within source category 3.B
3.D.2 Indirect soil emissions	
Atmospheric deposition	The amount of manure left for spreading was calculated within source category 3.B. Mineral fertiliser data
Nitrogen leaching (and Run-off)	see above (synthetic fertilizers, animal waste, sewage sludge)

Table 193 Consumption of synthetic fertilizers for the period 1988 – 2017:

	1988	1990	1995	2000	2005	2010	2015	2016	2017
Amount of synthetic fertilizers (t N/year)	541100	395900	129500	144900	159506	199083	341608	365913	351120

During the revision in October 2018 the AD for Inorganic fertilizers (2016) have been revised due to technical mistake. The data is available in EUROSTAT:

http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_usefert&lang=en .

Table 194 Sewage sludge spreading, 2008 – 2017:

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sewage sludge spreading (t/dm)	52 117	16644	13644	17561	21241	16680	16363	30444	26229	22702

In submission 2017 have been recalculated in this category for the entire time series due to:

- Emissions have been recalculated for the entire time series due to the recalculation in Manure management category (please see above);
- Emission from N fertilizers have been recalculated for the 2014 and 2015 year, due to revised data on the fertilizer consumptions (TERT recommendation);
- According to TERT and ERT recommendations from the ESD review 2017 and incountry review 2016, emissions from cultivation of organic soils have been estimated and included in the submission 2017;
- According to TERT recommendation from the ESD review 2017, for category 3.D.a.3 Urine and Dung Deposited by Grazing Animals, emission factor has been corrected as weighted average between animal categories and default emission factors in 2006 IPCC GL;
- FracGASF has been updated with the data provided by EMEP/EEA Guidebook 2016.

5.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty from the direct N_2O emissions from this source is 250% and from the indirect emissions - 500%.

Table 195 Uncertainty of sub-sector Agricultural soils for 2017, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
3D1	Direct soil emissions	N_2O	3	250	250
3D2	Indirect Emissions	N_2O	3	500	500

Default values

5.7.4 SOURCE-SPECIFIC QA/QC

All activities regarding QC as described in QA/QC System have been undertaken.

5.7.5 SOURCE-SPECIFIC RECALCULATIONS

The recalculation have been made for 2016 due to revised AD-population of sheeps (pease see chapter Manure management).

5.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

There are no planned improvements for this category.

5.8 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF SECTOR 3F)

5.8.1 SOURCE CATEGORY DESCRIPTION

This sector covers the emissions of non-CO_2 greenhouse gases from the burning (in the field) of crop residue and other agricultural waste on site.

Despite field burning is prohibited by the Bulgarian law, this "tradition" continues and is emission source not only of main GHGs but also of GHGs-precursors.

34,82Gg CO_2-eq. aggregated GHGs were emitted in 2017 (0,53 % of Agriculture emission). The estimations are based on the expert judgement that 3% of the vegetal residues, left on the fields after yielding the crops, are burned.

5.8.2 METHODOLOGICAL ISSUES

According to the provisions in the IPCC GPG 2000, the calculation methodology took into account the 1996 IPCC GL default emissions ratios (Table 4-16 of Reference Manual). Emission ratios are presented in Table 196.

The rationale for using the 1996 IPCC GL approach, and not the 2006 IPCC GL approach, is as follows:

(1) the 2006 IPCC GL equation was developed to be broadly applicable to all types of biomass burning, and, thus, is not specific to agricultural residues;

and (2) the 2006 IPCC GL default factors are provided only for four crops (corn, rice, sugarcane, and wheat), while this Inventory analyzes emissions from much more crops.

Table 196 Default emission factors for burning of agricultural residues

Gas	Default IPCC 1996 emission ratios
Methane	0.005
Carbon monoxide	0.06
Nitrous oxide	0.007
Nitrous oxides	0.121

Activity data for harvested production by crops is provided by the Statistical Department of the MAFF. Specific parameters used for calculations of the emissions are provided from the Agricultural University of Plovdiv (see Table 197).

Table 197 Specific parameters used for calculation of Total carbon released

GREENHOUSE GAS SOURCE AND SINK CATEGORIES						
	Residue/ Crop ratio	Dry matter fraction of residue	Fraction burned in fields	Fraction oxidized	C fraction of residue	N - C radio in biomass residues
1.Cereals						
Wheat	1,3	0.84	0,03	0,9	0,4853	0,006
Barley	1,2	0,85	0,03	0,9	0,4567	0,009
Maize	1	0,78	0,03	0,9	0,4709	0,02
Oats	1,3	0,92	0,03	0,9	0,4466	0,016
Rye	1,6	0,9	0,03	0,9	0,4238	0,01
Rice	1,4	0,85	0,03	0,9	0,4144	0,016
Maize for silage	1	0,78	0,03	0,9	0,4709	0,017
2.Pulses						
Dry beans	2,1	0,85	0,03	0,9	0,4812	0,03
Peas	1,5	0,87	0,03	0,9	0,4466	0,031
Soybean s	2,1	0,86	0,03	0,9	0,4129	0,056
Lentils	0,3	0,18	0,03	0,9	0,4642	0,036
Chick peas	0.3	0,18	0,03	0,9	0,4642	0,036
3.Tubers and Roots						
Potatoes	0,4	0.25	0,03	0,9	0,42	0,026
Sugar beet	2.2	0.72	0,03	0,9	0,53	0,014
4.Other						
Cotton	1.3	0.84	0,03	0,9	0.49	0.03
Sunflow er	1,3	0.84	0,03	0,9	0.49	0.03
Peanuts	1	0,86	0,03	0,9	0,46	0,023
Tobacco	1,3	0,84	0,03	0,9	0.49	0.03
Feetbeet	0,3	0,86	0,03	0,9	0,41	0,06
Alfalfa	0,3	0,90	0,03	0,9	0,41	0,06

5.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainty for the CH_4 emission factor is 50%, and for the N_2O – 20 % (default values based on the IPCC 1996).

For the AD uncertainty is 3 % (crop uncertainty base on the official statistics in the country).

5.8.4 SOURCE-SPECIFIC QA/QC

All activities regarding QC as described in QA/QC System have been undertaken.

Activity data has been cross-checked with FAO's statistical database.

5.8.5 SOURCE-SPECIFIC RECALCULATIONS

There are no recalculations for this category.

5.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

There are no planned improvements for this category.

5.9 CO_2 EMISSIONS FROM LIMING (CRF sector 3G)

There is no liming in Bulgaria after 1987.

During the UNFCCC review in October 2018, the ERT raised a question about Liming in Bulgaria. Bulgaria asked the INSTITUTE OF SOIL SCIENCE, AGROTECHNOLOGY AND PLANT PROTECTION "NIKOLA POUSHKAROV" in order to clarify if liming is a current practice in Bulgaria. The ERT confirmed that the liming is not a practice since 1988- after political reforms in the country. After the closure of the so-called 'Labor cooperative farm' the liming practice is unprofitable and does not apply in the country.

5.10 CO_2 EMISSIONS FROM UREA FERTILIZATION (CRF sector 3H)

5.10.1 SOURCE CATEGORY DESCRIPTION

Adding urea ($CO(NH_2)_2$) to soils during fertilization leads to a loss of CO_2 .

Emission of CO_2 from use of urea contributes with less than 1% of the CO_2 emission from the agricultural sector.

5.10.2 METHODOLOGICAL ISSUES

A Tier 1 method as given in the 2006 IPCC GL is used.

5.10.2.1 Activity data

The amount of urea used on agricultural soils is provided by National service for Plant Protection (see below).

According to the ERT recommendation, for the period 1988 – 2005, activity data have been interpolated base on the total consumption of N fertilizers, due to for this period of time there are no data on the urea consumption in agriculture sector.

Table 198 Consumption of urea fertilizers (t/year) for the period 2006 – 2017:

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Urea (t/year)	23348	21481	27686	33891	24619	35840	42712	50739	42082	42639	49000	45577

Data were provided by National service for Plant Protection

5.10.2.2 Emission factors

The default emission factor of 0.20 given in the 2006 IPCC GL is used.

5.10.2.3 Methods

CO_2 emissions from urea fertilization were estimated with Equation 11.13 from the 2006 IPCC GL:

$$CO_2 – C\ Emission = M \times EF$$

M – annual amount of urea fertilization, tones urea/year (see above);

EF – emission factor, tone of C/ tone of urea = 0,20 (2006 IPCC GL).

To convert CO_2 – C emissions in CO_2, emissions were multiply by 44/12.

Table 199 CO_2 emissions from urea fertilisation:

	2006	2007	2008	2009	2010	2011
CO_2 emissions (Gg)	17,12	15,75	20,30	24,85	18,05	26,28
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
CO2 emissions (Gg)	31,32	37,21	30,86	31,27	35,93	33,42

5.10.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty of emissions from this source is 50%.

5.10.4 SOURCE-SPECIFIC QA/QC

All activities regarding QC as described in QA/QC System have been undertaken.

5.10.5 SOURCE-SPECIFIC RECALCULATIONS

There are no recalculations for this category.

5.10.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

There are no planned improvements in this category.

6 LAND-USE, LAND-USE CHANGES AND FORESTRY (CRF SECTOR 4)

6.1 OVERVIEW OF SECTOR LULUCF

Land Use, Land-Use Change and Forestry (LULUCF) sector includes emissions and greenhouse gas removals from different land-use types, changes in the land-use and forestry. The greenhouse gas inventory of LULUCF sector comprises emissions and removals of CO_2 due to overall carbon gains or losses in the relevant carbon pools of the predefined six land-use categories. These pools are above-ground biomass, below-ground biomass, dead organic matter (litter and dead wood) and soils. Sources of the non-CO2 emissions in the LULUCF sector are the biomass burning, lime and urea application, as well as fertilisation.

Since reporting year 2015 the methodology used to calculate emissions and removals in LULUCF follows that of the 2006 IPCC Guidelines. The predefined land-use categories are Forest land (FL), Cropland (CL), Grassland (GL), Wetland (WL), Settlements (S), Other land (OL). In accordance with the 2006 IPCC Guidelines emissions and removals should be reported into two sub-categories – land remaining in the same category and land converted to another land-use category. All the land-use changes were traced down and reported for a transition period of 20 years (as require in IPCC 2006) after which they are reported in the respective categories.

6.1.1 SECTOR COVERAGE

In the 2019 Inventory submission Bulgaria reports carbon stock changes, as well as greenhouse gas emissions and removals from Forest Land (CRF 4.A), Cropland (CRF 4.B) and Grassland (CRF 4.C), Wetlands (CRF 4.D), Settlements (CRF 4.E) and Other land (CRF 4.F) and harvested wood products (HWP). The quantity of CH_4 and N_2O emissions are estimated for these sub-categories, where they occur. The completeness of the estimated emissions from sources and removals by sinks is shown in the table below.

Table 200 Overview of subcategories of CRF Sector 4 – LULUCF: status of emission estimates for CO_2, CH_4 and N_2O

Land-Use Categories	Net CO_2 emissions/removals	CH_4	N_2O
A. Forest Land	**x**	**x**	**x**
1. Forest Land remaining Forest Land	x	x	x
2. Land converted to Forest Land	x	x	x
B. Cropland	**x**	**NO**	**x**
1. Cropland remaining Cropland	x	NO	NO
2. Land converted to Cropland	x	NO	x
C. Grassland	**x**	**NO**	**NO**
1. Grassland remaining Grassland	NO	NO	NO
2. Land converted to Grassland	x	NO	NO
D. Wetlands	**x**	**NO**	**x**
1. Wetlands remaining Wetlands	NO	NO	NO
2. Land converted to Wetlands	x	NO	x
E. Settlements	**x**	**NO**	**x**
1. Settlements remaining Settlements	NO	NO	NO
2. Land converted to Settlements	x	NO	x
F. Other Land	**NO**	**NO**	**x**
1. Other Land remaining Other Land	x	NO	NO
2. Land converted to Other Land	x	NO	x
G Harvested Wood Products (HWP)	x		

Land-Use Categories	Net CO_2 emissions/removals	CH_4	N_2O
1. HWP Produced and Consumed domestically	x		
2.HWP Produced and Exported	x		

6.1.2 KEY CATEGORIES

The key source categories within this sector are presented in the table below.

Table 201 Key sources of LULUCF sector

Land-Use Categories	Gas	Level assessment	Trend assessment
4.A.1 Forest Land Remaining Forest Land	CO_2	x	x
4.A.2 Land Converted to Forest Land	CO_2	x	x
4.B.1 Cropland Remaining Cropland	CO_2	x	
4.C.2 Land Converted to Grassland	CO_2	x	x
4.E.2 Land Converted to Settlements	CO_2	x	x
4.F.2 Land converted to Other Land	CO_2		x
4.G Harvested Wood Products	CO_2	x	

6.1.3 EMISSION TRENDS

The emissions and removals in the different categories are presented in Table 202

Table 202 Net emissions and removals of greenhouse gases from land use, land use changes and forestry by categories in CO_2 eq.

Year	Total CO_2 removals	4 A Total Forestland	4 B Total Cropland	4 C Total Grassland	4 D Total Wetlands	4 E Total Settlements	4 F Total Other land	4 G HWP
1988	-12730.69	-12080.07	-1004.69	-2.22		524.35	11.93	-179.98
1990	-12257.43	-12112.88	-595.53	26.64		514.02	10.93	-100.61
1995	-10536.68	-12050.44	-108.72	67.61	14.34	488.27	8.40	1043.85
2000	-12233.89	-14120.44	784.55	-1252.39	98.89	541.24	1118.09	596.16
2005	-12060.76	-12939.01	898.32	-1211.52	186.25	555.89	802.00	-352.69
2010	-9929.81	-10704.07	661.45	-1166.35	273.03	815.77	580.95	-390.58
2015	-8032.43	-7203.05	1011.78	-1730.38	300.46	845.84	-399.88	-857.21
2016	-8395.68	-7133.08	910.35	-1767.85	295.48	833.17	-400.74	-1133.01
2017	-8153.06	-7170.68	818.88	-1687.29	281.62	846.79	-401.72	-840.65

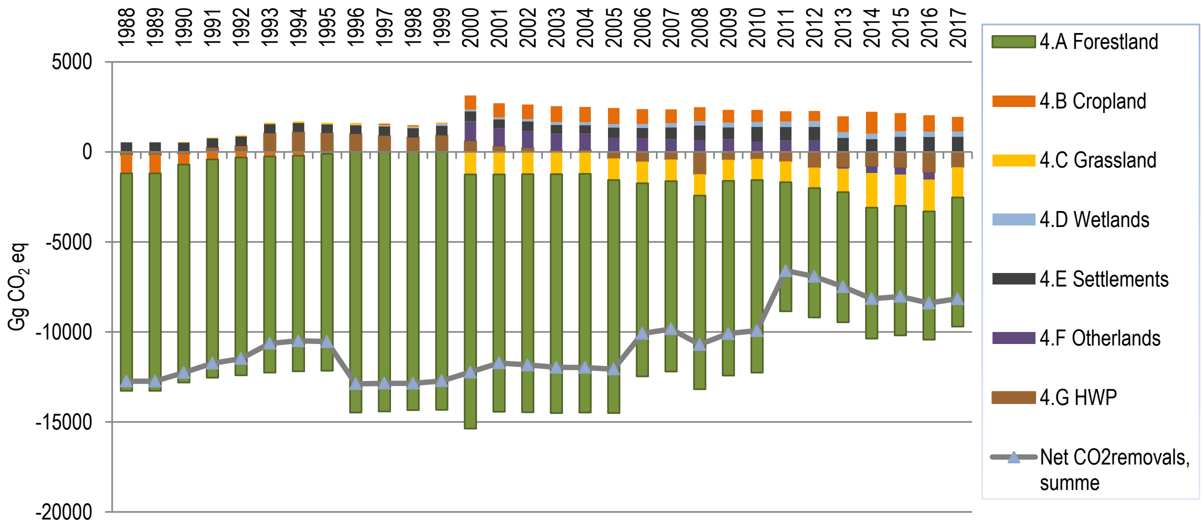

Figure 97 LULUCF emissions and removals 1988 – 2017 CO_2 eq.

The figure shows that the LULUCF sector is serving as a sink of greenhouse gases for Bulgaria. The category "Forest land" is removals of CO_2 during the whole time series. The contribution of the HWP, Cropland, Grassland and Other Land categories to the emissions/removals from LULUCF category is in both directions – as source and as a sink of emissions. All remaining categories (Settlements and Wetlands) are sources of CO_2 emissions. The trend of net CO_2 removals (CO_2 eq) from LULUCF decreases by 31% compared to the base year. The main reason for the overall decrease of the uptakes of CO_2 emissions from LULUCF is due to the fall in removals from category Forest land and the slight increase in emissions from CL, WL and SM categories. The key driver for the trend of emissions in LULUCF is the FL category. The major reason behind this dramatic decline is that in Bulgaria, since 2000, there is an increase in harvesting by 30% in 2002 compared to 2001 and by almost 70% in 2005 and 2010 compared to 2001. Although the increase in the wood removals, the harvesting in these years is still below to what was planned to be harvested. In 2017 the harvesting is 30% higher than 2010 and now it reaches the planned quantities according to FMPs. The increase in harvesting since 2010 is in response to the market demand and also to the fact that since the adoption of the new Forest Act (2011) there was an organizational change in the management of the forestry operations and in most cases the planned harvesting according to FMP is fulfilled. Although such an absolute increase in harvesting, the growing stock in Bulgaria is increasing during the years and it is expected to increase in the next 20-30 years.

Despite the decrease observed, the share of the removals from the total GHG emissions (in CO2eq) is still remarkable. The reason for this is that the emissions in the other sectors have dropped dramatically. The share of the removals in the base year has the figure of – 15% from the total GHG emissions in CO2eq, while in the inventoried year the share is - 13%.

Comparing with the base year an increase in the emissions in croplands, settlements and wetlands is observed. The total emissions from croplands fluctuate during the whole time series. The emissions from Settlements increase last couple of years due to changes from other land- uses to Settlements according to the risen infrastructural activities since Bulgaria's joined the EU.

In GHGI Submission 2018, all the emissions from N mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soils, has been included. More information on the estimations are presented in the relevant chapters.

6.1.4 METHODOLOGY

The inventory follows the methodologies and principles envisaged in the IPCC 2006. All land-use changes have been traced down and reported for a transition period of 20 years after which they are reported in the respective categories.

6.1.5 EMISSION FACTORS

The calculation of the emission factors follows to a great extent the methods, described in the 2006 IPCC Guidelines. In those cases, where possible, the emission factors are determined considering the specific conditions of the country. To calculate them data from national statistical sources and studies are used - the official reports of the forestry fund, the national system for environmental monitoring, the scientific research database in Bulgaria and other European countries.

6.2 LAND-USE DEFINITIONS AND THE CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES

6.2.1 LAND-USE DEFINITIONS AND CLASSIFICATION SYSTEMS

Forest land

For defining forest, Bulgaria uses the definition in the Bulgarian Forest Act (last amendment 07.08.2012, SG №60):

"***Area over 0.1 ha, covered with forest tree species higher than 5 meters and tree crown cover over 10% or with trees which can reach these parameters in natural environment***".

Areas of natural forest regeneration outside urban areas with a size of more than 0.1 ha also represent "forest". City parks with trees, forest shelter belts, and single row trees do not fall under the category "forests.

According to their functions, forests are divided into: forests for timber production, protective and recreation forests and forests in protected areas.

Forests are also:

- areas which are in a process of recovering and are still under the parameters, but it is expected to reach forest crown cover over 10% and tree height 5 meters;
- areas, which as the result of anthropogenic factors or natural reasons are temporarily deforested, but will be reforested;
- protective forest belts, as well as tree lines with an area over 0.1 ha and width over 10 meters;
- cork oak stands."

All forests in Bulgaria are managed.

Cropland

According to the area data available the category "Cropland" consists of annual crops (cornfields and kitchen gardens) and perennials (vineyards, fruit and berry plantation and nurseries).

Arable land is the land worked regularly, generally under a system of crop rotation - area with annual crops, set - aside area as well as area with seeds and seedlings.

Perennial crops include fruit and berry plantation, vineyards and other permanent crops, nurseries for wine, fruits, ornamental plants, forest trees etc. The orchard is a uniformly kept plantation (by annual pruning and regular treatment for protection from diseases and insects) of fruit trees (pip- trees, stone-trees and nut-trees). The orchard production may be used for direct consumption or processing. The density of plantation is a least 10 trees per decare and therefore the maximum distance between the trees a 10x10m.

Grassland

Part of this category is the permanent grasslands – natural meadows, low productive grasslands, permanent lawns and grassland which are not used for production purposes.

All grasslands are managed.

Wetlands

It is assumed that in the Wetlands category - wetlands surface water areas are included (wetlands) – covered with water or water saturated lands (throughout the year or partially in the year) which does not fall in the other categories. These are natural or artificial water-courses serving as water drainage channels, natural or artificial stretches of water, coastal lagoons, wetlands areas and peatbogs.

Settlements

The Settlements refer to all classes of urban formation. These areas are functionally or administratively associated with public or private land in cities, villages or other settlement types.

Other land

Other land category includes bare soil, rock and all area that do not fall into any of other five land-use categories, which include also area with soil and vegetation suitable for cultivation.

6.2.2 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USED DATABASES USED FOR THE INVENTORY PREPARATION.

As it was mentioned above, the LULUCF sector consists of the following categories: Forest land, Cropland, Grassland, Wetlands, Settlements and Other land. All land areas within a country should be assigned to one of these categories.

The land area representation is assembled based on data from different statistical sources (Table 203). Therefore, when compiling the data available for land area representation, the following hierarchical treatment of the data sources has been performed, from top to bottom:

- Top priority is given to the most reliable data which comes from systematically measured statistics and ortho photoimages. This data is used to present the total area of each particular land use cateogry for the whole time series
- Concerning estimation of LUCs between categories, priority is given to estimates based on specific information on land-use changes rather than to estimates of LUCs based on expert judgement

- ➢ Estimates of LUCs between categories based on expert judgement are with higher priority than estimates of LUCs based on data gaps
- ➢ Data gaps

Hence, the area of forestland is obtained from the National Forest Inventory and Forest Management Plans (data provider Executive Forest Agency). Information on CL and GL areas is gathered from National Statistical Yearbooks and orthophotoimages. The National Statistical Yearbooks provide information on CL and GL areas over the period 1988-2000. The balance of the territory of Bulgaria based on orthophotoimages has been available since 2010. To ensure a full time-series interpolation between the years 2000 and 2012 has been applied. The interpolation was made taking into account the data from orthophotoimages for 2012, because It was considered that the 2012 is more reliable than the 2010 data. Concerning the data on WL and SM, information on its area for single years (1994, 1996) has been obtain from the cadastral maps of the agricultural fund of Bulgaria (Balance by Type of Territories as per their Designation, Cadastre Agency) as well as data from the balance of the territory of Bulgaria based on orthophotoimages for the year 2012. In order to cover the time series – interpolation and extrapolation have been applied. Information on rocks, landslides and barren area from the forestry fund reporting forms (NFI, FMP) Executive Forest Agency) as well as information on other lands (sands, small-scale non-arable lands, lands with poor vegetation etc) from orthophotos are referred to category "Other land". The total national area of 11100.19 kha remains constant over time. Thus, in accordance with IPCC 2006, the difference of the area of all land-use categories and the whole area of the country is referred to "Other land" category.

Table 203 Information on data sources and providers

Land use category	Main data source		Data provider	
	1988-1999	1. 2000-2016	1988-2000	2000-2016
4A Forest land	National Forest Inventory, Forestry Management Plans and its Forestry fund reports		Executive Forest Agency (ExFA)	
coniferous				
deciduous				
forests out of yield				
4B Cropland	National Statistical Yearbooks	balance of the territory of Bulgaria based on orthophotoimages for the years 2010-2015; inbetween interpolation	National Statistic Institute (NSI)	Ministry of agriculture, food and forestry (MAFF)
annual cropland				
perennial cropland				
4C Grassland	National Statistical Yearbooks	balance of the territory of Bulgaria based on orthophotoimages for the years 2010-2015; inbetween interpolation	National Statistic Institute (NSI)	Ministry of agriculture, food and forestry (MAFF)
4D Wetlands	Cadastral maps of the agricultural fund for single years 1994 and 1996; balance of the territory of Bulgaria based on orthophotoimages for 2014 - inbetween interpolation		Cadastre Agency and MAFF	
4E Settlement				
4D Other land	National Forest Inventory, balance of the territory of Bulgaria based on orthophotoimages for the years 2010-2015		Executive Forest Agency (ExFA) and MAFF	

Major problem in presenting the land use pattern is the limited information on the land-use changes between particular categories. The activity data providers identify the total area for each individual land-use category, but they do not provide detailed information on changes of area between each category. Thus, the approach 1 according to the 2006 IPCC Guidelines has been used for representing the area. When data for completing the information is missing, information from available statistics as well as probability assumptions of known pattern on land-use changes have been used. Thereby, the remaining LUC areas to forests have been assumed to stem from cropland, grassland and other lands. The assessment of the former land use on the identified new forest areas is based on expert judgment on basis of likelihoods. The assessment of the former land use has been done by forestry experts from the Executive Forest Agency (ExFA).The time series in the area statistics shows different trends in the years before and after 2000. Therefore, the time series was divided into these two periods and the land-use changes from cropland, grassland and other lands to forest land were fitted to the different trends in these two periods.

As regards reporting of LUCs to cropland and grassland, information from agricultural statistics (BANSIK) has been used. The agrostatics provides information on LUCs between cropland and grassland as well as between annual and perennial crops and in reverse for a period of 15 years (2000-2015). The LUCs to cropland and grassland for the years before 2000 are unknown. Therefore, the LUCs between CL and GL have been estimated in order to fit the trend in the area. More information on the justification of the estimate is given in the category's chapters. Any conversions and re-conversions from wetlands and settlements are considered as unlikely.

Since Submission 2015, the LUCs to wetlands have been assumed to stem from cropland and other land. The determination of these land-use categories, as the possible land-use changes where the increase in wetlands may stem from, is based on the last step from the hierarchical treatment of the data sources – that is data gaps. It has been considered that the shares of these individual land use categories to the observed increase in wetlands behave like the ratios of the total areas of these land use categories in Bulgaria. In its previous submission Bulgaria reported LUCs from forestland to wetlands due to probability reasons. It was assumed that the observed increase in wetlands suggests also deforestation for wetlands. This forest loss to wetlands was estimated as a share of forest land in the totals of forest land, cropland plus grassland (it was supposed that the increase in wetlands comes from such lands). Actually the reported LUC from forestland to wetlands in the previous submissions of Bulgaria represented an overestimation of deforestation activity since all the information for forest loss due to changes in designation of forest was reported under LUCs to settlements (SM). Since the improvements in area representation made for the Submission 2014 LUCs from forestland to wetlands were not calculated. According to experts from the ExFA, the changes of designation of forest in the years 1988-2012 have been associated with conversion only to SM. There is only one new dam lake (Tsankov kamak) which was built up in recent years but the forest loss associated with its construction works has been already reported in the 70's. Therefore, Bulgaria reports all information provided by the ExFA for forest loss across the time series as LUC associated with conversion to SM. The reported estimates of land-use changes from grassland to other land use categories (forestland and cropland), which are based on specific data and expert judgment, fit very well to the observed decrease in the total grassland area since the base year. Therefore, no land-use changes from grassland to wetlands have been assumed and reported.

Concerning the LUCs to settlements there is information for LUC from forest land to settlements, which is available for the period 1990-1994 and for the years 2001 to 2015. The annual forest loss to settlements for the years 1988, 1989 and 1995-2000 is estimated as an average value of forest loss in the period 1990-1994. Information for LUC from arable land (e.g cropland and grassland) to settlements is available for the years 2001 to 2016. The share of annual cropland, perennial cropland and grassland within the available figure for the total area, which is changed to settlement between 2001 and 2016, was assumed to be the same as the share of the totals of these land-use categories. LUCs from arable lands to settlements for the years before 2001 are estimated using the data gaps approach. The reported land-use changes to settlement fit very well to the increases in settlement area.

Concerning the LUCs from and to OL, except these from OL to FL, are estimated using the data gaps approach. The reporting of changes from OL to CL and GL and in reverse has been implemented in the 2016 GHGI Submission.

Additional information in details on the methodologies and assumptions used in the estimation of land use over the reporting period is presented in the chapters for the different types of land-use.

In accordance with the 2006 IPCC Guidelines, Bulgaria reports the LUC areas within the LUC categories for a transition period of 20 years. Therefore, activity data back to 1968 is needed to report the LUC areas adequately. Due to the lack of data it is assumed that the trends of LUCs in the first years after 1988 were the same as in the years before. Consequently, the averages of the trends of the first years of the reporting period were extrapolated back to 1968 (1988-2000 or 1988-1999 depending on the split of the time series).

Table 204 presents the total area of the respective land uses and land-use changes between categories for the base and the inventoried year as well as the net changes for the period.

Table 204 Area by type of land use and land-use changes for the base year and the last year of inventory

area in kha	**1988**	2017	2017-1988
5.A Forest Land - Total	**3620.39**	3910.38	289.99
5A1. Forest land remaining forest land	***3480.21***	3677.96	197.75
5A1a. Forest land remaining forest land - coniferous	1198.91	1051.84	-147.07
5A1b. Forest land remaining forest land - deciduous	2259.78	2603.67	343.89
5A1c. Forest land remaining forest land - out of yield	21.52	22.45	0.93
5A2. LUC in forest land	***140.18***	232.42	92.25
5A2.1.a Annual Cropland in forest land	18.42	25.75	7.33
5A2.1.b Perennial Cropland in forest land	1.18	1.37	0.19
5A2.2 Grassland in forest land	119.07	204.37	85.30
5A2.3 Wetland in forest land	0.00	0.00	0.00
5A2.4 Settlement in forest land	0.00	0.00	0.00
5A2.5 Other land in forest land	1.51	0.93	-0.58
5.B Cropland - Total	**4139.10**	4147.18	8.08
Cropland annual	3843.30	3940.47	97.17
Cropland perennial	295.80	206.71	-89.09
5B1. Cropland remaining cropland	***3615.30***	3590.91	-24.39
5B1a annual cropland remaining annual cropland	3294.03	3358.34	64.30
5B1b perennial cropland remaining perennial cropland	198.80	110.10	-88.70
5B1c LUC perennial cropland in annual cropland	57.34	57.34	0.00
5B1d LUC annual cropland in perennial cropland	65.13	65.13	0.00
5B2. LUC in cropland	***523.80***	556.27	32.47
5B2.1a Forest land in annual cropland	0.00	0.00	0.00
5B2.1b Forest land in perennial cropland	0.00	0.00	0.00
5B2.2a Grassland in annual cropland	291.11	323.94	32.83
5B2.2b Grassland in perennial cropland	18.90	15.56	-3.34
5B2.3a Wetlands in annual cropland	0.00	0.00	0.00
5B2.3b Wetlands in perennial cropland	0.00	0.00	0.00
5B2.4a Settlements in annual cropland	0.00	0.00	0.00
5B2.4b Settlements in perennial cropland	0.00	0.00	0.00
5B2.5a Other land in annual cropland	200.82	200.86	0.04
5B2.5b Other land in perennial cropland	12.98	15.92	2.94
5.C. Grassland - Total	**2113.42**	1730.41	-383.01
5C1. Grassland remaining grassland	***1858.96***	1284.47	-574.48
5C2. LUC in grassland	***254.47***	445.93	191.47
5C2.1 Forest land in grassland	0.00	0.00	0.00
5C2.2.a Annual cropland in grassland	15.00	244.53	229.54
5C2.2.b Perennial cropland in grassland	134.97	39.79	-95.18
5C2.3 Wetlands in grassland	0.00	0.00	0.00

5C2.4 Settlements in grassland	0.00	0.00	0.00
5C2.5 Other land in grassland	104.50	161.61	57.11
5 D Wetlands - Total	**213.50**	231.57	18.07
5D1. Wetlands remaining wetlands	***213.50***	215.49	1.99
5D2. LUC in wetlands	***0.00***	16.08	16.08
5D2.1 Forest land in wetlands	0.00	0.00	0.00
5D2.2.a Annual Cropland in wetlands	0.00	14.04	14.04
5D2.2.b Perennial Cropland in wetlands	0.00	0.00	0.00
5D2.3 Grassland in wetlands	0.00	0.00	0.00
5D2.4 Settlement in wetlands	0.00	0.00	0.00
5D2.5 Other land in wetlands	0.00	2.04	2.04
5 E Settlements - Total	**445.21**	523.43	78.22
5E1. Settlements remaining settlements	***404.20***	462.75	58.55
5E2. LUC in settlements	***41.02***	60.68	19.66
5E2.1 Forest land in settlements	1.43	4.87	3.44
5E2.2.a Annual Cropland in settlements	23.31	32.18	8.87
5E2.2.b Perennial Cropland in settlements	1.46	1.70	0.24
5E2.3 Grassland in settlements	12.00	16.77	4.77
5E2.4 Wetlands in settlements	0.00	0.00	0.00
5E2.5 Other land in settlements	2.82	5.17	2.34
5 F Other land - Total	**568.56**	557.22	-11.35
5F1. Other land remaining other land	***533.36***	64.79	-468.58
5F2. LUC in other land	***35.20***	492.43	457.23
5F2.1 Forest land in other land	0.00	0.00	0.00
5F2.2.a Annual Cropland in other land	22.19	289.87	267.67
5F2.2.b Perennial Cropland in other land	1.44	32.08	30.64
5F2.3 Grassland in other land	11.57	170.49	158.92
5F2.4 Wetlands in other land	0.00	0.00	0.00
5F2.5 Settlements in other land	0.00	0.00	0.00
Total area Bulgaria	**11100.19**	**11100.19**	**0.00**

The data shows that over the period 1988-2017 the areas in the categories "Forest land", "Wetlands", "Settlements" and "Cropland" have increased by 289,99 kha, 18,07 kha, 78,22 kha and 8.08 kha and they have decreased in the categories and "Grassland" and "Other land" by 383.01 kha and 11,35 kha respectively.

In addition to the information presented above, it should be noted that a change in the pattern of LUCs from and to CL and GL has been implemented. This change has followed the plan for improvement of land area representation. As it was explained above Bulgaria uses different statistical sources when compiling the inventory. Thus, Bulgaria has kept the totals of land-use categories closer as much as possible to the original data. Bulgaria does not have detailed information on LUCs between categories. Anyway, a combination between the available statistics and probability assumptions has been used. In the past two inventories this approach resulted in a rather good fit in the trend of area changes over ten or twenty plus year period between categories, but did not provide a good fit in CL category which area has more than 30% share from the total country territory. This has led to the need of revising the land use pattern. The trend of area change in CL and GL has shown a steady decrease since the year 2000. This is as a result of the abandons of agricultural area. However, there is no such increase in other land-use categories. At the same time, the difference of the area of all land-use categories and the whole area of the country is referred to "Other land" category. It was noted also that this difference in the areas increases in the past several years, so this means that for more area is hard to assign to particular land-use category. These are usually lands under agricultural fund (CL and GL) and represent areas with shrubs, non-temporarily unmanaged perennial fields, meadows and etc. So in order to deal with this situation it was decided to distribute these areas within CL, GL and OL categories based on their relative shares to the total country's territory. LUCs between these categories are also estimated. In order to avoid double counting of area it was necessary to revise the land area pattern under SM category.

6.3 FOREST LAND (4.A)

6.3.1 DESCRIPTION OF THE CATEGORY

In 2017, forests in Bulgaria cover an area of 3910 kha which represents 35% of the country's territory. Over the reporting period, a steady increase in forest territory is observed. In 2017 the forests cover is by 8% more compared to the base year.

In accordance with the IPCC Guidelines the evaluation of the emissions/removals from Forest land category includes an assessment of the changes in the carbon stock in 3 pools – living biomass (above- and below-ground biomass), dead organic matter (dead wood and litter) and soil. For subcategory FLrFL Bulgaria provides estimates for carbon stock changes in living biomass at Tier 2 - with country specific data and emission factors. Concerning the carbon stock changes in DOM and soil pools for subcategory FLrFL, Bulgaria applies Tier 1, assuming there is no change in these pools. This has been changed since its last Submission, where Bulgaria reported (for two consecutive years) emissions and removals from these pools by using directly and then extrapolating the results from a study, conducted by JRC and published in a report32. Bulgaria understands that using the results from this study leads to a lack of comparability between the methods and assumptions used to estimates the changes in the living biomass pool and the methods and assumptions used to calculate the carbon stock changes in deadwood, litter and soil, estimated by CBM. Unfortunately, at the moment Bulgaria is not able to apply higher tier and report for emissions and removals from DOM and soil in FLrFL but intends to allocate extra efforts to provide estimates in the coming years. Concerning the subcategory LUC to Forests, Bulgaria estimates and reports carbon stock changes in all pools – living biomass, DOM and soil. More information on the methods used is provided in the respective chapters.

CO_2 and non- CO_2 emissions from wildfires (Figure 101) are allocated between the subcategory 4.A.1 and 4.A.2 according to their area share in total forestland. N_2O emission from N mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soils are estimated in the sub-categories where loss of carbon is reported.

There is no fertilization on forest land in Bulgaria; therefore, direct N2O emissions from fertilization are reported as NO (not occurring). Non-CO_2 emissions associated with drainage of organic soils are reported as NO, since such activity is not occurring in Bulgarian forests.

6.3.1.1 Trends in the emissions/removals from Forest land category

The Forest category is serving as a sink of CO2 emissions over the entire time series. The amount of CO_2 removals from the category ranges between -12,789.35 Gg CO_2 eq. for 1988 and -8,472.08 Gg CO_2 eq for 2017. Despite the observed increase in forest area (Figure 99), there is a drop in the amount of the removals from the category and this tendency is expecting to continue.

[32] *"LULUCF contribution to the 2030 EU climate and energy policy"*, available at http://publications.jrc.ec.europa.eu/repository/handle/JRC102498

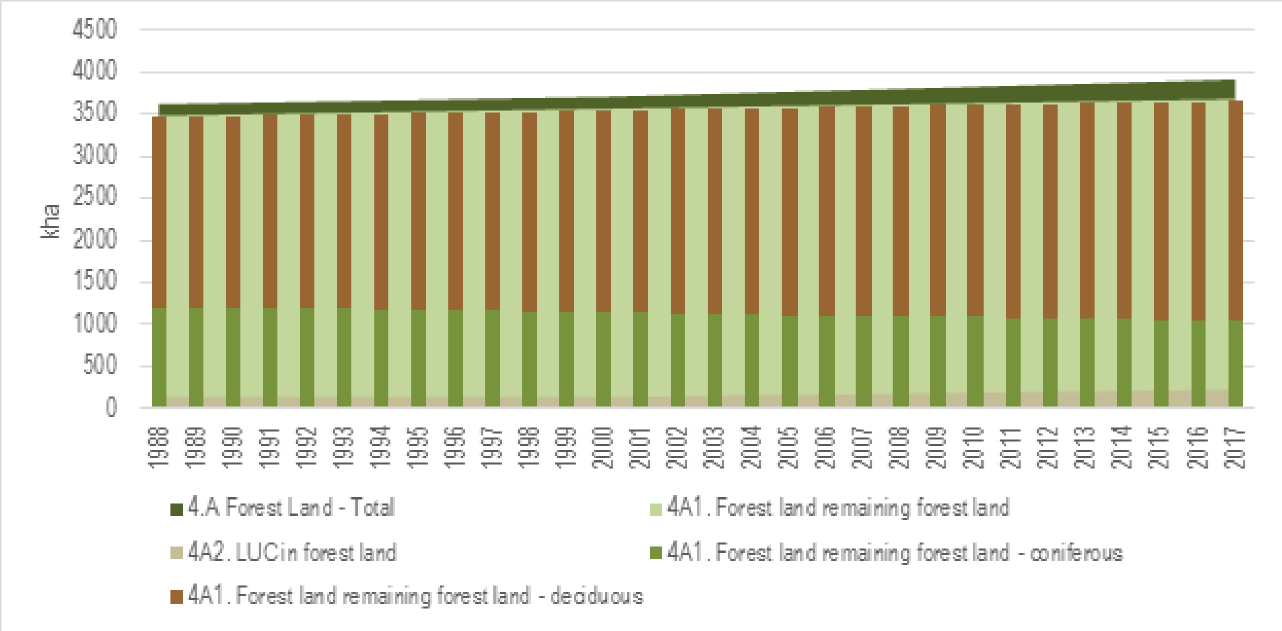

Figure 98 Trend in forest area 1988-2017

This is due to a fall (by 30%) in removals from living biomass pool since 2000 in subcategory Forest land remaining forest land. At the same time the changes in soil carbon pools when converting other land to forests are associated with emissions – 924 Gg CO_2. This is caused by the higher level of the organic carbon stock in soils of grassland and cropland compared to those of forest land.

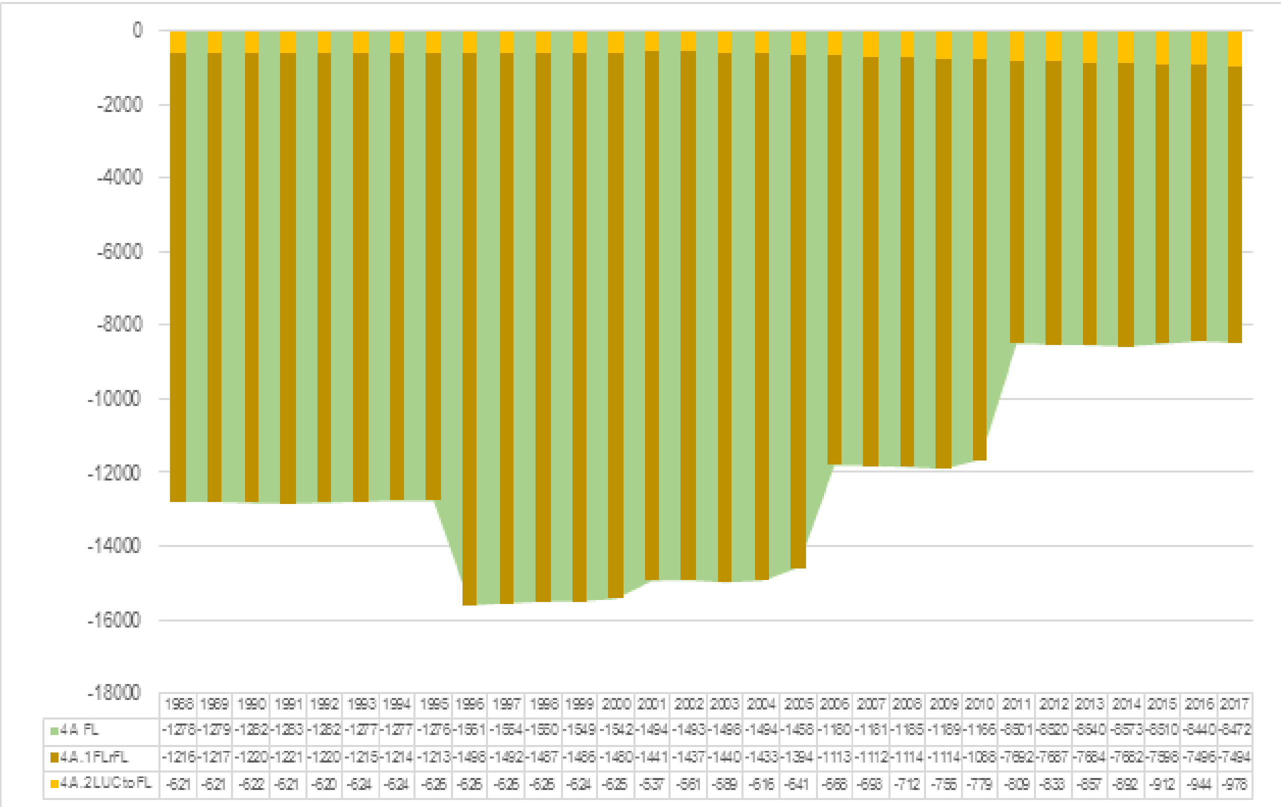

Figure 99 Trends in CO2 removals from category Forest Land

The major reason behind this dramatic decline is that in Bulgaria, since 2000, there is an increase in harvesting by 30% in 2002 compared to 2001 and by almost 70% in 2005 and 2010 compared to

2001. Although the increase in the wood removals, the harvesting in these years is still below to what was planned to be harvested. In 2017 the harvesting is 30% higher than 2010 and now it reaches the planned quantities according to FMPs. The increase in harvesting since 2010 is in response to the market demand and also to the fact that since the adoption of the new Forest Act (2011) there was an organizational change in the management of the forestry operations and in most cases the planned harvesting according to FMP is fulfilled. Although such an absolute increase in harvesting, the growing stock in Bulgaria is increasing during the years and it is expected to increase in the next 20-30 years.

In addition to the observed increase in harvest, there are other peculiarities of Bulgarian forest which could affect the rate in biomass accumulation. Concerning the broadleaves, these are the big shares of old coppices and low-stem forests (>40 years). Coppice forests make up 35% of forests in Bulgaria. 80% of them are aged over 40 years and 40% are over 60 years of age, which is the result of being unsuccessfully grown into seed forests. Many of these forests have lost their ability to regenerate through offshoots, and seed undergrowth is often crowded by the shrub vegetation under the canopy of coppice forests. These stands do not grow intensively and are now subject to harvest activities. Regarding coniferous forests, the peculiarities are related to the big share of the coniferous plantations (60% of coniferous forest). Many of these plantations (almost 40%) have been planted on lower altitude (below 1000 m from the sea level) before 40-50 years (90% of plantations are at age of the stands 30-60). Now, these stands are not in a good condition. They suffer from droughts, pathogens and insects. Their productivity is not intensive anymore and they are slowly declining. Thus, these stands are intensively thinned now.

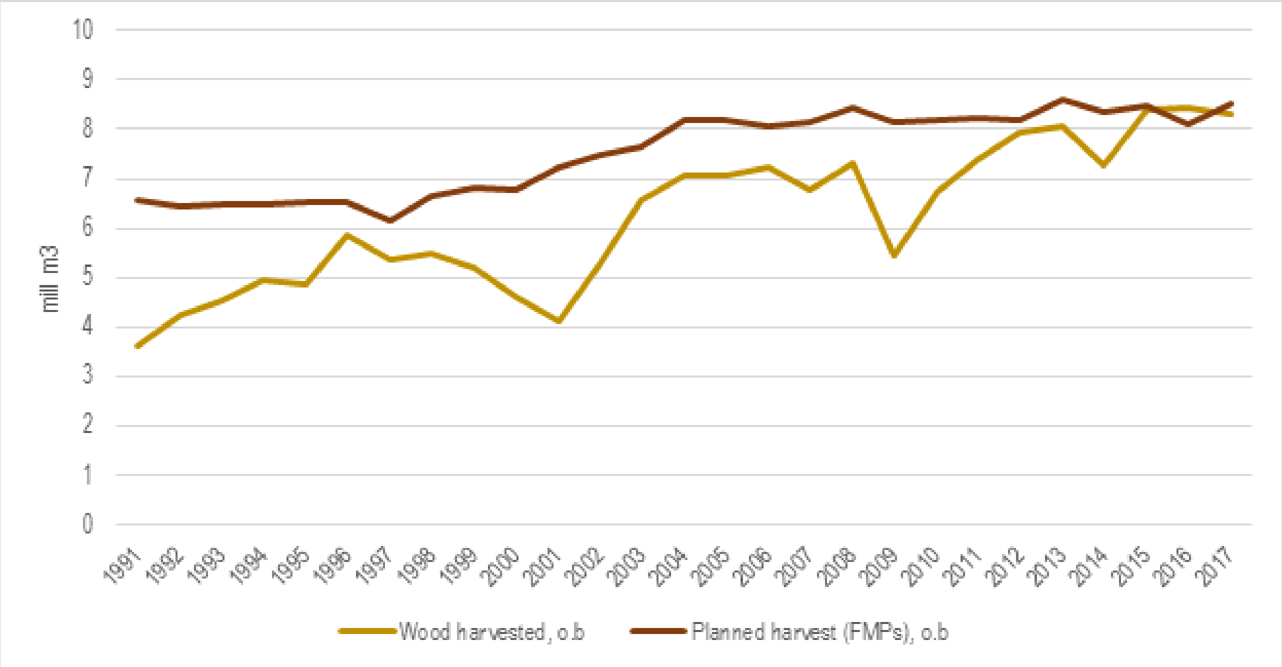

Figure 100 Trend in wood harvested vs planned harvest (mill m3 o.b)

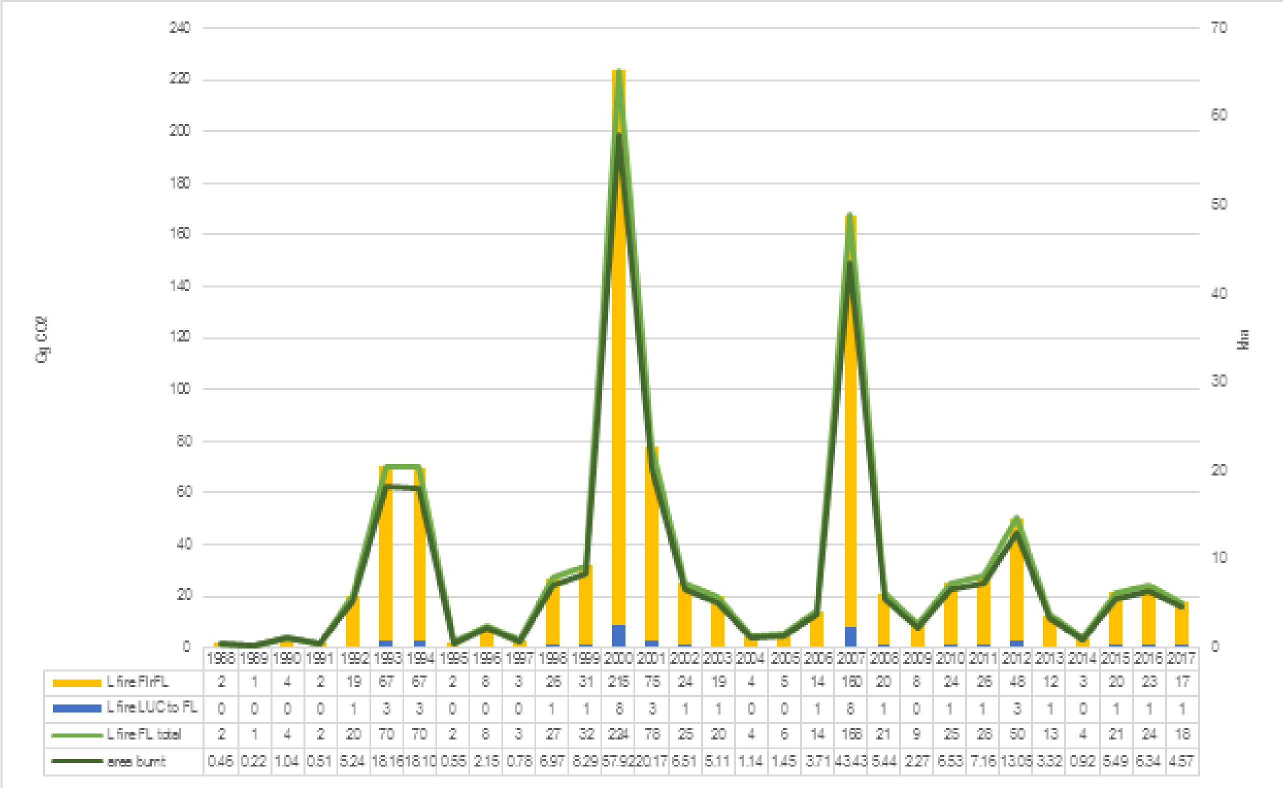

Figure 101 Non-CO_2 emissions associated with biomass burning from wildfires

Trend in Non-CO_2 emissions from biomass burning (wildfires) are shown on Figure 3. Only emissions of CH_4 and N_2O are reported here as the emissions of CO2 are included in the living biomass pool as Bulgaria applies the stock-change method in estimating the carbon stock changes living biomass pool.

Table 205 Total N_2O emissions from N mineralization associated with loss of soil organic matter in CO_2 eq

year	4.A.2.1 Cropland converted to Forestland (N_2O converted into CO_2 equivalents)	4.A.2.2 Grassland converted to Forestland (N_2O converted into CO_2 equivalents)
1988	3,35	47,04
1990	3,35	47,03
1995	3,35	47,09
2000	3,35	47,04
2005	3,73	56,64
2010	4,13	66,67
2015	4,52	76,59
2016	4,60	78,66
2017	4.69	75.69

6.3.1.2 Activity data and information used

Source of information

The Forest Inventory (FI) and the information from the Forest Management Plans (FMP) are the main sources of information for the area of forest land and its land-use changes. The FI in Bulgaria covers assessments for the entire country territory in 10 years' cycles. Therefore, all forest stands are surveyed once in every 10 years. The stand-wise inventory in Bulgaria measures the main data as tree composition, origin, age, management purpose, tree height and diameter; annual increment, bonitat, density of stand, tree growing stock etc. Forest inventory presents collection of qualitative and quantitative data about the investigated area. On the other side, the management planning gives recommendations about the silvicultural operations and activities for the next 10 years period. The plans contain data for forests' territorial division and management, basic characteristics of the forest stands; complex of activities for protection, regeneration and optimal utilization of the forest resources; economic justification, considering ecological and social effects from the implementation of the planned activities. These plans are prepared in accordance with Regulation № 8/2015 for conducting the forest inventory and planning in forest areas in Bulgaria (before 2015 the Regulation № 6 on the structure of the forests and land included in the forest fund and the hunting reserves of Republic of Bulgaria have been into force).

Data information used and its application

The quantitative information about forests in Bulgaria are presented in the Wooded Area Report (RF) and the Forestry Management Plans (FMP).

The Forest Management Plans include the Forest Stand Descriptions ("the descriptions"), which are its information base, plus tables, lists, text and maps and it is made for each subcompartment of each forest stand or bare forest area. The description contains the parameters of the site (yield class) and the forest stand (the living trees), as well as the planned measures - felling and afforestation. The descriptions are the most complete and most accurate information available to forests, but they are updated for 10 or even more years and don't contain data on the current activities of the territorial units. For the purpose of the GHGI preparation, data from FMP is used to trace the LUCs to FL.

The main data for conducting the GHGI estimates for Forest land category comes from Wooded area reports (RF). These are aggregated data (overview tables). They are updated annually or periodically and collected in a national database maintained by Executive Forest Agency (EFA) (Table 206).

The RF represents 7 reporting forms (tables), prepared by the territorial units, which have been collected since 1960 in the same format. Since 1991, they are collected via an electronic data bank and are available electronically.

Forms are known with the traditional designations RF1, RF2, ..., RF7. Forms RF1 and RF5 (area report and harvesting report) are collected annually. The other forms are collected over 5 years. In electronic form, they are available for the years 1995, 2000, 2005, 2010 and 2015.

RF1 is the distribution of the area by land types (forested land, bare land for afforestation and non-productive bare land) and forest types (conifer forests, broadleaved high-stem forests, conversion coppice forests and low-stem forests). RF1 also gives some other details about the site and vegetation. The aggregated data in RF 1 is the sum of the data at the level of subcompartments. For example, the area of a subcompartment in which the conifers predominate will be added in the row of "conifers", although it may contain some deciduous species. This is the main source of data to provide a complete time series with annual data on forest.

RF2 and RF3 are distributions of area and growing stock according to forest types, tree species and age. Areas in RF2 and volumes in RF3 are parcelled – for each and every tree species in a forest stand it is assigned an area and growing stock to. In RF2 and RF3 they are added to the row of these tree species. RF2 and RF3 do not provide information about the yield class and do not provide some necessary details about the origin, in particular, what part of the areas are on the natural stand, and what are the plantations. Since RF1 works with the area of whole stands, and RF2 - with parcelled areas, there are unavoidable differences in the area of the conifers or broadleaves according to RF1 and RF2, but the total forested area remains the same in both reporting forms.

RF4 is a distribution of area and stock by function (wood production land, protective forests, recreation forests, protected forests).

RF5 is a comparison of the planned wood removals with the actual wood removals throughout the year. It gives information on the areas being harvested, the total harvest and the quantity of wood extracted. For state forests EFA also has more detailed data that feeds RF5, but for non-state forests RF5 is the only source. RF5 works with simplified lists of tree species (high-stem beech, oak and poplar, coppices, conifers) and fellings (final fellings and thinnings). For us, RF5 is the only data source for actual wood removals.

RF6 is a distribution of the area by forest types (conifers, etc.), stand age and stocking rate (Bestockungsgrad). It served as information on the average stocking rate of the renewed areas.

RF7 is the distribution of the area by tree species composition (pure pine stands, mixed stands dominated by beech, mixed stands dominated by the broad-leaved, etc.) and site index (Höhenbonität). Its aim was to monitor a practice that is currently abandoned - the replacement of non-productive stands with productive ones in order to improve productivity.

RF4, RF6 and RF7 work with the area of whole stands and their areas are aligned with RF1.

Table 206 Description of the content of the wooded area reports (RF)

Reporting form №	Description	Update period
1	Forest area (forested and non-forested lands inside the forest fund)	Annually
2	Forested area distributed by age classes	Every 5 years since 1960; data used for the years 00-05-10
3	Growing stock by age classes	Every 5 years since 1960; data used for the years 00-05-11
4	Forested area distributed by forest functions	Every 5 years since 1960; data used for the years 00-05-12
5	Harvested amounts	Annually, separately for regeneration fellings and thinning
6	Forested area distributed by canopy cover and age classes	Every 5 years since 1960; data used for the years 00-05-12
7	Forested area distributed by age classes and yield classes	Every 5 years since 1960; data used for the years 00-05-13

When compiling the data on forest areas, data from the forestry reporting forms have been used. Although the high reliability of the gathered data, some adjustments of the original data have been made. In the Submission 2011 it was identified that the net increase in forest land was not only due to afforestation/reforestation (AR) activities but also due to inclusion of area, which were forested before 1990. In order to distinguish those new forest areas which were forested before 1.1.1990 from the total increase in forest area, Bulgaria submitted a plan for improvement of the estimation of AR units of land. In its submission 2014 Bulgaria continues to follow this plan as accepted by the ERT team as answer to the related Saturday paper issue of the 2011 review. The plan has been implemented in stages starting in Submission 2012 and completed for the Submission 2014. According to this plan the following improvement steps have been implemented:

Bulgaria examined the Forest Management Plans (FMPs – see below) for all State Forest Enterprises (SFE), which were inventoried for the period 1991-2012. Like this all changes since 1992 in forest area for each and every SFE has been traced and identified. For those SFE, where there is an increase in the forest area since 1990, the increase is derived into:

- New forest areas which are included in the forest total, but which were forested before 1990, so new forests with stands of older age classes.
- And the new forested areas with stands of the youngest age class, which are due to afforestation and reforestation activities (planting and seeding) on arable lands and barren

areas or afforestation and reforestation activities (planting, manual and natural seeding) on grassland or on croplands.

These improvement steps have been performed by the experts from Executive Forest Agency, by using the following sources of information:

- Forest Inventory and FMPs;
- Forestry Fund Reporting Form 1FF (forest area) for the 1990;
- Forest maps

The observed increase in forest area due to AR activities for every single SFEs is given for two periods - 1992-2000 and since 2000. The amount of the "new" forest areas since 1.1.1990 which were forested before 1990 (point a) was added to the total forest area in 1991 and the years after according to Forestry Fund Reporting Form 1FF (forest area). Like that the total forest area (particularly those of forest land remaining forest land) in 1991 and in the years after has been adjusted by using interpolation. The new forest areas between 2012 and 1992 according to point b represent the net increase in forest due to planting or seeding (manually or naturally) activities. Changes in forest area for the years 1988 – 1991 are based on extrapolation using the same forest change as in the year 1992.

In order to get information for the former land uses that became forests, an expert judgement has been used. Land use (cropland, grassland, other land) typically follows ecological site condition. The experts going through the FMPs know the dominating land uses in the SFE region, so they made an expert judgement of former land use on basis of likelihoods. For example, there are regions where grassland (GL) dominates, because growth/site conditions are not good enough for cropland (CL) plants or CL management or, site conditions are so good that CL dominates. Similarly, other land (OL) can be found in extreme site conditions where FL, CL, GL cannot grow.

Forest ownership and Forest Inventory coverage

Most of the forest territory in Bulgaria is state own – 73% (according to data from 2015). The municipalities and religious organizations own around 13% of the forests. The share of the private forests in Bulgaria has increased in recent years and it is around 11% from the total forest area. 94% of these private forests are properties with an area up to 2 ha.

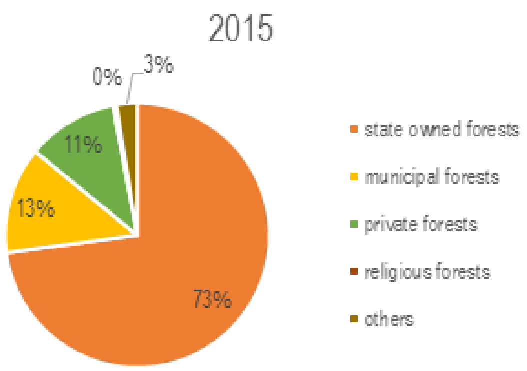

Figure 102 Breakdown of forest ownership in 2015, Source: EFA

According to the Law on Forests 2011 (art.13, 16, 19) for the forest territories – state and Municipal property, as well as for the private forest territories with land property above 50 hectares, forestry plans shall be developed. For the private forests with total area of their land up to 50 hectares a forestry programmes shall be developed. The forestry plans and programmes shall be drawn up on the basis of forestry maps, cadastre maps, maps of the restores property and performed inventory of the forest territories. The forestry plans and programmes for the private forests with total of land up to 2 ha are conducted together with forest inventory and is funded by the state. The data of the forest inventory shall be public and the procedure for access to them shall be determined by the ordinance. The Executive Forest Agency shall create and maintain an information system about the forest territories and about the activities in them. The state forestry and the state hunting reserve, the owners and users of forest territories shall be obliged to provide free information to the Executive Forest Agency and to its structures, needed for maintaining the information system. The activity data used for the accounting of the emissions/removals from Forest land category is provided by the ExFA and it covers both the state and private forests

6.3.2 METHODOLOGY

6.3.2.1 Forest Land remaining Forest Land (4.A.1.)

6.3.2.1.1 Changes in the carbon stock in the living biomass

Bulgaria follows IPCC Guidelines 2006 and applies the stock-difference method when defining carbon stock changes in living biomass. Conversion coefficients used are specific for Bulgaria and the ones given in the IPCC 2006 tables. The main database includes: forest area by type (coniferous and deciduous), forested area by tree species and age-class structure, and the volume stock (stem wood and branches) by forest type and tree species obtained from the reporting forms (1, 2 and 3 RFs). To calculate the changes in the carbon stock of the living biomass Method 2 is used.

$$\boldsymbol{C_B = (C_{t2} - C_{t1})/(t_2 - t_1)}$$

The carbon stock in the biomass is calculated using the equation:

$$\boldsymbol{C = A \cdot V \cdot BCEF_s \cdot (1 + R) \cdot CF}$$

where:

A – area of land remaining in the same land-use category

V – tree stock (stemwood and branches) m3 .ha-1

$BCEF_s$ – biomass conversion and expansion factor for expansion of merchantable growing stock volume to above-ground biomass, tonnes above-ground biomass (m3 growing stock volume)-1

$$\boldsymbol{BECF_s = BEF_2 \cdot D}$$

Where:

BEF_2 - expansion factor for conversion of the stem wood plus branches into a total aboveground tree biomass (stem, branches, leaves),D - basic wood density, tonnes m -3

R – root to shoot ratio

CF – carbon fraction in the dry matter in tonnes C (tonnes d.m.)-1

For Submission 2019, Bulgaria improved its estimation of emissions and removals from living biomass in FLrFL subcategory. The changes affect the level at which calculations are made and consequently the emission factors applied. At the current submission the emissions and removals are reported for coniferous and deciduous forests, but the reported figures are the sum of the most common tree species from these forest types. Thus, the strata used in the calculations is as follow:

1. Coniferous:
    - Scots pine

- Norway spruce
- Black pine
- Silver fir
- Other conifers

2. Deciduous:
    - Oak
    - Beech
    - Poplar
    - Others

This stratification reflects the main tree species distribution in Bulgaria. The reason to put the poplars into a separate stratum is that these forests are fast growing forests and are managed in a completely different way from the rest of the broadleaved forests.

The forest inventory in Bulgaria assess not only the stemwood volume (o.b) but also the volume of the branches of the trees. Such data have been published on a regular basis in the reporting forms over a five-year period since 1965. For this inventory, data on the wood volume by tree species are used for the years 1990, 1995, 2000, 2005, 2010 and 2015.

Table 207 Growing stock (o.b) - stemwood and branches by stratum

Stratum	unit	1990	1995	2000	2005	2010	2015
Scots pine	m3/ha	134	161	189	214	240	247
Norway spruce	m3/ha	199	211	254	294	330	356
Black pine	m3/ha	62	109	159	196	226	246
Silver fir	m3/ha	279	298	304	366	404	436
Other conifers	m3/ha	119	164	220	205	177	268
Oak	m3/ha	16	17	20	21	26	25
Beech	m3/ha	136	153	171	196	204	220
Poplar	m3/ha	98	88	81	98	122	126
Others	m3/ha	24	28	31	39	39	44

To convert the volume stock into aboveground biomass, Bulgaria applies conversion factors – BEF_2 to add the leaf biomass and D (wood density). There are no country-specific values for BEF_2 which has only to add the leaf biomass as the data on growing stock in Bulgaria contains also the volume of the branches. To estimate this specific BEF_2 data from literature sources on results from ecosystem studies for Spruce, Scots pine, Beech and Oaks were used (compiled in *Korner, C., Schilcher B. und Pelaez-Riedl S. 1993: Vegetation und Treibhausproblematik: Eine Beurteilung der Situation in Österreich unter besonderer Berücksichtigung der Kohlenstoff- Bilanz. In: ÖAW (Hrsg.): Anthropogene Klimaänderungen: Mögliche Auswirkungen auf Österreich – mögliche Maßnahmen in Österreich. Dokumentation, Österreichische Akademie der Wissenschaften, Wien, 6.1-6.46*). BEF_2 values are age-dependent. The BEF_2 for each tree species is calculated as a weighted mean value considering the actual volumes of the individual age classes for each of the major tree species. The BEF_2 values used are presented in the table below. It also shows information on which species from the literature source we used to end up with BEF_2 value for the main tree species.

Concerning basic wood density (D) national data is used. The calculations are based on values determined for Bulgaria for shrinkage and the density of the absolutely dry wood (Bluskova, G., 1994; Enchev, E., 1984). Density and shrinkage of the main Bulgarian tree species are available (Norway spruce, Scots pine, Silver fir, Oaks, Common beech, Ash, Willow, White birch, Common hornbeam, Elm).

Table 208 Calculated BEF_2 values used in the emission/removals estimates

Tree species	BEF_2 estimated based on the actual age-class distribution	BEF_2 literature
Scots pine	1.07	Scots pine
Norway spruce	1.15	Spruce
Black pine	1.07	Scots pine
Silver fir	1.13	Spruce
Other conifers	1.12	Average of Scots pine and Spruce
Oak	1.02	Oak
Beech	1.01	Beech
Poplar	1.015	Average of oak and beech
Others broadleaves	1.015	Average of oak and beech

The tree specific values for basic wood density are presented in the table below.

Table 209 Wood density (D)

Tree species	kg/m3
Scots pine	0.432
Norway spruce	0.381
Black pine	0.479
Silver fir	0.364
Other conifers	0.430
Oak	0.661
Beech	0.562
Poplar	0.360
Other broadleaves	0.604

Due to the lack of specific data for the ratio of the below-ground to above-ground biomass (R) for Bulgaria, coefficients presented in the 2006 IPCC GIs have been used according to the quantity of the aboveground biomass of each stratum during the timeseries.

Table 210 Root-to-shoot ratio (R)

Tree species	R	R	R
Above-ground biomass	*<50 tonnes d.m ha-1*	*50-150 tonnes d.m ha-1*	*>150 tonnes d.m ha-1*
Scots pine	0.40	0.29	0.20
Norway spruce	0.40	0.29	0.20
Black pine	0.40	0.29	0.20
Silver fir	0.40	0.29	0.20
Other conifers	0.40	0.29	0.20
Above-ground biomass	*<75 tonnes d.m ha -1*	*75-150 tonnes d.m ha-1*	*>150 tonnes d.m ha-1*
Oak	0.46	0.23	0.24
Beech	0.46	0.23	0.24
Poplar	0.46	0.23	0.24
Other broadleaves	0.46	0.23	0.24

The carbon fraction in the dry matter (CF) is adopted by default form the 2006 IPCC Guidelines (Table 4.3). It is 0.51 tonnes C for coniferous and 0.48 for deciduous.

The annual stock changes in biomass pool are obtained by estimating the difference between the years for which biomass stock by tree species is estimated divided by 5 (1990,1995, 2000, 2005, 2010, 2015). Then the stock changes by tree species are multiplied by their respective area in order to estimate the annual emissions/removals from the pool.

6.3.2.1.2 Changes in the carbon stock in the dead organic matter

Changes in carbon stock in dead wood

For the changes in dead wood, the 2006 IPCC Guidelines Tier 1 approach has been used, assuming that there are no changes in dead wood stocks in all managed forests remaining forests.

Changes in carbon stock in litter

Bulgaria reports CSC in litter under Tier 1 (2006 IPCC Guidelines), where litter inputs and outputs are assumed to balance, and the pools therefore taken to be stable.

6.3.2.1.3 Changes in carbon stock in soils

The soils in Bulgaria are mostly mineral soils and are characterized by the presence of carbon accumulation processes. In support of this we reviewed the current national scientific literature on the subject of soil carbon stock in forests (Zhiyanski et al, 2008, 2009,2011, 2013, 2016, Sokolovska et al., 2007, 2009 and others). Natural disturbances are common for Bulgaria but at relatively small areas, where we consider that cannot cause emissions in soils in particularly high dimensions. In addition, in the forestry practice in Bulgaria the soil preparation through scarification is not applied. Significant part of Bulgarian forest regenerates naturally (79%). In support of the above, there are also scientific publications confirming that changes in the management of forests do not cause significant changes in soil organic carbon stock. Therefore, the tier 1 approach (2006 IPCC Guidelines) has been applied, which assume that the carbon stock change in mineral soils for sub-category Forest land remaining Forest land is zero.
Histosols cover 0,06% of the total area of Bulgaria and are in protected areas, where all anthropogenic impacts are forbidden. Therefore, there is no peat extraction, draining of soils or other anthropogenic activities that affect the water regime, the temperature on soil's surface and the species. Due to this reasons Histosols are not subject to evaluation.

6.3.2.1.4 Forest fires

There is no biomass burning as in Bulgarian forests the controlled fires are forbidden by law. Therefore, in the current report only emissions of CH_4 and N_2O from wildfires have been calculated and reported. CO_2 emissions from wildfires are reported as IE to avoid double accounting as Bulgaria applies Stock-difference method in its GHGI estimates. For the calculation, Tier 1 has been applied, equation 3.27 of IPCC 2006:

For the mass of fuel, available for combustion (Mb) a value of 19,8 tonnes/ha has been used (2006 IPCC Guidelines). The values of the emission factors (G) have been taken from Table 2.5 from the 2006 IPCC Guidelines (for CO2- 1569, for CH_4 - 4.7 and for N_2O - 0.26).

Annual data for the areas affected by fires (A) has been obtained from the Executive Forest Agency and the National Parks in Bulgaria – Rila, Pirin and Central Balkan. Thus, all forest areas were covered by these data. Since the reporting system for wildfires in forests cannot define whether the wildfire happens in AR units of land or not, Bulgaria has shared these emissions between sub-category Forest lands remaining forest land and LUCs to forest land (Afforestation/reforestation areas). Therefore, the emissions from wildfires between these two sub-categories have been estimated according to their area share in total forestland.

The total emissions from wildfires (e.g. 4.A.1 and 4.A.2) are presented in Figure 101.

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6.3.2.2 Lands converted to forests (4.A.2.)

This subcategory includes activities related to the conversion of other land-use to forests. The changes in the carbon stocks in living biomass, litter and soil of lands converted to forests have been estimated. Changes to FL come from GL, CL and OL. The biggest share of all LUCs to FL (85-89%) has the LUC from GL to FL, followed by annual CL (13%), perennial CL and OL.

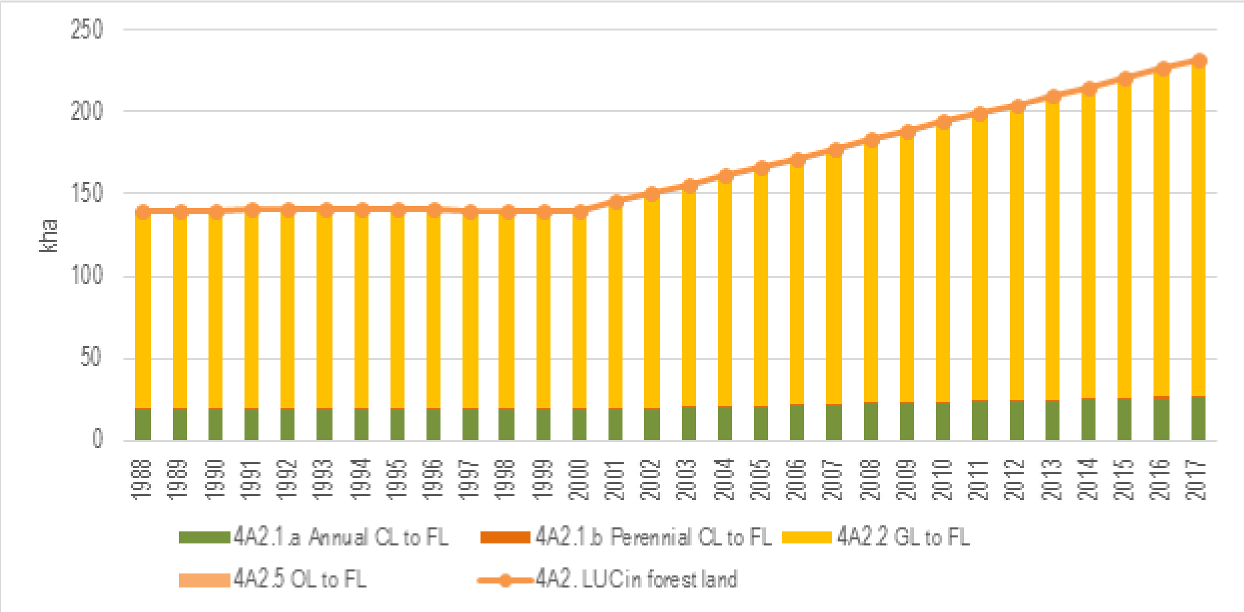

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Figure 103 Area of LUCs to FL (20 years)

6.3.2.2.1 Changes in the carbon stock in the living biomass

Changes in carbon stock in living biomass in Lands converted to forest are estimated at tier 2 level with application of some default emissions factors. Tier 2 method uses country-specific data on annual changes and allows to for more precise estimates of changes in carbon stocks in biomass. The net annual CO_2 removals are calculated as a sum of increase in biomass due to biomass growth on converted lands, changes due to actual conversion (difference between biomass stocks before and after conversion) and losses on converted lands (Equations 15 and 16, Chapter 2, 2006 IPCC GIs)

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

Where:

ΔC_B = annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr-1

ΔC_G = annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr-1

$\Delta C_{CONVERSION}$ = initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr-1

ΔC_L = annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tonnes C yr-1

$$\Delta C_{CONVERSION} = \sum \{(B_{AFTER_i} - B_{BEFORE_i}) \bullet \Delta A_{TO\ OTHERS_i}\} \bullet CF$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C yr-1

B_{AFTERi} = biomass stocks on land type i immediately after the conversion, tonnes d.m. ha-1

$B_{BEFOREi}$ = biomass stocks on land type i before the conversion, tonnes d.m. ha-1

$\Delta A_{TO\_OTHERSi}$ = area of land use i converted to another land-use category in a certain year, ha yr-1

CF = carbon fraction of dry matter, tonne C (tonnes d.m.)-1

i = type of land use converted to another land-use category

To determine the annual increase in carbon stock in biomass due to growth on lands converted to FL (ΔC_G), data on growing stock (stemwood and branches) for the first age class (1-20 years) has been used. The growing stock of the stands of I^{st} age class for coniferous and deciduous forests was divided by the average age of 10 years. This was done for all years when data on volume per age-class and area (RF2 and RF3) are available – 1995, 2000, 2005, 2010, 2015. Once we obtained the weighed mean by forest type (coniferous and deciduous) for these years an average of them equals to 6.03 m3/ha/y, which represents the average current increment. In order to convert the average annual increment of the I^{st} age class to an average annual biomass growth, biomass conversion and expansion factors have been used as shown in the table below. To estimate the carbon stock, the coefficient for carbon content as shown in the table has been used.

Table 211 Expansion and conversion factors used to convert the average annual increment into average annual biomass growth

	BEF2	D	R	CF
coniferous	1.09	0.48	0.40	0.51
deciduous	1.02	0.62	0.46	0.48
weighted mean	1.07	0.52	0.42	0.50

BEF_2 coefficient adds the biomass of the leaves and needles. The values of BEF_2 for coniferous and deciduous forests are estimated as a weighted mean considering the volumes of different coniferous and deciduous species. To estimate the average $BEF_{2,}$ data from literature sources on results from ecosystem studies for Spruce, Scots pine, Beech and Oaks for the Ist age class stands were used (compiled in Korner et al.1993).

Basic wood density for the Ist age class of coniferous and deciduous forests is estimated as a weighted mean considering the share of the volume of coniferous and deciduous species. Country-specific data on the basic wood density of the main tree species were used (compiled by Bluskova, G., 1994; Enchev, E., 1984).

The coefficient for the ratio of the below-ground biomass to above-ground biomass is estimated as a weighted mean considering the share of the volume of coniferous and deciduous forests. The estimates are based on the default values for R (table 4.4 2006 IPCC GIs) for the biomass stock <50 tonnes d.m per ha for coniferous and <75 tonnes d.m per ha for hardwoods.

The carbon fraction is again estimated as a weighted mean.

Like this, the calculated ΔC_G equals to 2.39 tC/ha.

The biomass stocks on land converted to FL immediately after the conversion, tonnes d.m. ha-1 (B_{AFTER}) is assumed to be 0. The biomass stock on lands before the conversion depends on the type of land and its vegetation. The average biomass stock for the respective land types converted to FL is:

- Annual cropland – 3 tC/ha
- Perennial cropland – 63 tC/ha
- Grassland – 6.07 tC/ha
- Other land – 4.5 tC/ha

More information on how the average biomass stocks of these lands have been estimated can be found in the respective chapters.

The annual decrease in biomass carbon stocks due to losses (ΔC_L) on lands converted to FL is assumed to be insignificant (zero) because the thinnings start in older age classes, which is implicitly accounted for within the category Forest Land remaining Forest Land.

6.3.2.2.2 Changes in dead organic matter

Changes in the carbon stock in dead wood

Due to the young age of the forests in the area converted to forests it is assumed that there is no dead wood and there is no change in this carbon stock.

Changes in the carbon stock in litter in lands converted to forests

According to IPCC definition litter pool includes all non-living biomass in a various state of decomposition, so this means – litter layer (fresh dead plant material), fumic and humic layers. As it was explained in chapter Forest remaining forest, changes in carbon stock in soil the source of information in order to estimate a country specific value for the carbon stock in litter is EEA-MOEW. The database resulted from the implementation of the ICP "Assessment and Monitoring of Air Pollution Effects on Forests"-UN/ECE Convention on Long Range Transboundary Air Pollution.

When analysing carbon content in litter Bulgaria follows ICP Forests Manual methodological approach http://www.icp-forests.org/pdf/FINAL_soil.pdf (see Annex 7 Soil horizon designation p.195) where litter definition is :

OL-horizon (Litter, Förna): this organic horizon is characterised by an accumulation of mainly leaves/needles, twigs and woody materials (including bark), fruits etc. This sub layer is generally indicated as litter. It must be recognized that, while the litter is essentially unaltered, it is in some stage of decomposition from the moment it hits the floor and therefore it should be considered as part of the humus layer. There may be some fragmentation, but the plant species can still be identified. So, most of the original biomass structures are easily discernible. Leaves and/or needles may be dis coloured and slightly fragmented. Organic fine substance (in which the original organs are not recognisable with a naked eye) amounts to less than 10 % by volume.

According to IPCC-GPG definition this represents the "litter layer" (a horizon consisting of relatively fresh dead plant material). For Bulgaria there are no data gathered for the carbon content in this layer during the soil surveys. However, since the changes in biomass fully account for all leaves and needles (the tree biomass estimates accounts for these pools) that represent the material of the litter layer within one year any further accounting of this material would end in double accounting.

In the Submission 2010 Bulgaria reported carbon stock changes in litter in the figure of the carbon model stock for soils. The estimation of the model carbon stock in soils for Bulgaria was based on the data for the carbon stock in the 30 cm layer and OFH horizons (OH+OF, the fumic and humic layers which are the further parts of the "litter pool" in sense of IPCC GPG definition).

OF-horizon (fragmented and/or altered) is a zone immediately below the litter layer. This organic horizon is characterised by an accumulation of partly decomposed (i.e. fragmented, bleached, spotted) organic matter derived mainly from leaves/needles, twigs and woody materials. The material is sufficiently well preserved to permit identification as being of plant origin (no identification of plant species). The proportion of organic fine substance is 10 % to 70 % by volume. Depending on humus form, decomposition is mainly accomplished by soil fauna (mull, moder) or cellulose-decomposing fungi. Slow decomposition is characterised by a partly decomposed matted layer, permeated by hyphae.

OH-horizon (humus, humification): characterised by an accumulation of well-decomposed, amorphous organic matter. It is partially coprogenic, whereas the F horizon has not yet passed through the bodies of soil fauna. The humified H horizon is often not recognized as such because it can have friable crumb structure and may contain considerable amounts of mineral materials. It is therefore often misinterpreted and designated as the Ah horizon of the mineral soil and not as part of the forest floor as such. To qualify as organic horizon, it should fulfil the FAO requirement, as described above. The original structures and materials are not discernible. Organic fine substance amounts to more than 70 % by volume. The OH is either sharply delineated from the mineral soil where humification is dependent on fungal activity (mor) or partly incorporated into the mineral soil (moder).

According to the ICP Forests Manual samples are taken separately for the different depth. OH and OF layers should be sampled together (see Table 5, p. 15 ICP Forests Manual). The data is available for each depth. The estimation for the model carbon stock in litter pool is based on database for carbon content in OFH layers available for the years 2000 – 2002. According to the data available it was estimated that the carbon stock in litter is 5.38 tC/ha.

6.3.2.2.3 Changes in the carbon stock in soils

The changes in soil organic carbon pool followed the land-use conversion from other land-use to forests have been estimated based on reference stock of the soil organic carbon from the soil under different land-use type using the equation:

$$\Delta \boldsymbol{C_{mineral\ soil}} = \left[(\boldsymbol{SOC_{ref}} - \boldsymbol{SOC_{non\ forest\ land}}) \cdot \boldsymbol{A_{Aff}}\right] / \boldsymbol{T_{Aff}}$$

where:

$\Delta C_{mineral\ soil}$ - annual change in the carbon stock in mineral soils in the year of assessment, tonnes C/ yr

SOC_{ref} – reference carbon stock in forest's, tonnes C/ ha

$SOC_{non\ forest\ land}$ - stable carbon stock in the soil in a previous type of land-use (croplands, grasslands and other lands), tonnes C/ ha

A_{Aff} - total afforestated area after the conversion, ha

T_{Aff} - duration of the transition from non-forest land to forest , yr

The used transition period is 20 years according to 2006 IPCC Guidelines.

Source of information for the contents of organic carbon in forest soil is the database of the ICP "Assessment and Monitoring of Air Pollution Effects on Forests"-UN/ECE Convention on Long Range Trans-boundary Air Pollution (CLRTAP)". The data provider is the Executive Environment Agency, which is the responsible authority for the reporting under CLRTAP. Regular assessments on soils have been carried out since 1986. Taking into account the representativeness of the data and the purpose of the estimate, the reference soil organic carbon stock in forest's soil has been evaluated based on dataset since 1998. The dataset on soil contains information on the soil chemistry and physical parameters. The measurements of the soil's parameters are made for layers (0-5cm, 5-10cm, 0-10cm, 10-20cm, 20-40cm.). The content of organic matter is presented in percentage. In order to estimate the organic carbon stock (tC/ha), data on bulk density is needed. However, the data on bulk density is not available for all layers. Therefore, the bulk density of the soil from different layers has been estimated using the Alexander B (1980) PTF function 4:

$$\boldsymbol{\rho_b} = \mathbf{1.72} - (\mathbf{0.294} - \boldsymbol{org.C}, \%)^{\mathbf{0.5}}$$

Thus, the organic carbon stock has been calculated for all samples from the dataset. Then, the samples have been grouped by soil type and an average value for carbon stock in the different soil types has been derived. Data on the area of the particular soil types under forest land-use is available according to Soil map of Bulgaria (1:400 000) and Corine land cover data (1:100 000). Therefore, the reference soil organic carbon stock in forest's soil has been derived as a weighted mean from the averages SOCs of every particular soil types which are presented in Bulgarian forests. The procedure to derive the reference carbon stock in forest soils, which has the value of 78.26 tC/ha (0-40 cm) is presented in the figure below. The statistics and the uncertainty associated with the evaluation of the reference stock are presented in the table below. They are derived by using Monte Carlo analysis.

Table 212 Statistics of the evaluation of the reference carbon stock in forest's soil and its uncertainty assessment

statistics	value
Trials	10000
Min	48.231
Median	76.429
Mean	78.257
Max	204.950
Std. Dev.	12.751
Variance	162.576
Skewness	1.372
Kurtosis	5.257

probability	value
0.025	58.976
0.05	61.311
0.1	64.219
0.25	69.592
0.5	76.429
0.75	84.898
0.9	93.890
0.95	100.808
0.975	107.922

uncertainty	-24.6	37.9

G.TAULYA et al., 2005 Validation of pedotrasfer functions for soil bulk density estimation on a Lake Victoria Basin soilscape

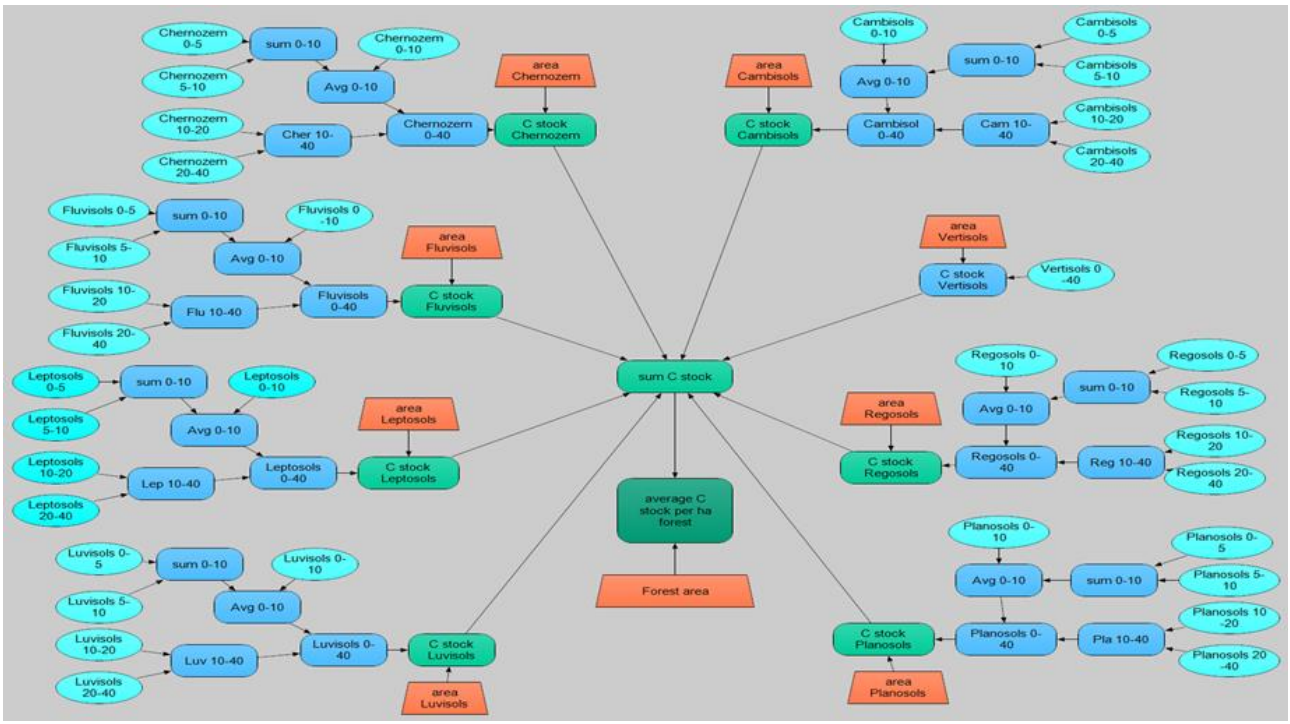

Figure 104 Procedure to derive the organic carbon reference stock in forest's soils

For the stable stock of organic carbon in soils (0-40 cm) of previous types of land-use the following country specific values for annual and perennial cropland, grassland and other land have been used:

- annual crops: 89.9 t C/ha
- perennial crops: 76.5 t C/ha
- grasslands: 103.57 t C/ha
- settlements: 19.7 t C/ha
- other land: 69 t C/ha

Following the recommendation from the ERT Bulgaria re-estimated the reference organic carbon stock in soils under other land use. This has been done by using the default SOC reference level as described in table 2.3 in 2006 IPCCC Guidelines. In order to choose the most appropriate default SOC reference level Bulgaria did the following:

According to "Classification scheme for default climate regions" (IPCC, 2006) Bulgaria is in the "warm temperate dry" (appr. 60%), "cool temperate dry" (appr. 20%) and "cool temperate moist" (appr. 20%) regions (please see the map from the link below).

http://forest.jrc.ec.europa.eu/media/cms_page_media/122/BGR_Climate_1.pdf

Concerning the soil type, more than 80% of the territory is under high activity clay soils (please see the map from the link below).

http://forest.jrc.ec.europa.eu/media/cms_page_media/123/BGR_Soil.pdf

Therefore, Bulgaria estimated a weighted mean value for the SOC reference level in soils taking into account the SOC reference levels for HAC soils (table 2.3 from the2006 IPCC Guidelines) for the respective climate regions. The result for the 0-30 cm depth is 51.8 tC/ha. Bulgaria in its inventory estimates the CSC in mineral soils for 0-40 cm depth. Therefore, the value of 51.8 tC/ha had to be corrected for consistency reason. The final result is 69 tC/ha for 0-40 cm.

A description of the methods of deriving these soil C stocks can be found in the respective chapters.

6.3.2.2.4 N_2O emissions from N mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soils

Emissions has been estimated for all situations where C losses in mineral soils occur (according 2006 IPCCC Guidelines), based on equations 11.1, 11.2, 11.8.

The ratio C/N in the mineral soils is default from 2006 IPCCC Guidelines – 15. N_2O emissions from N mineralization associated with a loss of soil rganic matter are presented in Table 205

6.3.3 UNCERTAINTY ASSESSMENT

The uncertainties of gas emission estimations (CO_2 and other contaminants) were determined by sources within sub-categories using empirical data, expert judgments and reference values recommended by FAO (FAO, 2006). The uncertainties were aggregated, according to the error propagation formulae, separately for the emission factors and for the activity data, and combined uncertainties by sub-category and source were calculated and analysed as percentages of the overall uncertainty in the year (Table 214). Trend uncertainties of the gas emissions due to activity data and emission factors and their combined effect on the uncertainty of the predicted tendency were estimated (Table 214). Inferences by sub-categories and sources as well as general conclusion about the IPCC category "Forests" were derived.

The overall uncertainty over a year for the category "Forests" is **345** %. The trend uncertainty due to activity data and emission factors amounts to **59** %.

The combined uncertainty for the sub-category "Forest land remaining forest land" is **393** % and the uncertainty in the trend of the gas emissions is **45** %.

The uncertainties for the sources "Living biomass", "Forest fires" and "Harvested wood products" within the sub-category "Forest land remaining forest land" were determined.

The overall uncertainty over a year for the "Living biomass" is **436** %. The trend uncertainty due to activity data and emission factors amounts to **34**%.

The combined uncertainty for „Forest fires" is **66 %** and the uncertainty in the trend of the gas emissions is **41** %.

The overall uncertainty over a year for the „Harvested wood products" is **73** %. The trend uncertainty due to activity data and emission factors amounts to **269** %.

The combined uncertainty for the sub-category „Land use changed to forest land" is **191** %. The trend uncertainty in gas emissions is **57** %.

The uncertainties of gas emission estimations from "Living biomass", "Litter" and "Soil" for the sources "Crop land changed to forest land", "Grassland changed to forest land" and "Other land changed to forest land" as well as for the emissions from "Forest fires" within the sub-category „Land use changed to forest land" were estimated.

The combined uncertainty for "Living biomass" is **51** %. The trend uncertainty due to activity data and emission factors amounts to **27** %.

The overall uncertainty over a year for „Litter“ is **126** %. The trend uncertainty due to activity data and emission factors is **23** %.

The combined uncertainty for „Soil“ is **160** %. The uncertainty in the estimated tendency for the gas emissions is **24**%.

The overall uncertainty over a year for “Forest fires under changed land use” is **67** %. The trend uncertainty due to activity data and emission factors amounts to **215** %.

Table 213 Uncertainties of the emission factors and the activity data and sources of information

Activity/Emission factor	Uncertainty %	Source of information
Forest land remaining forest land, ha	3	for industrial countries, 2006 IPCC GNGGI
Land use changed to forest land, ha	10	expert judgment
Standing biomass, m^3 ha^{-1}	8	default, 2006 IPCC GNGGI
Biomass expansion factor (BEF)	20	expert judgment
Bulk density of wood (D)	20	expert judgment
Emission factor, g kg^{-1} dry matter burnt (Gef)	CO_2 - 16.7 CH_4 – 80.9 NO_2 – 53.8	default, 2006 IPCC GNGGI
Mass of the fuel available for combustion, t ha^{-1} . combustion factor * (Mb.Cf)	CO_2 - 63.6 CH_4 – 63.6 NO_2 – 63.6	default, 2006 IPCC GNGGI
Half-life (HL)	50	default, 2006 IPCC GNGGI
Production, import, export of wood products	15	for countries with systematic census or surveys since 1961, 2006 IPCC GNGGI
Carbon content (CF)	Conifers – 3.92 Broadleaved – 2.08 Combined – 2.13	default, 2006 IPCC GNGGI
Yield biomass from grassland (B cut)	10	National Statistical Institute
Biomass of the growth in the grassland (B peak)	75	default, 2006 IPCC GNGGI
Aboveground biomass of perennials	75	default, 2006 IPCC GNGGI
Aboveground biomass of annuals	75	default, 2006 IPCC GNGGI
Aboveground biomass of other land	75	expert judgement
Annual accumulation of C in the aboveground biomass of perennials	75	default, 2006 IPCC GNGGI
Annual accumulation of C in the aboveground biomass of annuals	75	default, 2006 IPCC GNGGI
C stock in litter pool	141.5	empirical data
Soil C stock in forestland	32.6	empirical data
Soil C stock in annual cropland	25.0	empirical data
Soil C stock in perennial cropland	55.0	empirical data
Soil C stock in grassland	32.9	empirical data
Soil C stock in other land	75	expert judgment

Table 214 Uncertainties in the gas emissions from the IPCC category “Forests”

IPCC sub-category	Pool	Level of estimation	Gas	BY emissions	Current year emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total in the current year	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend
FLrFL	LB	conifers	CO2	-7458.06	-3162.37	3.00	654.74	654.75	260.45	-58.10	0.99	58.11
	LB	deciduous	CO2	-5319.84	-3121.65	3.00	574.12	574.13	225.45	0.12	0.98	0.98
	Forest fires		CO2, CH4, N2O	15.51	150.10	3.00	65.90	65.97	-1.25	-0.69	-0.05	0.69
	HWP	SW	CO2	-75.79	-121.141	0.00	110.18	110.18	1.68	0.62	0.00	0.62
		WBP	CO2	-56.30	-745.51	0.00	80.55	80.55	7.55	4.23	0.00	4.23
		P&PB	CO2	-47.87	26.00	0.00	55.33	55.33	-0.18	-0.22	0.00	0.22

IPCC sub-category	Pool	Level of estimation	Gas	BY emissions	Current year emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total in the current year	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend
LUCtoFL	LB	new forest biomass	CO2	-1228.91	-2037.64	10.00	42.06	43.23	11.08	4.08	2.13	4.60
		Convers. of CL a	CO2	10.01	15.13	10.00	75.00	75.66	-0.14	-0.05	-0.02	0.05
		Convers. of CL p	CO2	16.18	16.66	10.00	75.00	75.66	-0.16	-0.04	-0.02	0.04
		Convers. of GL	CO2	132.50	248.40	10.00	78.57	79.21	-2.47	-0.99	-0.26	1.02
		Convers. of OL	CO2	1.24	0.69	10.00	75.00	75.66	-0.01	0.00	0.00	0.00
	Litter	Convers. of CL a	CO2	-18.17	-25.40	10.00	141.51	141.86	0.45	0.15	0.03	0.16
		Convers. of CL p	CO2	-1.17	-1.35	10.00	141.51	141.86	0.02	0.01	0.00	0.01
		Convers. of GL	CO2	-117.44	-201.58	10.00	141.51	141.86	3.60	1.38	0.21	1.40
		Convers. of OL	CO2	-1.49	-0.92	10.00	141.51	141.86	0.02	0.00	0.00	0.00
	Soil	Convers. of CL a	CO2	39.37	55.05	10.00	291.33	291.51	-2.02	-0.69	-0.06	0.69
		Convers. of CL p	CO2	-0.38	-0.44	10.00	2829.16	2829.18	0.16	0.05	0.00	0.05
		Convers. of GL	CO2	552.48	948.30	10.00	168.29	168.58	-20.11	-7.75	-0.99	7.82
		Convers. of OL	CO2	-2.57	-1.58	10.00	623.02	623.10	0.12	0.00	0.00	0.00
	Forest fires		CO2, CH4, N2O	0.62	9.48	10.00	65.90	66.66	-0.08	-0.04	-0.01	0.05
		Total emissions		**-13560.094**	**-7949.7693**	**Overall uncertainty in the year (%)**			**345**	**Trend uncertainty (%)**		**59**

6.3.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

See Chapter 6.10 QA/QC VERIFICATION

6.3.5 CATEGORY-SPECIFIC RECALCULATIONS

See Chapter 6.12 Recalculations

6.3.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS INCLUDING THOSE IN RESPONSE TO THE REVIEW PROCESS

See Chapter 6.11 Planned improvements

6.4 CROPLAND (4.B)

6.4.1 DESCRIPTION OF THE CATEGORY

Croplands in Bulgaria cover an area of 4147181,03 ha which represents 37% of the country's territory. Annual crops have a share of 95% from the total cropland's territory and the rest 5% are referred to perennial crops. Since the year 2000 a steady decrease in cropland areas is observed. In 2017 the area of cropland increases in comparison to that of 2016 and is similar to those from the base year.

The evaluation of the emissions/removals from Cropland category is based on estimates of the changes in the carbon stocks in living biomass and soil. The changes in biomass stock are estimated only for perennial crops. For annual crops, increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year - thus there is no net accumulation of biomass carbon stocks.

The assumption in Tier 1 (according 2006 IPCCC Guidelines) is that the DOM carbon stock in all cropland remaining cropland and land converted to cropland are insignificant or are not changing and therefore no emission/removal factors and activity data are needed.

Non-CO_2 emissions associated with the management of permanent agricultural lands are estimated as part of Agriculture Chapter from this report. N_2O emissions from land-use conversions to cropland as a result of soil oxidation are reported under LULUCF sector.

There is no agricultural lime application in Bulgaria during the reporting period so CO_2 emissions from liming are reported as NO (not occurring).

Table 215 Categories assessed for emissions/removals

Categories
4 B. Cropland- total
4.B.1 Cropland remaining cropland
- carbon stock change in living biomass of perennial cropland and LUC between annual and perennial cropland
- carbon stock change due to changes in organic matter input (harvest residues) to cropland soils
4 B 2 Land converted to cropland
4 B 2 1 Forest land converted to cropland
4 B 2 2 Grassland converted to cropland
- carbon stock change in living biomass of annual/perennial cropland
- carbon stock change due to changes in organic matter input to cropland soils

The trend in the areas of cropland category is presented in the figure below. The annual cropland's emissions over the reporting period range from - -1004.69 Gg CO_2 eq. to 910.35 Gg CO_2 eq. As it can be seen from the table below, emissions from subcategory Cropland remaining cropland has a high level of inter-annual variability. The reason for the variation in the emissions is that Bulgaria reports changes in carbon stock within cropland category (e.g. change from perennial to annual, annual crops to perennial and perennials remaining perennials). Major source of the emissions within subcategory Lands converted to croplands is the carbon stock change in the soil pool when converting grassland to cropland.

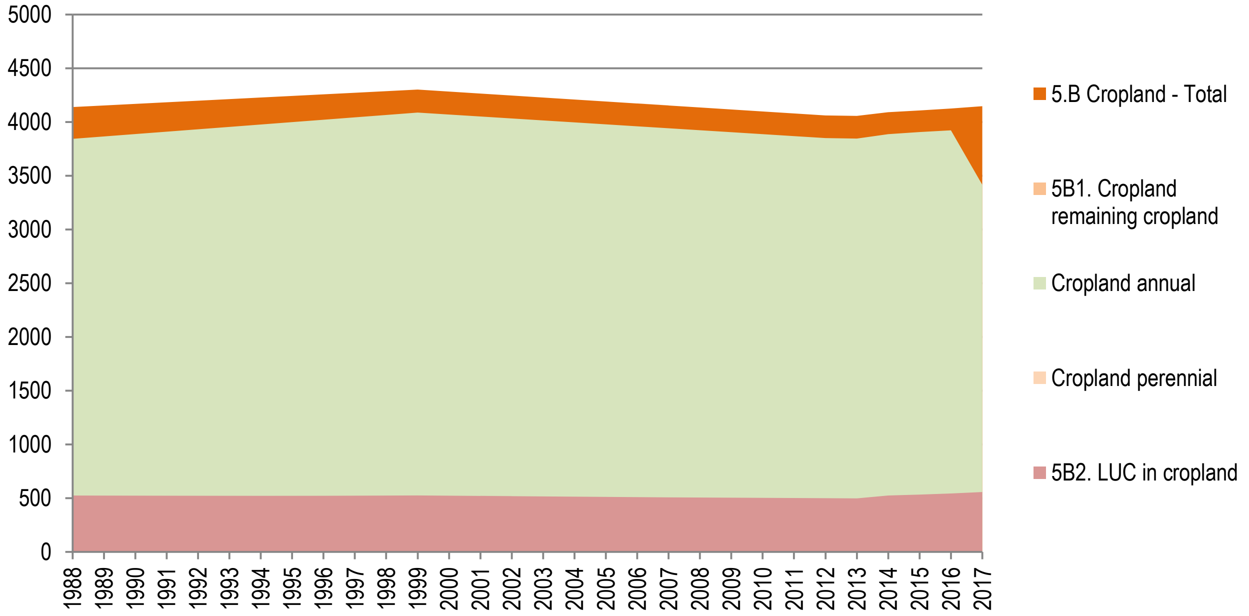

Figure 105 Trend in the areas within Cropland category

Table 216 Emissions /removals of CO_2 within Cropland category (Gg CO_2 equivalent)

Year	4 B Total cropland	4.B.1 Cropland remaining cropland	4.B.2 Land converted to cropland	4.B.2.2 Grassland converted to cropland	4.B.2.5 Other land converted to cropland	4.B.2.2 Grassland converted to cropland (N2O converted into CO2 equivalents)
1988	-1074,69	-1109,81	35,12	860,47	-825,36	70,01
1990	-665,51	-702,30	36,79	859,26	-822,47	69,98
1995	-178,73	-224,65	45,92	860,95	-815,03	70,01
2000	714,17	660,23	53,94	887,07	-833,13	70,38
2005	826,16	659,08	167,08	913,61	-746,53	72,15
2010	587,48	310,18	277,30	943,59	-666,29	73,96
2015	936,45	672,75	263,70	955,97	-692,27	75,33
2016	834,92	601,33	233,59	958,15	-724,56	75,44
2017	743.28	540.60	202.68	960.57	-757.89	74.50

6.4.2 INFORMATION ON THE APPROACHES USED FOR PRESENTING THE DATA FOR THE AREAS AND THE DATABASE FROM THE LAND-USE USED OF THE INVENTORY.

Information on total Cropland and Grassland area is available from different data sources during the years. The National Statistical Yearbooks provide information on CL and GL areas over the period 1988-2000. The data shows a steady increase in the CL area and a decrease in GL for the period 1988-1999. However, in order to smooth annual variability in LUCs in CL and GL an interpolation method between 1988-1999 has been used. The balance of the territory of Bulgaria based on orthophotoimages has been available since 2010. To ensure a full time-series interpolation between the years 1999 and 2010 has been applied. Like this, the time series has been divided into two periods which actually represent the land area pattern in these categories.

As regards reporting of LUCs, there are no LUCs from forests to CL or GL. Any conversions and re-conversions from wetlands and settlements to cropland and grassland are considered as unlikely. Thus, it has been considered that the only possible change from other land use to cropland and grassland is between these categories and OL. The agricultural statistics (BANSIK) provides information on LUCs between cropland and grassland as well as between annual and perennial crops and in reverse for a period of 2000-2016.

The LUCs to cropland and grassland for the years before 2000 are unknown. Therefore, the LUCs between CL, GL and OL for this period have been estimated in order to fit the trend in the area.

6.4.3 METHODOLOGY

6.4.3.1 Cropland remaining Cropland (4.B.1.)

6.4.3.1.1 Changes in the carbon stocks in the living biomass

The change in biomass is only estimated for perennial woody crops. For annual crops, increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year - thus there is no net accumulation of biomass carbon stocks. The estimates of the change in carbon in perennial biomass follow the approach for estimating the annual rates of growth and loss which is recognised as Tier 1 method according to 2006 IPCC Guidelines. There is no national data on the dynamics of the biomass in the perennials influenced by the changes in the land use. According to the 2006 IPCC Guidelines the perennials accumulate biomass through the first 30 years. Emissions from perennials occur in the year of their clearing, assuming that annually 3,33% of the area of perennials are being replanted.

The area of the perennials over the time series ranges from 296 kha to 207 kha. In general there is a trend of decrease in their area. The changes are as a result of the reorganization that took place in the Bulgarian agriculture and especially in land ownership. To determine the annual change in the biomass carbon stock of the perennials the following equation has been used:

$$\begin{aligned}\boldsymbol{Annual\ change\ in\ the\ biomass\ carbon\ stock}\\ &= (\boldsymbol{area\ of\ the\ perennials\ remaining\ perennials}\\ &\cdot \boldsymbol{coefficient\ of\ accumulation\ of\ carbon})\\ &- \left(\boldsymbol{area\ of\ the\ perennials\ 30\ year\ earlier}^{\mathbf{1}}\ \cdot \mathbf{0.033}\right.\\ &\left.\cdot \boldsymbol{coefficient\ of\ accumulation\ of\ biomass}\right);\end{aligned}$$

$$^{\mathbf{1}}\ \boldsymbol{excluding\ area\ lost\ through\ land - use\ change}$$

For the aboveground biomass stock at maturity the value 63 tonnes C.ha-1 has been adopted, and for the annual accumulation - 2,1 tonnes C.ha^{-1}.y^{-1} (2006 IPCC Guidelines).

Table 217 Accumulation and loss of carbon in the aboveground biomass and period of clearing of perennials using the 2006 IPCC Guidelines default method

Climatic zone	Aboveground biomass C stock at maturity (tonnes C/ ha)	Period of clearing (years)	Annual accumulation of C in the aboveground biomass (tonnes C/ha/yr	Loss of carbon in the aboveground biomass (tonnes C/ha/yr)	Uncertainty
Temperate (all humidity regimes)	63	30	2,1	63	±75

6.4.3.1.2 Changes in the carbon stock in the biomass of perennials converted to annual crops

The annual change in biomass C stock is equal to the area of the converted lands ($A_{Conversion}$), multiplied by the carbon stock in the biomass of the perennials ($L_{Conversion}$) plus the changes in the carbon stock in the biomass during the first year after the conversion (ΔC_{Growth}).

$$\boldsymbol{The\ annual\ change\ \ of\ carbon\ stock\ in\ biomass} = \boldsymbol{A_{conversion}}(\boldsymbol{L_{conversion}} + \Delta \boldsymbol{C_{growth}})$$

where,

$L_{conversion} = C_{after} - C_{before}$

$A_{conversion}$ – area of the lands converted to annual crops, ha yr^{-1}

$L_{conversion}$– carbon stock in the biomass of lands which were converted to annual crops, tonnes C ha-1

ΔC_{growth} – change of the carbon stock in the biomass in the first year after the conversion, tonnes C ha-1

For Bulgaria ΔC_{Growth} has been calculated on the basis of the NSI's yield data for annual crops (cereals, industrial crops, vegetables, fodder crops) for 1995, 2000 and 2005. The absolutely dry weight of these crops was corrected with national coefficients (Krachunov, I, Al. Alexandrov, 2007). To obtain the total biomass of the plants for the expansion from the yield biomass to the total biomass the following coefficients[33] have been used (Table 218). The expansion factors for the rest of the aboveground biomass stem from Austria and the root–to-shoot ratios - from US. Since both countries belong like Bulgaria to the temperate region, they are considered as appropriate for Bulgarian conditions.

Table 218 Coefficients used for calculating the total biomass of the annual crops

Crop	Rest of aboveground biomass (in % of yield biomass)	Aboveground/belowground ratio	Root-to–shoot ratio
wheat	100	-	0,21
rye	140	-	NE
barley	110	-	1,02
oats	150	-	0,4
maize	140	-	0,18
fied peas	100	-	NE
rape	210	-	NE
sunflower	250	-	0,06
sugar beet	80	-	0,43
fodder beet	30	-	NE
potato	30	-	0,07
soya	150	-	0,15
corn silage	20	-	0,18
lucerne	10	-	NE
red clover	10	-	NE
cotton		0.4	0,17
rice		0.4	0,46
peanuts		0.4	0,07
tabacco		0.6	0,8

[33] The expansion factors according to Bodenfruchtbarkeitsbeirat 2001 (pers. comm.)
Root-to-shoot ratios are published by West, T.O., 2008

To estimate the total, the yield biomass is expanded with a coefficient for the rest of the aboveground biomass. After that the aboveground biomass is expanded to the total biomass with the root-to-shoot ratios. An average weighed mean of the cropland biomass was calculated then on basis of the yields of the individual crops in Bulgaria for single years - ΔC_{Growth} = 3 tonnes C ha-1.

The calculations are based on the following steps:

$$\boldsymbol{Ba\ total_x = B\ yield_x \cdot Cdrm_x + B\ yield_x \cdot C\ drm_x \cdot F\ rab_x}$$

Where,

Ba total - Total aboveground biomass

B yield – yields of annual crops – cereals, vegetable crops, fodder crops, industrial crops etc., tonnes

C drm – coef. for absolutely dry matter, % (lit source: Krachunov, I, Al. Alexandrov, 2007)

F rab – factor of the rest of the aboveground biomass, %

x – any particular annual crop for which data is gathered

$$\boldsymbol{Bb\ total_x = Ba\ total_x \cdot R_x}$$

Where,

Bb total – total belowground biomass

R – root to shoot ratio

x – any particular annual crop for which data is gathered for single year

$$\boldsymbol{B\ total_x = \ Ba_x + Bb_x}$$

Where,

B total – total biomass (above and belowground)

Ba total - Total aboveground biomass

Bb total – total belowground biomass

$$\boldsymbol{B_{\frac{t}{ha},1995,2000,2005} = \sum B\ total\ x / \sum area\ x}$$

Where,

B – biomass in t/ha

B total – total biomass (above and belowground)

Area – ha

Average of B t/ha for 1995,2000,2005 = 3 t/ha

The changes in the carbon stock immediately after the conversion is assumed to be 0 as the biomass is taken away (C_{After}=0).

The value of 63 tonnes C/ha (C_{Before}) (2006 IPCC Guidelines) is used for the carbon stock immediately before the conversion.

6.4.3.1.3 Changes in the carbon stock in the biomass of annual crops converted to perennials

To calculate the annual change of carbon in living biomass in annual crops converted to perennial the same equation as described in chapter 6.4.3.1.2. For the annual increase of the carbon stock in the biomass of the perennials the value 2.1 tonnes C $ha^{-1}y^{-1}$ is used (for each year of the transition period) given in the 2006 IPCC GL.. The value 3 tonnes C ha^{-1} (item 6.4.3.1.2.) is used for the loss of carbon from the biomass of annual crops.

The annual change in the carbon stock of the biomass is equal to the area of the converted lands for a transition period of 20 years ($A_{Conversion}$) multiplied by the annual carbon stock growth of the perennial biomass (ΔC_{Growth} = 2.1 tonnes C ha^{-1}). For the biomass losses the actual annual land use change area annual to perennial is multiplied by the biomass carbon stock of annual crops.

$$\boldsymbol{Annual\ change\ in\ carbon\ stock\ in\ biomass = \left(area\ of\ the\ converted\ lands\ for\ 20\ yeats \cdot \Delta C_{growth}\right) + (actual\ annual\ area\ of\ conversion \cdot L_{conversion})}$$

where,

$L_{conversion} = C_{after} - C_{before}$

$L_{conversion}$– carbon stock in the biomass of lands which were converted to annual crops, tonnes C ha^{-1}

ΔC_{growth} – change of the carbon stock in the biomass in the first year after the conversion, tonnes C ha^{-1}

Change of the carbon stock immediately after the conversion is considered to be 0 as the biomass is taken away (C_{After} =0).

For the carbon stock immediately before the conversion the value calculated for Bulgaria is used: 3 tonnes C $ha^{-1}y$ (item 6.4.3.1.2).

6.4.3.1.4 Changes in the carbon stock in soils of croplands remaining croplands

The assessment of the carbon stock in soil is performed at 0-40 cm. The carbon stock of the plant residues on the surface (dead organic matter) and the changes in the non-organic carbon (in the carbonate minerals) are not estimated. The estimates of carbon stock changes in soils are carried out only for mineral soils. The emissions of organic soils are not assessed, because there is no peat extraction or other type of impact on Histosols under annual crops and perennials.

In the period after 1990 Bulgaria is witnessing substantial changes in the land ownership and worsening of the agricultural practices. We could assume that this has affected the emissions/removals of carbon in the soils. There are no representative, official data concerning the impact of the changes that happened in the management of the lands on the stock of organic carbon in the soils. There is no information also for the exact size of the areas which have been affected by the changes in the soils. Due to that an assessment of emissions/removals of carbon by mineral soils in croplands which remain croplands is not carried out.

Source of information for the contents of organic carbon in cropland and grassland soils is the National System for Environment Monitoring (EAEW-MOEW). Taking into account the representativeness of the data and the purpose of the estimate, the reference soil organic carbon stock in cropland and grassland soils has been evaluated based on dataset from a full soil inventory carried out in 2012. The dataset on soil contains information on the soil chemistry and physical parameters from soils under different land use (e.g cropland and grassland). The measurements of the soil's parameters are made for layers (0-20cm, 20-40cm.). The content of organic matter is presented in percentage. In order to estimate the organic carbon stock (tC/ha), data on bulk density is needed. However, the data on bulk density is available only for the upper layer. Therefore, the bulk density of the soil from the layer 20-40 cm has been estimated using the Alexander B (1980) PTF function[34]:

$$\rho_b = \mathbf{1.72 - (0.294 - \mathit{org.C}, \%)^{0.5}}$$

Thus, the organic carbon stock has been calculated for all samples from the dataset. Then, the samples have been grouped by land use and soil type and an average value for carbon stock in the different soil types has been derived. Data on the area of the particular soil types under cropland or grassland management is available according to Soil map of Bulgaria (1:400 000) and Corine land cover data (1:100 000). Therefore, the reference soil organic carbon stock in soils of cropland and grassland has been derived as a weighted mean from the averages SOCs of every particular soil types under cropland and grassland categories. The reference soil organic carbon stocks in cropland (0-40 cm) are 89.92 tC/ha for annual crops and 76.52 tC/ha (STD – 21.05; CV – 27.51) for perennial crops. The statistics and the uncertainty associated with the evaluation of the reference stock in soils of annual crops are presented in the tables below. They are derived by using Monte Carlo analysis.

Table 219 Statistics of the evaluation of the reference carbon stock in soils of annual crops and its uncertainty assessment

statistics	value
Trials	10000
Min	46.890
Median	89.731
Mean	**89.920**
Max	136.662
Std. Dev.	**11.221**
Variance	125.906
Skewness	0.197
Kurtosis	0.114

probability	value
0.025	68.954
0.05	72.043
0.1	75.904
0.25	82.111
0.5	89.731
0.75	97.121
0.9	104.325
0.95	109.061
0.975	113.291

uncertainty	**-23.3**	**26.0**

6.4.3.1.4.1 Changes in the carbon stock in the soils of lands with perennials converted to annual crops

The average annual change in the carbon stock in mineral soils of perennials, converted to annual crops (ΔSOC_{20}) has been calculated using the equation:

$$\Delta \boldsymbol{SOC_{20}} = \frac{[(\boldsymbol{SOC_0} - \boldsymbol{SOC_{0-T}})]}{\mathbf{20}} = \mathbf{0.67}\ \boldsymbol{tC/ha}$$

where,

SOC_0 – carbon stocks in the soils after 20 years of transition = 89.92 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 76.52 t C/ha.

To find the net change in the carbon stock in the soil, the annual change (ΔSOC_{20}) has been multiplied by the converted area.

[34]G.TAULYA et al., 2005 Validation of pedotrasfer functions for soil bulk density estimation on a Lake Victoria Basin soilscape

6.4.3.1.4.2 Changes in the carbon stock in the soils of lands under annual croplands converted to perennials

The average change in the carbon stock in mineral soils of lands under annual crops converted to perennials (ΔSOC_{20}) has been calculated using the equation:

$$\Delta \boldsymbol{SOC_{20}} = \frac{[(\boldsymbol{SOC_0} - \boldsymbol{SOC_{0-T}})]}{\boldsymbol{20}} = -\boldsymbol{0.67}\ \boldsymbol{tC/ha}$$

where,

SOC_0 – carbon stocks in the soils after 20 years of transition = 76.52 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 89.92 t C/ha.

To find the net change in the carbon stock in the soil, the annual change (ΔSOC_{20}) has been multiplied by the converted area.

6.4.3.1.5 Liming

There is no liming after 1987.

6.4.3.2 Lands converted to croplands (4.B.2.)

6.4.3.2.1 Changes in the carbon stock in the living biomass in lands converted to annual crops

The calculation of the annual changes of the carbon stock in the living biomass in lands converted to annual crops is calculated using the following equations:

$$\boldsymbol{The\ annual\ change\ \ of\ carbon\ stock\ in\ biomass} = \boldsymbol{A_{conversion}}(\boldsymbol{L_{conversion}} + \Delta \boldsymbol{C_{growth}})$$

where,

$L_{conversion} = C_{after} - C_{before}$

$A_{conversion}$ – area of the lands converted to annual crops, ha yr-1

$L_{conversion}$– carbon stock in the biomass of lands which were converted to annual crops, tonnes C ha-1

ΔC_{growth} – change of the carbon stock in the biomass in the first year after the conversion, tonnes C ha-1

The the carbon stock in the living biomass after the conversion (C_{After}) is equal to 0. The biomass stock before the conversion is 6.07 t/ha for GL and 4.5 t/ha for OL, which represent the average annual stock in biomass of GL and OL. The average annual biomass stock in GL is calculated on basis of statistical data (National Statistical Yearbook) for the average yield of hay from grasslands for a period of 10 years (1995-2005). The values were recalculated to the absolutely dry matter (Krachunov, I., Alexandrov, A, 2007) and expanded with the remaining aboveground stubble biomass (1.6 t ha-1) (according to 2006 IPCC GL) and with a coefficient for the root-to-shoot ratio 2.8 (according to 2006 IPCC GL). The figure of average biomass carbon stock in OL is obtained from scientific paper based on case study in BG under the project Land-use and management impacts on carbon sequestration in mountain ecosystems" under the framework of the Bulgarian-Swiss Research Programme ("BSRP")

The annual accumulation of carbon in the annual cropland biomass in the first year after the conversion (ΔC_{Growth}) is = 3,0 tonnes C ha-1. The approach for determining the ΔC_{Growth} is described in section 6.4.3.1.2.

The quantity of carbon in the biomass is adopted by default -0,5 t C/t absolute dry matter (2006 IPCC).

6.4.3.2.1.1 Changes of the carbon stock in the living biomass lands converted to perennials.

For perennials a value for the average annual growth of the biomass has been used according to IPCC GPG (2,1 tC/ha y), for the whole period of conversion – 20 years.

$$\boldsymbol{Annual\ change\ in\ carbon\ stock\ in\ biomass} = \left(\boldsymbol{area\ of\ the\ converted\ lands\ for\ 20\ yeats} \cdot \Delta \boldsymbol{C_{growth}}\right) + (actual\ annual\ area\ of\ conversion \cdot L_{conversion})$$

where,

$L_{conversion} = C_{after} - C_{before}$

$L_{cnversion}$– carbon stock in the biomass of lands which were converted to annual crops, tonnes C ha-1

ΔC_{growth} – change of the carbon stock in the biomass in the first year after the conversion, tonnes C ha-1

To calculate the changes in the carbon stocks in the biomass the following values were used:

ΔC_{growth} = 2,1 tC/ha y (IPCC GPG)

C_{after}= 0

C_{before} = 6.07 t C/ha, calculated for Bulgaria (for GL) and 4.5 t/ha for OL.

6.4.3.2.1.2 Changes in the carbon stock in soils of grassland converted to annual crops

To assess the emissions/removals of carbon specific data for the country has been used. The reference carbon stock in grassland soils (103.57) has been calculated as described in 6.4.3.1.4. The statistics and the uncertainty associated with the evaluation of the reference stock are presented in the table below. They are derived using Monte Carlo analysis.

Table 220 Statistics of the evaluation of the reference carbon stock in grassland's soil and its uncertainty assessment

statistics	value
Trials	10000
Min	37.778
Median	103.366
Mean	**103.566**
Max	172.060
Std. Dev.	**17.058**
Variance	290.976
Skewness	-0.015
Kurtosis	-0.063

probability	value
0.025	70.234
0.05	75.803
0.1	81.742
0.25	92.022
0.5	103.366
0.75	115.104
0.9	125.669
0.95	131.326
0.975	136.872

uncertainty	**-32.2**	**32.2**

The average annual change in the carbon stock in the soils of lands converted to annual crops (ΔCLG_{Soils}), is calculated using the following equation:

$$\Delta \boldsymbol{C_{LGsoil}} = \frac{[(\boldsymbol{SOC_0} - \boldsymbol{SOC_{0-T}})]}{\boldsymbol{20}}$$

where,

ΔC_{LGsoil} - annual change in carbon stock in soils in land converted to CL

SOC_0 – carbon stocks in the soils after 20 years of transition = 89.92 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 103.57 t C/ha and 69 t/ha.

T – period assessed, years (equal to 20 years),

The change in the carbon stock in soils of lands converted to annual crops was calculated by multiplying the annual change in carbon stock by the area of the converted territory.

6.4.3.2.1.3 Changes in the carbon stock in soils of lands converted to perennials

To assess the emissions/removals of carbon specific data for the country has been used.

The average annual change in the carbon stock in the soils of grassland (ΔCLG_{Soils}), converted to perennials is calculated using the following equation:

$$\Delta \boldsymbol{C}_{\boldsymbol{LGsoil}} = \frac{[(\boldsymbol{SOC_0} - \boldsymbol{SOC_{0-T}})]}{\mathbf{20}} =$$

where,

ΔC_{LGsoil} - annual change in carbon stock in soils in land converted to CL

SOC_0 – carbon stocks in the soils after 20 years of transition = 76.52 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 103.57 t C/ha.

T – period assessed, years (equal to 20 years),

The change in the carbon stock in soils of lands converted to perennials was calculated by multiplying the annual change in carbon stock by the area of the converted territory.

6.4.3.2.1.4 N_2O emissions in grasslands converted to croplands

N_2O emissions from land-use conversions to cropland as a result of soil oxidation has been estimated based on tier 1 approach and equations 11.1, 11.2, 11.8. (2006 IPCC Guidelines).

The ratio C/N in the mineral soils is default from 2006 IPCCC Guidelines – 15

6.4.4 UNCERTAINTY ASSESSMENT

The uncertainties associated with the estimates of CO_2 emissions and removals have been calculated using both Tier 1. Tier 1 method combines the uncertainties by means of the error propagation equations (IPCC Good Practice Guidance, IPCC, 2003). The input uncertainties, associated with the different emission factors and the activity data as well as the sources of information (default values, empirical data or expert judgment) are presented in Table 274. The total uncertainty for Cropland remaining cropland is ±184% while for Land converted to Cropland is ±415%.

6.4.5 DATA VERIFICATION CATEGORY-SPECIFIC QA/QC AND VERIFICATION, IF APPLICABLE

See 6.10. QA/QC VERIFICATION

6.4.6 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations are due to revised of estimations of N_2O emissions in grasslands converted to croplands.

6.4.7 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS INCLUDING THOSE IN RESPONSE TO THE REVIEW PROCESS

For Cropland category it is planned to continue working on the land-use classification and representation across the time series.

6.5 GRASSLAND (4.C)

6.5.1 DESCRIPTION OF THE CATEGORY

Grassland in Bulgaria cover an area of 1 753 436.3 ha which represents 16 % of the country's territory. Over the reporting period there is a trend of gradual decrease in grassland areas. In the 2016 the area of grassland is by 17 % lower compared to the base year.

The evaluation of the emissions/removals from Grassland category is based on estimates of the changes in the carbon stocks in living biomass and soil.

The assumption in Tier 1 (according 2006 IPCCC Guidelines) is that the DOM carbon stock in grassland remaining grassland and land converted to grassland are insignificant or are not changing and therefore no emission/removal factors and activity data are needed.

Some management practices, like burning of stubble-fields are forbidden in Bulgaria. There is no peat extraction, draining of peat soils or other anthropogenic activity which affects their water regime, the temperature on their surface and the species. Due to these reasons the carbon stock change in Histosols is not subject to evaluation.

The area of Grassland category (e.g Grassland remaining grassland 4.C.1 and Lands converted to grassland 4.C.2) and its associated emissions/removals are presented in the tables below.

Table 221 Categories assessed for emissions/removals

Categories
4.C. Grassland-total
4.C.1. Grassland remaining grassland
4.C.2. Land converted to grassland
4.C.2.1. Forest land converted to grassland
4.C.2.2. carbon stock change in living biomass of grassland
4.C.2.3. carbon stock change due to changes in organic matter input (harvest residues) to grassland soils
4.C.2.4. Settlements converted to grassland
4.C.2.5. Other land converted to grassland

Table 222 Land use and land-use changes in the category Grassland (kha) (other land- use changes are not occurring)

year	4.C Grassland Total	4.C.1 Grassland remaining Grassland	4.C.2 LUC in Grassland	4.C.2.2.a Annual cropland in Grassland	4.C.2.2.b Perennial cropland in Grassland	4.C.2.5 OL converted to GL
1988	2113,42	1858,96	254,47	15,00	134,97	104,50
1990	2094,13	1839,54	254,59	15,02	135,18	104,39
1995	2045,89	1790,10	255,79	15,20	136,81	103,78

year	4.C Grassland Total	4.C.1 Grassland remaining Grassland	4.C.2 LUC in Grassland	4.C.2.2.a Annual cropland in Grassland	4.C.2.2.b Perennial cropland in Grassland	4.C.2.5 OL converted to GL
2000	1983,74	1720,50	263,25	28,29	132,63	102,33
2005	1865,95	1575,63	290,31	93,10	106,06	91,15
2010	1748,15	1431,57	316,58	157,86	79,04	79,68
2015	1754,22	1326,95	427,28	220,92	50,93	155,43
2016	1753,44	1311,19	442,24	232,71	45,22	164,31
2017	1730.41	1284.47	445.93	244.53	39.79	161.61

Table 223 Emissions (+)/removals of CO_2 in Grassland Remaining Grassland and Lands Converted to Grassland (Gg CO_2 equivalent) (other land use changes are not occurring)

year	4 C Grassland Total	4.C.1 Grassland remaining grassland	4.C.2 Land converted to grassland	4.C.2.2 Cropland converted to grassland	4.C.2.5 Other land converted to grassland
1988	-2,22	0,00	-2,22	690,83	-693,05
1990	26,64	0,00	26,64	718,66	-692,02
1995	67,61	0,00	67,61	755,87	-688,25
2000	-1252,39	0,00	-1252,39	-585,92	-666,47
2005	-1211,52	0,00	-1211,52	-616,35	-595,16
2010	-1166,35	0,00	-1166,35	-644,40	-521,95
2015	-1730,38	0,00	-1730,38	-642,51	-1087,86
2016	-1767,85	0,00	-1767,85	-643,71	-1124,14
2017	-1687.29	0.00	-1687.29	-646.35	-1040.95

6.5.2 INFORMATION ON THE APPROACHES USED TO PRESENT THE DATA ON THE AREAS AND THE DATABASE ON THE LAND-USE USED FOR THE INVENTORY

The approach used for deriving the area information for sub-categories 4.C.1 and 4.C.2 is described in 6.4.2

6.5.3 METHODOLOGY

6.5.3.1 Grassland Remaining Grassland (4.C.1.)

6.5.3.1.1 Changes of the carbon stock in the living biomass

In line with 2006 IPCC Guidelines (Tier 1) the biomass in the grassland remaining grassland is not a source of emissions.

6.5.3.1.2 Changes of the carbon stock in soils

In accordance with the data available in the country it is assumed that there are no changes in the organic carbon stock in the soils of grassland remaining grassland. There is no liming of grassland in Bulgaria.

6.5.3.2 Lands converted to grasslands (4.C.2)

6.5.3.2.1 Forests converted to grassland

This category is not assessed as during the reporting period forests were not converted to grassland.

6.5.3.2.2 Lands converted to grassland

6.5.3.2.2.1 Changes in the carbon stock in the living biomass of lands converted to grassland

The estimates of the changes in biomass carbon stock are based on country-specific data. The average value of the aboveground and belowground biomass of the annual crops is 3 t C ha (Section 6.4.3.2).

The carbon stock in the living biomass of grassland has been estimated. Source of information for the aboveground biomass in grassland is the National Statistical Yearbook, Agroststistics, where the information for the hay yield is published. To recalculate the absolute dry matter a coefficient of 0.8 was used (Krachunov, I, Al. Alexandrov, 2007). The total biomass was calculated after a correction and adding of the rest of the aboveground stubble biomass and the root-to-shoot ratio.

The equation below has been used to aggregate the annual growth of the total stock of the biomass in grasslands (aboveground and belowground)

$$\boldsymbol{B_{total}} = \left[(\boldsymbol{B_{cut}} \cdot \mathbf{0.47}) + (\boldsymbol{B_{peak\ aboveground}} \cdot \mathbf{0.47})\right] \cdot (\mathbf{1} + \boldsymbol{R})$$

where:

B_{total} – total biomass (aboveground and belowground), tonnes d.m.

B_{cut}- yield biomass, tonnes d.m =1.8

$B_{peak\ aboveground}$ – biomass of the growth, tonnes d.m =1.6 (according to 2006 IPCC Guidelines)

R - root-to-shoot ratio = 2.8 (according to 2006 IPCC Gidelines)

To calculate the annual carbon stock changes in the living biomass of lands converted to grassland the following equation has been used:

$$\boldsymbol{The\ annual\ change\ \ of\ carbon\ stock\ in\ biomass} = \boldsymbol{A_{conversion}}(\boldsymbol{L_{conversion}} + \Delta\boldsymbol{C_{growth}})$$

where,

$L_{conversion} = C_{after} - C_{before}$

$A_{conversion}$ – annual area of the lands converted to grassland, ha yr-1

$L_{conversion}$– carbon stock in the biomass of lands which were converted to grassland, tonnes C ha-1

ΔC_{growth} – change of the carbon stock in the biomass in the first year after the conversion, tonnes C ha-1

ΔC_{growth} = 6.07 tC/ha y (2006 IPCC GL)

C_{after}= 0

C_{before} = 3 t C/ha, for annual crops (calculated for Bulgaria)

C_{before} = 63 tC/ha for perennials (2006 IPCC Gudelines)

C_{before} = 4.5 tC/ha for Other lands (calculated based on research data on case study area)

6.5.3.2.2.2 Changes in the carbon stock in soils of lands converted to grassland

The reference carbon stock in soils of grassland and cropland has been calculated as described in 6.4.3.1.4. and 6.4.3.2.1.2. The annual change in the carbon stock in soils of lands under annual crops (ΔCLG_{Soils}), converted to grassland is calculated using the following equation:

$$\Delta C_{LGsoil} = \frac{[(SOC_0 - SOC_{0-T})]}{20}$$

where,

ΔC_{LGsoil} - annual change in carbon stock in soils in land converted to GL

SOC_0 – carbon stocks in the soils after 20 years of transition = 103.57 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 89.92 t C/ha for annual crops, 76.5 t C/ha for perennials and 69 tC/ha for other lands.

T – period assessed, years (equal to 20 years),

The change in the carbon stock in soils of lands under annual crops converted to grassland has been calculated by multiplying annual change in carbon stock in soils by the area of the converted territory.

6.5.4 UNCERTAINTY ASSESSMENT

The uncertainties associated with the estimates of CO_2 emissions and removals have been calculated using both Tier 1. Tier 1 method combines the uncertainties by means of the error propagation equations (IPCC Good Practice Guidance, IPCC, 2003). The input uncertainties, associated with the different emission factors and the activity data as well as the sources of information (default values, empirical data or expert judgment) are presented in Table 274. The total uncertainty for Land converted to Grassland is ±445%.

6.5.5 DATA VERIFICATION CATEGORY-SPECIFIC QA/QC AND VERIFICATION, IF APPLICABLE

See 6.10. QA/QC VERIFICATION

6.5.6 CATEGORY-SPECIFIC RECALCULATIONS

There are no recalculations..

6.5.7 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS INCLUDING THOSE IN RESPONSE TO THE REVIEW PROCESS

There are no planned improvements for the next submission.

6.6 WETLANDS (4.D)

Due to the lack of information it is assumed that the carbon stocks in the biomass, the dead organic matter and the soils of the surface waters is equal to 0.

The areas of the wetlands range between 214 to 232 kha over the reporting period.

Table 224 presents data on the area of wetlands.

Table 224 Land- use and land- use changes in the category Wetlands (kha) (other land use changes are not occurring)

year	4.D Wetlands - Total	4.D.1 Wetlands remaining wetlands	4.D.2 LUC in wetlands	4.D.2.2.a Annual Cropland in wetlands	4.D.2.5 Other land in wetlands
1988	213,50	213,50	0,00	0,00	0,00
1990	213,50	213,50	0,00	0,00	0,00
1995	214,00	213,50	0,49	0,44	0,05
2000	218,50	213,50	5,00	4,51	0,48
2005	223,51	213,50	10,00	8,94	1,06
2010	228,52	213,50	15,01	13,24	1,77
2015	231,15	214,00	17,15	15,02	2,13
2016	231,36	214,49	16,87	14,76	2,11
2017	231.57	215.49	16.08	14.04	2.04

It was assumed that during the period of inventory the conversion to wetlands comes out from annual crops and other lands. The emissions of carbon dioxide from the wetlands are presented in Table 225.

Table 225 Emissions (+)/removals of CO_2 in Wetlands Remaining Wetlands and Lands Converted to Wetlands (Gg CO_2 equivalent)

year	5.D Wetlands Total	5.D.2.2 Cropland converted to Wetlands	5.D.2.5 Other land in wetlands	5.D.2.2 Cropland converted to Wetlands 2 (N_2O converted into CO_2 equivalents)	5.D.2.5 Other land in wetlands 2(N_2O converted into CO_2 equivalents)
1988	0,00	0,00	0,00	0,00	0,00
1990	0,00	0,00	0,00	0,00	0,00
1995	14,34	12,16	1,51	0,62	0,06
2000	98,89	84,31	7,73	6,33	0,52
2005	186,25	157,03	15,52	12,55	1,14
2010	273,03	227,61	24,92	18,58	1,91
2015	300,46	249,64	27,45	21,08	2,30
2016	295,48	245,36	27,13	20,72	2,27
2017	259.72	233.52	26.20	20.86	2.98

Note: The reporting of the subcategory "wetland remaining wetland" follows Tier 1 – no changes in carbon stocks.

6.6.1 INFORMATION ON THE APPROACHES USED TO PRESENT THAT DATA FOR THE AREAS AND THE DATABASE FOR THE LAND-USE USED FOR THE INVENTORY

The data on total of Wetlands areas for single years (1994, 1996) has been obtain from the cadastral maps of the agricultural fund of Bulgaria (Balance by Type of Territories as per their Designation, Cadastre Agency) as well as data from the balance of the territory of Bulgaria based on orthophotoimages for the year 2012 and 2013. In order to cover the time series – interpolation has been applied. The wetlands area for 1996 according to the cadastral map is much lower than the wetlands area according to the balance of the territory based on orthophotoimages. The difference is about 30 kha. Such a dramatic increase in wetlands area has been considered as unlikely. Probably the observed increase is due to the different data sources used in the aggregation of the area data. However, the data from orthophotoimages has been considered as more reliable. Then, in order to level out the big increase in wetlands area a correction of the 1996 data on wetlands has been made. The correction coefficient of 12.38 kha is the net increase in wetlands from 1996 to 2012 according to

Corine Land Cover data (1996-2006 CLC data and extrapolated to 2012) as it was reported in the previous submissions. The value of 12.38 kha has been added to the total wetlands area in 1996 and 1994 according to the cadastral map. Then the interpolation between 2012 and 1996 has been applied. The areas of wetlands for the years before 1994 have been considered to be the same as in 1994.

The LUCs to wetlands have been assumed to stem from cropland and other land. The determination of these land use categories as the possible land-use changes where the increase in wetlands may stem from is based on the last step from the hierarchical treatment of the data sources – that is data gaps. It has been considered that the shares of these individual land use categories to the observed increase in wetlands behave like the ratios of the total areas of these land use categories in Bulgaria. In its previous submission Bulgaria reported LUCs from forest land to wetlands due to probability reasons. It was assumed that the observed increase in wetlands suggests also deforestation for wetlands. This forest loss to wetlands was estimated as a share of forest land in the totals of forest land, cropland plus grassland (it was supposed that the wetlands increase comes from such lands). Actually the reported LUC from forestland to wetlands in the previous submissions of Bulgaria represented an overestimation of deforestation activity since all the information for forest loss due to changes in designation of forest was reported under LUCs to settlements (SM). Since the last improvements in area representation made for the Submission 2014 LUCs from forestland to wetlands were not calculated. According to experts from the ExFA, the changes of designation of forest in the years 1988-2012 have been associated with conversion only to SM. There is only one new dam lake (Tsankov kamak) which was built up in recent years but the forest loss associated with its construction works has been already reported in the 70’s. Therefore, Bulgaria reports all information provided by the ExFA for forest loss across the time series as LUC associated with conversion to SM. The reported estimates of land-use changes from grassland to other land use categories (forestland and cropland), which are based on specific data and expert judgment, fit very well to the observed decrease in the total grassland area since the base year. Therefore, no land-use changes from grassland to wetlands have been assumed and reported.

6.6.2 METHODOLOGY

6.6.2.1 Lands converted to wetlands (4.D.2)

6.6.2.1.1 Changes in the carbon stock in living biomass of croplands converted to wetlands

The annual change in the carbon stock in the living biomass of croplands converted to wetlands is calculated using the following equation.

$$\mathbf{The\ annual\ change\ in\ the\ carbon\ stock} = \mathbf{anual\ area\ of\ lands\ converted\ to\ wetlands} \cdot (\mathbf{B_{after}} - \mathbf{B_{before}}) \cdot \mathbf{CF}$$

where,

B_{before}– living biomass stock in lands before the conversion – 3.0 tC/ha for annual crops and 4.5 tC/ha for othe land.

B_{after} – living biomass immediately after the conversion, t d.m./ha (for Tierl 1 = 0),

CF –carbon fraction in the dry matter (d.m.) (under Tier 1 = 0.5 t C/t d.m.).

6.6.2.1.2 Changes in the carbon stock in soils in lands converted to wetlands

Changes in the carbon stock in the soils when converting annual crops to wetland areas are calculated using the equation:

$$\Delta C_{wl} = A \cdot \frac{SOC_{after} - SOC_{before}}{20}$$

where:

A – area of the converted lands for a transition period of 20 years, ha.

SOC_{before} – carbon stock in the soil immediately before the conversion, tC/ha; for soils of annual crops 89.92 t C/ha and 69 tC/ha for other lands

SOC_{after} – carbon stock in the soil 20 years after the conversion, t C/ha. The conversion of carbon in the soils 20 years after the conversion is assumed to be 0.

6.6.2.1.3 N_2O emissions from N mineralization associated with loss of soil organic matter resulting from change of land use

Emissions has been estimated for all situations where C losses in mineral soils occur (according 2006 IPCCC Guidelines), based on equations 11.1, 11.2, 11.8.

The ratio C/N in the mineral soils is default from 2006 IPCCC Guidelines – 15.

6.6.3 UNCERTAINTY ASSESSMENT

The uncertainties associated with the estimates of CO_2 emissions and removals have been calculated using both Tier 1. Tier 1 method combines the uncertainties by means of the error propagation equations (IPCC Good Practice Guidance, IPCC, 2003). The input uncertainties, associated with the different emission factors and the activity data as well as the sources of information (default values, empirical data or expert judgment) are presented in Table 274. The total uncertainty for Land converted to Wetlands is ±25%.

6.6.4 DATA VERIFICATION CATEGORY-SPECIFIC QA/QC AND VERIFICATION, IF APPLICABLE

See 6.10. QA/QC VERIFICATION

6.6.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations are due to N_2O emissions from N mineralization associated with loss of soil organic matters resulting from change of land use have been included in the current submission.

6.6.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS INCLUDING THOSE IN RESPONSE TO THE REVIEW PROCESS

There are no planned improvements.

6.7 SETTLEMENTS (4.E)

Settlements cover an area of 523,43 kha in 2017, which represent 2.1% of the total territory of the country. The area of settlements has increased gradually over the period. The settlements area in 2016 is by 17% higher compared to the base year. The reporting of the subcategory "settlements remaining settlements" follows Tier 1 – no changes in carbon stocks. It is assumed that dead wood and litter do not exist in the settlements, therefore only emissions/removals from changes in living biomass and in soil have been calculated. The land-use changes to settlements origin from the categories Forests (data provided by the Executive Forest Agency), Cropland, Grassland (data provided by the Ministry of Agriculture and Food) and Other land.

Table 226 Land-use and land-use changes in the category Settlements (kha) (other land use changes are not occurring)

year	4.E SM Total	4.E.1 SM remaining SM	4.E.2 LUC in SM	4.E.2.1 Forest land in SM	4.E.2.2.a Annual Cropland in SM	4.E.2.2.b Perennial Cropland in SM	4.E.2.3 Grassland in SM	4.E.2.5 OL converted to SM
1988	445,21	404,20	41,02	1,43	23,31	1,46	12,00	2,82
1990	448,80	408,32	40,47	1,41	22,93	1,46	11,86	2,82
1995	457,75	418,65	39,11	1,58	21,97	1,41	11,41	2,73
2000	470,26	428,97	41,29	1,43	23,51	1,46	12,07	2,82
2005	478,61	439,30	39,32	1,55	22,21	1,33	11,47	2,76
2010	504,94	448,79	56,15	2,89	30,99	1,71	16,06	4,50
2015	515,93	457,54	58,39	3,91	31,54	1,68	16,37	4,89
2016	519,68	459,98	59,70	4,14	32,10	1,70	16,69	5,08
2017	523.43	462.75	60.68	4.87	32.18	1.70	16.77	5.17

Table 227 Emissions (+)/removals of CO_2 in Settlements remaining settlements and Lands converted to settlements (Gg CO_2 equivalent)

Year	4.E Settlements	4.E.1 Settlements remaining Settlements	4.E.2 Land converted to Settlements	4.E.2.1 Forests converted to Settlements	4.E.2.2 Cropland converted to Settlements	4.E.2.3 Grassland converted to Settlements	4.E.2.5 OL converted to Settlements
1988	478,34	NE	478,34	22,54	273,54	162,51	19,75
1990	468,64	NE	468,64	19,12	269,08	160,75	19,68
1995	444,47	NE	444,47	13,01	257,41	155,04	19,00
2000	494,92	NE	494,92	28,38	279,66	166,90	19,98
2005	511,83	NE	511,83	50,97	274,93	164,90	21,03
2010	753,19	NE	753,19	89,91	391,86	235,75	35,66
2015	781,05	NE	781,05	164,19	361,52	221,55	33,79
2016	718,94	NE	718,94	83,78	371,49	227,64	36,04
2017	788.09	NE	788.09	149.27	373.30	229.21	36.32

Table 228 Total N_2O emissions from N mineralization associated with loss of soil organic matter in Gg CO_2 equivalent

Year	4.E.2 Land converted to Settlements	4.E.2.1 Forests converted to Settlements	4.E.2.2 Cropland converted to Settlements	4.E.2.3 Grassland converted to Settlements	4.E.2.5 OL converted to Settlements
1988	46,01	1,30	26,82	15,71	2,17
1990	45,38	1,28	26,41	15,52	2,17
1995	43,80	1,44	25,32	14,94	2,10
2000	46,32	1,30	27,05	15,80	2,17
2005	44,05	1,41	25,51	15,00	2,12
2010	62,58	2,64	35,46	21,02	3,46
2015	64,80	3,57	36,04	21,43	3,76
2016	66,19	3,78	36,67	21,84	3,91
2017	67,12	4,44	36,76	21,95	3,97

6.7.1 INFORMATION FOR THE APPROACHES USED TO PRESENT THE DATA FOR THE AREAS AND THE DATABASE FOR THE LAND-USE USED FOR THE INVENTORY

Information on the total Settlements area is aggregated using the data on settlements area from the cadastral maps of the agricultural fund of Bulgaria for the years 1994,1996 (Balance by Type of Territories as per their Designation, Cadastre Agency) and data from the balance of the territory of Bulgaria based on orthophotoimages for the year 2012 and 2013. In order to ensure the time series consistency interpolation and extrapolation have been applied. The total settlements area according to the balance from the orthophotoimages is lower than the area from the cadastral map. Since a decrease in settlements area is considered as unlikely, it was assumed that the discrepancy in the extent of the settlements territory is because of using different methodology by the data providers. The settlements area according to cadastral map includes also lands next to villages, which usually are under cropland or grassland management. In the orthophotos these lands are in separate class but are referred to CL. In order to avoid double counting of lands the SM area pattern has been recalculated. The following has been applied:

- Adjustment of the total settlements area for 1996 to match with the known increase in settlements for the period 2001-2016
- Interpolation between the adjusted settlements area for 1996 and 2015
- Extrapolation of settlements area for the period 1988-1996 considering the available data on LUC to settlements

Concerning the LUCs to settlements there is information for LUC from forest land to settlements, which is available for the period 1990-1994 and for the years 2001 to 2016. The annual forest loss to settlements for the years 1988, 1989 and 1995-2000 is estimated as an average value of forest loss in the period 1990-1994. Information for LUC from arable land (e.g cropland and grassland) to settlements is available for the years 2001 to 2015. The share of annual cropland, perennial cropland and grassland within the available figure for the total area, which is changed to settlement between 2001 and 2015, was assumed the same as the share of the totals of these land-use categories. LUCs from arable lands to settlements for the years before 2001 are estimated using the data gaps approach. The reported land-use changes to settlement fit very well to the observed increase in settlements area.

6.7.2 METHODOLOGY

6.7.2.1 Land use change to settlements (4.E.2.)

6.7.2.1.1 Forests converted to settlements

The methodology and the data for the forests are presented in Chapter 6.3.

The estimates include the losses of forest biomass as well as the annual increase of the settlement biomass over the transition period (20 years) and also the changes in the litter (humic and fumic layers) and soil C stock (including the losses in litter). The converted forest area to settlements ranges between 1-2 kha.

6.7.2.1.1.1 Changes in the carbon stock in living biomass of forests converted to settlements

For estimating biomass loss associated with deforestation, data from NFI on volume stock over bark has been used. The data on volume stocks over the five years period since 1990 has been expanded and converted with the related country specific (or default) expansion/conversion factors: wood density (0.43 t/m3 for coniferous, 0.60 t/m3 for deciduous), stemwood plus branches expanded to the whole aboveground tree biomass (1.08 for coniferous, 1.03 for deciduous), root-to-shoot ratios (0.29 for coniferous, 0.24 for deciduous) and C-content (0.48 t C/t d.m.). Then it has been estimated the share of the coniferous and deciduous stocks in the total biomass stock for the respective years. Like this the weighted means for tree biomass stock have been calculated. The means have been used for estimating biomass loss from deforestation for the years across the time series.

Table 229 Living biomass stocks which are used to calculate the emissions associated with forest loss to settlements

		1990	1995	2000	2005	2010	2015- 2016
Weighted mean tree biomass stocks	tC/ha	36,07	41,41	45,88	49,49	53,04	54,83

Estimates for living biomass in settlements are based on the results of scientific study 35 carried out in Bulgaria on mapping and assessment of ecosystem services in urban areas (Project TunesinUrb, funded by EEA Grants). The information used comes from case study area of Pleven district. Biomass data from the following urban subsystems has been used – residential and public areas, urban area, industrial sites, urban green areas. Based on the biomass data of trees (Zhiyanski et al.(2015a))36, shrubs (Nowak et al. (2002)37) and ground vegetation ((Zhiyanski et al. 2013)38) in this study an average biomass per ha settlement area was calculated (see table below) using the relative share of each urban subsystem.

Table 230 Average biomass stock and annual growth in biomass on settlement, tC/ha

	tC/ha	data source:	rotation length	annual growth in biomass in SM
trees in parks	36,5	Zhiyanski et al. (2015a)	60	0,61
scaterred trees	25,0	Nowak et al. (2002)	60	0,42
estimated weighted mean value	27,3		60	0,46
shrubs	4,5		20	0,23
tress and shrubs				**0,68**
ground veg.	2,0	(Zhiyanski et al. 2013)	1	**2,00**

6.7.2.1.1.2 Changes in carbon stock in dead organic matter of forests converted to settlements

The calculation of the emissions from litter pool (humic and fumic layer) as a result of the conversion of forests to settlements was made by using national data for the carbon stocks in litter (humic and fumic) in forests (5.4 t C/ha). The estimation of changes in litter pool are done based on annual

[35] Nedkov, S., M. Zhiyanski**,** M. Nikolova, A. Gikov, P Nikolov, L. Todorov. 2016. Mapping of carbon storage in urban ecosystems: a Case study of Pleven District, Bulgaria. Proceedings of scientific conference "Geographical aspects of land use and planning under climate change". Varshets 23-25.09.2016. pp. 223-233

[36] **Zhiyanski M.,** A. Hursthouse, S. Doncheva. 2015. Role of different components of urban and peri-urban forests to store carbon – a case-study of the Sandanski region, Bulgaria. Journal of Chemical, Biological and Physical Sciences. JCBPS, Section D; May 2015 – July 2015, Vol. 5, No. 3; 3114-3128. IF (2013) = 0,723

[37] Nowak, D.J., Crane, D.E., 2002. Carbon storage and sequestration by urban trees in the USA. Environmental Pollution 116 (3), 381-389.

[38] Zhiyanski, M., V. Doichinova, K. Petrov. 2013. The social aspects and role of green infrastructure in mitigating climatic changes at regional level. Proceedings of
3rd International Conference "Ecology of urban areas 2013", Zrenjanin, October 11, 2013, Serbia, 451-459

change from FL to WL, cause it is assumed that the litter is oxidised in the year of conversion. Litter does not occur in Settlements, so the carbon stock here is considered as 0 t C/ha.

For estimating changes in DW stock due to deforestation activity it was assumed that the dead wood stocks is equal to 5% of the standing biomass stock of the Bulgarian forests. This is a percentage magnitude for dead wood that is frequently reported for managed forests in Europe. The resulting values are given in the table below.

Table 231 Dead wood stocks used for estimating the changes in DW pool after deforestation

		1990	1995	2000	2005	2010	2015 - 2016
DW stock	tC/ha	1,80	2,07	2,29	2,47	2,65	2,74

6.7.2.1.1.3 Changes in the carbon stock in soils of forests converted to settlements

The calculation of the emissions from soils as a result of the conversion of forests to settlements has been made by using national data for the carbon stocks in the soils in forests (78.26 t C/ha) and the carbon stocks in the soils of the settlements (19.7 tC/ha). The carbon stock in the soils of settlements is determined on the basis of data for the carbon stock in the soils of the green areas in Sofia for 40 cm depth (94 t C/ha), corrected as per the relative share of the green areas in Sofia (2.63%).

6.7.2.1.2 Cropland converted to settlements

6.7.2.1.2.1 Changes in the carbon stock in living biomass of the croplands converted to settlements

When calculating the changes in the carbon stock in the biomass during the conversion of cropland to settlements the values used are the average annual stock of carbon in the biomass of annual crops (3.0 t C/ha) and perennials (63 t C/ha) and the growth rates of the carbon stock in the biomass of the settlements (Section 6.4.3.1)

The annual emissions of carbon dioxide are presented in Table 227.

Changes in the carbon stock in soils for croplands converted to settlements

When calculating the changes in the carbon stock of soils during conversion of croplands to settlements the values used are those of the carbon stock in the soils of annual crops (89.92 t C/ha) and perennials (76.52 t C/ha), and values of the carbon stock in the soil of the settlements – 19.7 t C/ha.

6.7.2.1.3 Grassland converted to settlements

6.7.2.1.3.1 Changes in carbon stock in living biomass of the grasslands converted settlements

When calculating the changes in the carbon stock of the biomass during the conversion of grassland to settlements the values used are the average annual carbon stock in the biomass of grassland determined for Bulgaria (6.1 t C/ha) and the annual growth rates of the carbon stock in the biomass of the settlements.

6.7.2.1.3.2 Changes in the carbon stock in soils from grassland converted to settlements

When calculating the changes in the carbon stocks in the soil during conversion of other land to settlements the values used are those of the carbon stock in the soil of grassland (103.57 t C/ha).

6.7.2.1.4 Other land converted to settlements

6.7.2.1.4.1 Changes in carbon stock in living biomass of other land converted to settlements

When calculating the changes in the carbon stock of the biomass during the conversion of other land to settlements the values used are the average annual carbon stock in the biomass of other land (4.5 t C/ha) and the annual growth rates of the carbon stock in the biomass of the settlements.

6.7.2.1.4.2 Changes in the carbon stock in soils from other land converted to settlements

When calculating the changes in the carbon stocks in the soil during conversion of grassland to settlements the values used are those of the carbon stock in the soil of grassland (69 tC/ha).

6.7.2.1.5 N_2O emissions from N mineralization associated with loss of soil organic matter resulting from change of land use

Emissions has been estimated for all situations where C losses in mineral soils occur (according 2006 IPCCC Guidelines), based on equations 11.1, 11.2, 11.8.

The ratio C/N in the mineral soils is default from 2006 IPCCC Guidelines – 15.

6.7.3 UNCERTAINTY ASSESSMENT

The total uncertainty for Land converted to Settlements is ±75 % based on expert judgment.

6.7.4 DATA VERIFICATION CATEGORY-SPECIFIC QA/QC AND VERIFICATION, IF APPLICABLE

See 6.10. QA/QC VERIFICATION.

6.7.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations are due to N_2O emissions from N mineralization associated with loss of soil organic matters resulting from change of land use have been included in the current submission.

6.7.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS INCLUDING THOSE IN RESPONSE TO THE REVIEW PROCESS

There are no category-specific planned improvements.

6.8 OTHER LAND (4.F)

Data on area of other land is gathered from Executive Forest Agency and Ministry of Agriculture and Food. The EFA provides data on rocks and landslides from the forestry fund while the MAFF provides information on sands, small-scale non-arable lands, lands with poor vegetation. The share of Other land to the total country's territory is 4%. The total national area of 11100.19 kha remains constant over time. Thus, in accordance with IPCC 2006, the difference of the area of all land-use category and the whole area of the country is referred to "Other land" category in order to avoid double accounting or omission of an area. Like this the difference between the area of all land use categories and the total area of Bulgaria ranges between 0.01-3.85%.

The improvements made in the land area representation have led to reporting of the LUCs to/from OL. The reported LUCs from/to OL have been estimated based on data gap approach, following the trends in the area of the respective land-uses and considering its shares. These changes have led also to the need of reporting the emissions/removals associated with the conversion of lands from/to OL. The figure of annual carbon stock in biomass (4.5 tC/ha) is derived from results of a case study under the project Land-use and management impacts on carbon sequestration in mountain ecosystems" under the framework of the Bulgarian-Swiss Research Programme ("BSRP").

6.9 HARVESTED WOOD PRODUCTS

The contribution of the Harvested Wood Products (HWP) to the emissions and removals from LULUCF is estimated and reported. The annual changes in carbon stocks and associated CO2 emissions and removals from the HWP pool are estimated, following the production approach described in the Annex to Volume 4, Chapter 12, of the 2006 IPCC Guidelines (IPCC, 2006), in line with Decision 2/CMP.7 and the guidance provided by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement, IPCC 2014). The estimation follows the Tier 2 method - first order decay, which is based on Eq. 2.8.5 (KP Supplement, IPCC 2014). This equation considers carbon stock in the particular HWP categories, which is reduced by an exponential decay function using the specific decay constants. The default half-life constants were used:

- 35 years for sawnwood,
- 25 years for wood-based panels
- years for paper and paperboard.

The second part of Eq. 2.8.5 (IPCC 2014) adds the material inflow in the particular year and HWP categories.

The activity data (production of sawnwood, wood based panels and paper and paperboard) are derived from FAO forest product statistics (Food and Agriculture Organization of the United Nations: forest product statistics, http://faostat3.fao.org/download/F/FO/E). Equation 2.8.1 (IPCC, 2014) has been applied to estimate the annual fraction of the feedstock coming from domestic harvest for the HWP categories sawnwood and wood-based panels and eq. 2.8.2 for category paper and paperboard. In addition, Equation 2.8.3 has been applied to allocate the domestic harvest to the relevant forest activities (AR, D and FM). For HWP coming from Deforestation tier 1 – instantaneous oxidation is applied. The initial stock has been estimated using Equation 2.8.6 of KP Supplement with t0=1987. Default conversion factors has been applied as provided in Table 2.8.1 KP Supplement. The trend of inflows and associated emissions and removals from HWP are provided in the next figures.

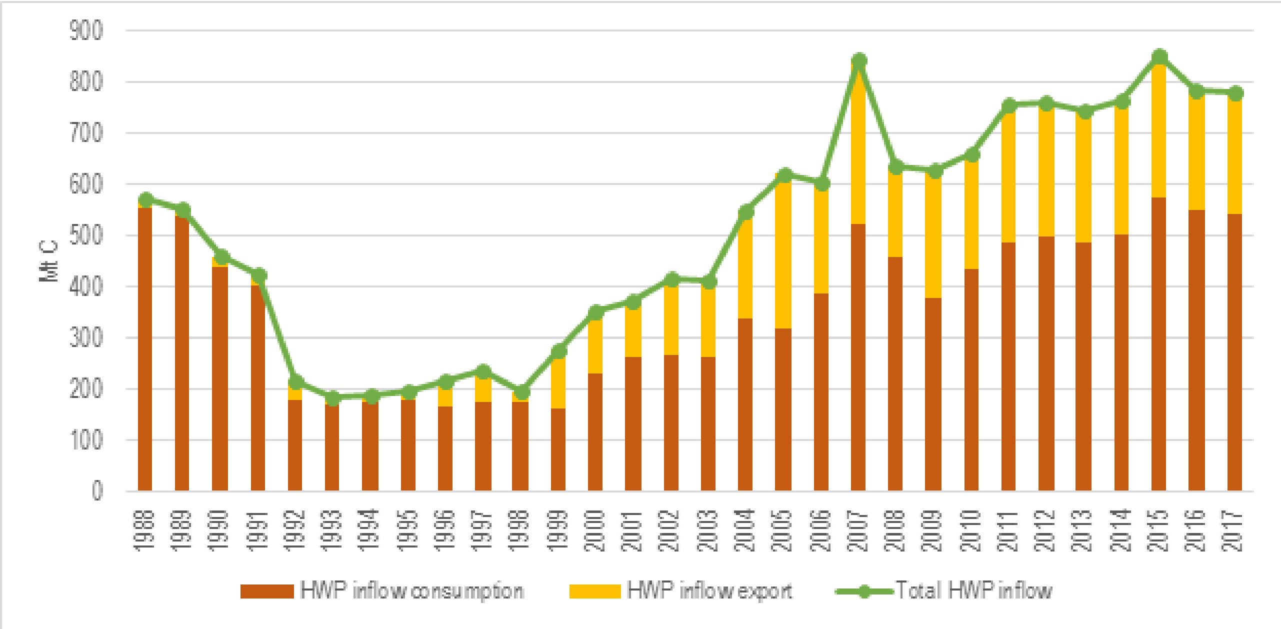

Figure 106. Annual HWP Inflow,

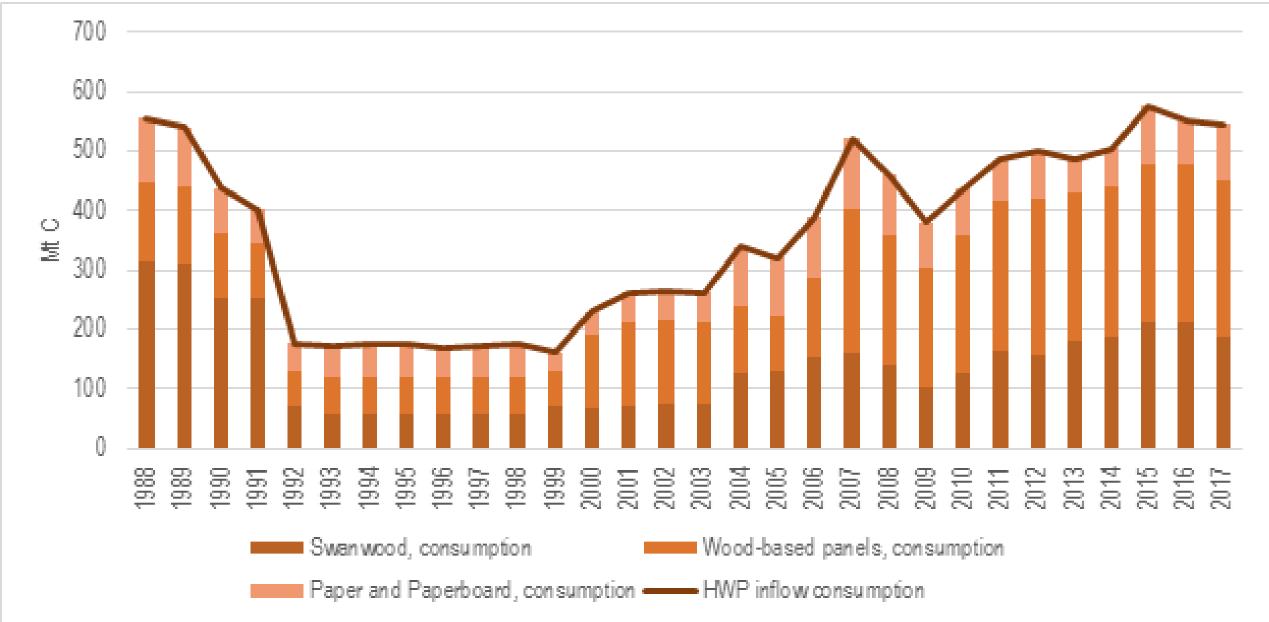

Figure 107 Annual Inflow of HWP in consumption by semi-finished products, Mt C

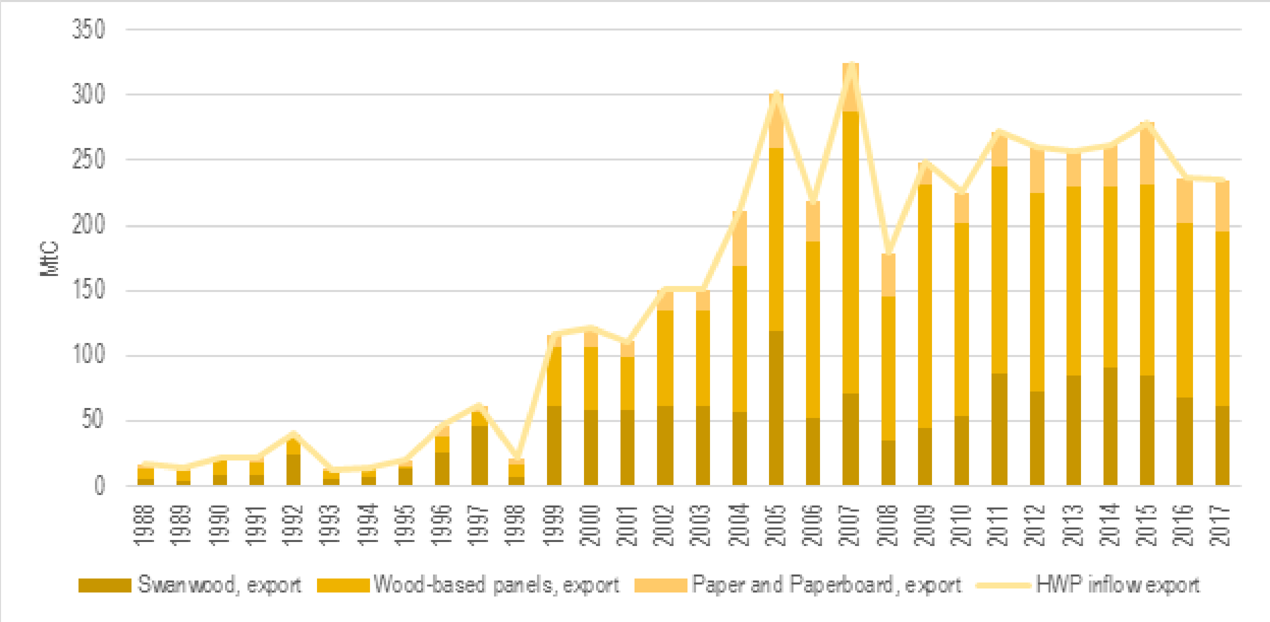

Figure 108 Annual Inflow of exported HWP by semi-finished products, Mt C

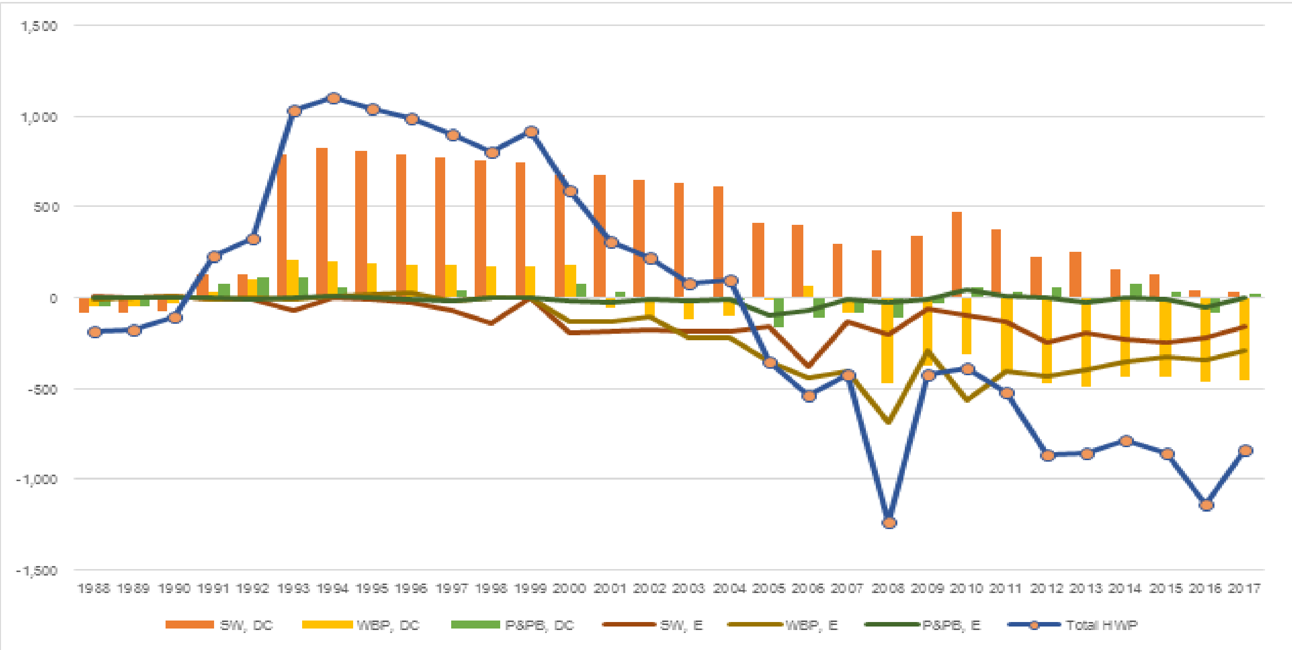

Figure 109 Emissions and removals from HWP, Gg CO2 eq

6.10 QA/QC VERIFICATION

The input data, estimates and results are checked as follows.

- Bottom-up check
- Input data
- Check for the plausibility of the activity data and their trend
- Check for plausibility of the emission factors as well as the related input data and their trends
- Check of input data for completeness

- Estimations
- Check of the correctness of all equations in the estimate files
- Check of the correctness of all interim results
- Check of the plausibility of the results and their trends
- Check of the correctness of all data and results transfer
- Top-down check
- Check of the consistence of the total area for Bulgaria.

Comparison of the activity data used with those from other statistics. Comparison of the used emission factors and underlying input data with those of other data sources (e.g. from literature, results in NIRs of other comparable regions, IPCC default values).

The correctness of the data on the areas and the tree stock is controlled during the preparation, the adoption and the execution of the Forest Management Plans (FMP). The quality control is exercised by the Executive Forest Agency and its subdivisions. Quality control could be exercised by other institutions, e.g. the Ministry of Environment and Waters, municipal authorities as well as by forest landowners. Quality control is exercised at every phase of the preparation of the FMP and the results of the check are documented and the mistakes are corrected.

Concerning the agrostatistical data, from the Agrostatistics and Strategies Directorate of MAFF together with the Regional Directorates "Agriculture and forestry" and Municipal Services on agriculture and forestry at MAFF organized and conducted the agricultural census in Bulgaria. Around 4000 surveyors participated in the data collection process. Around 400 controllers supervised the work of the surveyors and provided methodological assistance. The controllers delivered the checked questionnaires to the agrostatistics experts from the Regional Directorates "Agriculture and Forestry" according to a previously adopted schedule. The operators did the data entry in the census software spread in the regional offices. The regional data bases are aggregated on national level by Agrostatistics and Strategies Directorate of MAFF. The data entry from the filled in questionnaires into computer software was followed by crosschecks and coherence control in order to ensure the data quality.

6.11 PLANNED IMPROVEMENTS

The following improvements are planned and expected to be implemented in the next few years:

1. **Land representation** – Bulgaria will try to implement some of the planned improvement in land representation which were not implemented in the last 3 Submissions due to lack of expertise, administrative capacity and financial resources. These improvements refer to 2 options:
    a. To continue using the available data from different data sources but to further disaggregate the area of CL, GL and OL in order to trace more proper the LUC between these categories;
    b. To further investigate the updates in Cadastral map;
    c. To initiate separate study (pilot or for the whole country) which would use different technologies and data sources (from satellite image, ortophoto etc.) and software (GIS) to obtain proper and reliable data on land representation and LUCs. There are many constraints here related to financial resources.
2. Methods used for **estimating biomass carbon stock changes** – Currently there is an ongoing project on implementing the default method (gain-loss) in estimating the biomass carbon stock changes in FLrFL category. There are preliminary results available but further assessments are needed before the implementation of gain-loss method in GHGI calculations.

3. **Changes in carbon stock in DOM and soil in FLrFL** – we plan to allocate extra efforts and resources to engage the scientific community in order to be able to move to higher tier method in reporting changes in these pools in subcategory FLrFL.
4. To estimate carbon stock changes in mineral soils in sub-categories CLrCL and GLrGL
5. To initiate a study for **carbon content on other lands**. Other lands are not only rocks and landslides, there is also some areas which cannot be assigned to the rest of land-use types but there is vegetation on it.
6. To continuously check the coherence of reported data, **ensuring consistency and accuracy in the estimation process and in the reporting phase**

6.12 RECALCULATIONS

In the current submission emissions and removals from DOM and soil in subcategory FLrFL are assumed to be 0 (Tier 1 assumption). This has been changed since Submissions 2017 and 2018, where Bulgaria reported emissions and removals from these pools by using directly and then extrapolating the results from a study, conducted by JRC and published in a report[39]. Bulgaria understands that using the results from this study leads to a lack of comparability between the methods and assumptions used to estimates the changes in the living biomass pool and the methods and assumptions used to calculate the carbon stock changes in deadwood, litter and soil, estimated by CBM. Unfortunately, now Bulgaria is not able to apply higher tier and report for emissions and removals from DOM and soil in FLrFL but intends to allocate extra efforts to provide estimates in the coming years.

Other recalculations include changes in the estimation of CSC in living biomass of both subcategories – FlrFL and LUCs to FL. For the current Submission, the estimates in FlrFl are prepared at level of tree species and then grouped for the reporting into forest types - coniferous and deciduous. Like this, more detailed data is used, and more specific emission factors are applied accordingly. For category LUC to FL, the annual average biomass growth has been recalculated as the expansion and conversion factors have been recalculated. More information about these changes is presented in 6.3.2

[39] *"LULUCF contribution to the 2030 EU climate and energy policy"*, available at http://publications.jrc.ec.europa.eu/repository/handle/JRC102498

7 WASTE (CRF SECTOR 5)

7.1 OVERVIEW OF SECTOR

This Chapter includes information on the GHG emissions from the Waste sector. The categories and activities for estimation of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions are described in detail.

According to the IPCC nomenclature, the following categories are included in this sector:

- Solid Waste Disposal on Land (5 A)
- Biological treatment of waste (5 B)
- Waste incineration (5 C)
- Wastewater handling (5 D)

The report includes information on methods for estimating greenhouse emissions as well as references of activity data and emissions factors concerning waste management and treatment activities reported under CRF Category 5 Waste.

The most important gas produced in this category is methane.

7.1.1 EMISSION TREND

The major greenhouse gas emissions from Waste sector are CH_4, CO_2 and N_2O. The GHG emissions trends in this sector are presented in Table 232 and following figures.

Table 232 Trend in GHG emissions from Waste by sub-sectors for 1988-2017

GHG gases	CH_4				N_2O			CO_2
Category	5 A	5 B	5 C	5 D	5 B	5 C	5 D	5 C
1988	196.90	NO	7.01E-05	121.83	NO	0.004864	0.802	21.76
1990	197.79	NO	7.49E-05	112.50	NO	0.005224	0.666	23.23
1995	197.32	NO	7.9E-05	74.76	NO	0.005498	0.586	24.54
2000	190.14	NO	0.000231	55.70	NO	0.016854	0.561	70.91
2005	163.94	NO	0.000206	43.16	NO	0.014506	0.482	63.79
2010	144.52	NO	5.25E-05	33.24	NO	0.003425	0.490	16.52
2011	143.98	0.33	3.88E-05	32.11	0.0201	0.002411	0.492	12.31
2012	139.60	0.37	7.68E-05	30.15	0.0221	0.005221	0.476	23.98
2013	134.51	0.43	0.000144	36.14	0.0256	0.01044	0.485	44.31
2014	129.92	0.23	4.3E-05	36.10	0.0141	0.002931	0.482	13.425
2015	125.35	1.24	3.88E-05	35.25	0.0746	0.002612	0.479	12.142
2016	120.26	1.05	8.52E-06	35.01	0.0631	0,003211	0,476	14.510
2017	113.30	0.95	5,57E-05	30.15	0.0571	0.003863	0.472	17.315

For 2017 Solid Waste Disposal on Land contributes 74.86%, Wastewater Handling about 23.63%, Waste Incineration about 0.42% and compost production about 1.08% sector's total emissions.

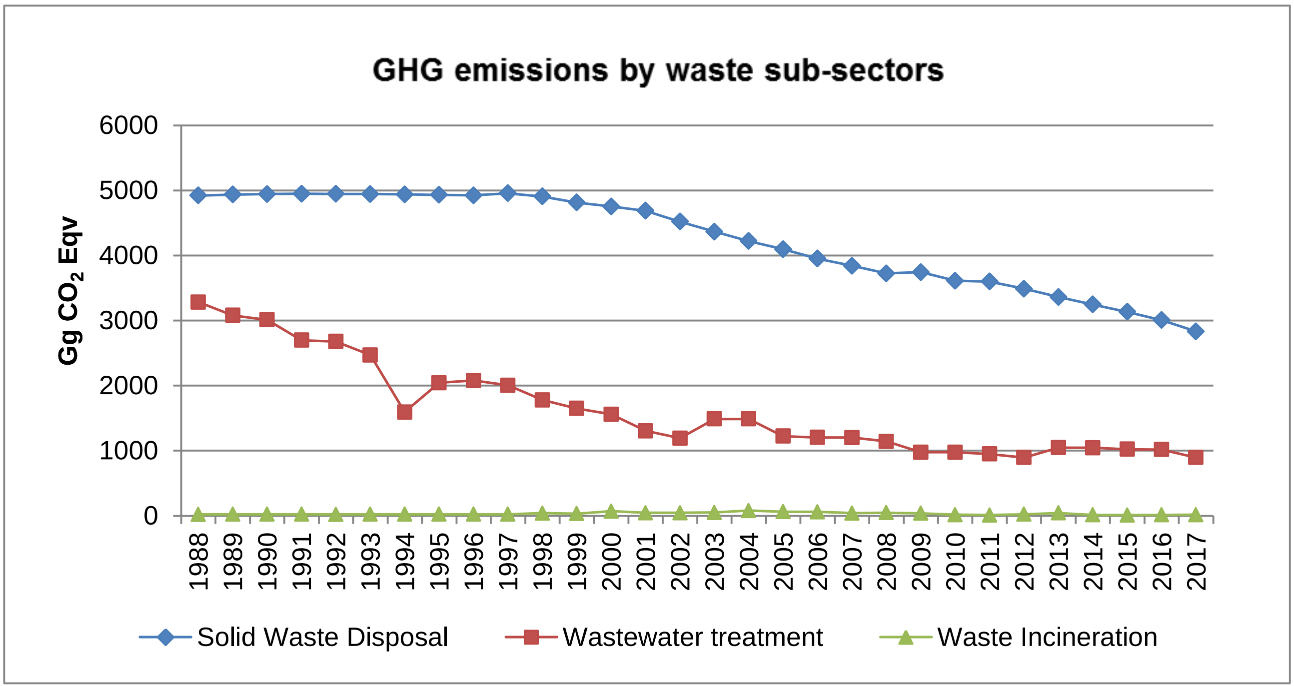

Figure 110 Emissions by waste sub-sectors

Emissions from the waste sector in 2017 decreased by 54.01 % (3783.78 Gg CO_2-eq in 2017 compared to 8227.31 Gg CO_2-eq in 1988) compared to the base year.

Figure below presents the total CO_2 eqv from the whole waste sector.

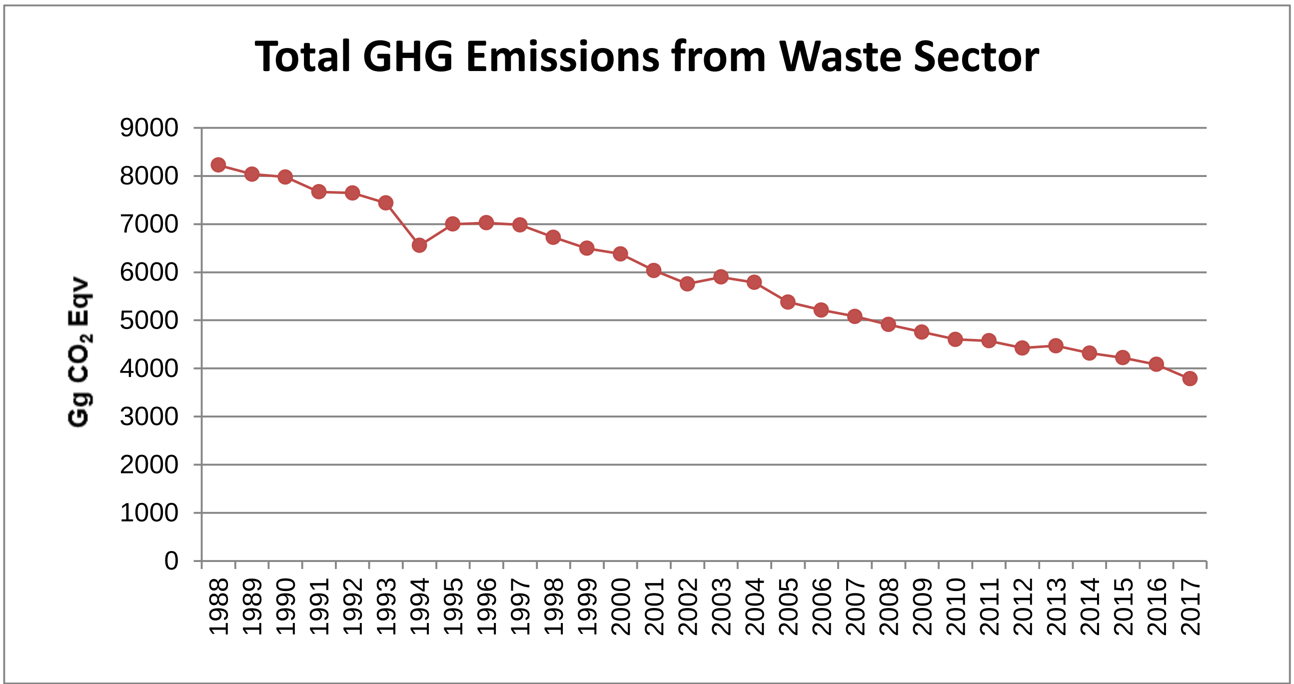

Figure 111 GHG emissions from Waste sector

7.1.2 KEY CATEGORIES

Table 233 described the key categories of the waste sector and type of emitted greenhouse emissions.

Table 233 Key categories, Waste sector (Tier 1)

CRF categories	Category	Key category Y/N	GHG	Assessment of Key Source excluding LULUCF	Assessment of Key Source including LULUCF
5A	Solid Waste Disposal on Land	Yes	CH_4	L,T	L,T
5D	Wastewater handling	Yes	CH_4	L,T	L,T

7.1.3 METHODOLOGY

A more detailed description on the methodology for calculating emissions can be found, described in each subcategory of waste sector.

7.1.4 QUALITY ASSURANCE AND QUALITY CONTROL

Generally described checks and improvements have been taken and are described in sub chapters.

7.1.5 UNCERTAINTY ASSESSMENT

Uncertainty assessments are provided in respective subchapter.

7.1.6 COMPLETENESS

Table 234 Description of the completeness

Waste IPCC Category	Waste IPCC Category	CO_2	CH_4	N_2O
5A Solid waste Disposal on land	5A1 Managed waste disposal	NA	✓	NA
5A Solid waste Disposal on land	5A2 Unmanaged waste disposal	NA	✓	NA
5B Biological treatment of solid waste	5B1Composting Municipal Solid Waste	NA	✓	✓
5C Waste Incineration	5C1 Incineration of municipal waste	NA	NA	NA
5C Waste Incineration	5C1 Incineration of hospital waste	✓	✓	✓
5C Waste Incineration	5C1 Incineration of sewage sludge	NO	NO	NO
5C Waste Incineration	5C1 Incineration of different type of hazardous waste	✓	✓	✓
5D Wastewater handling	5 D1 Domestic wastewater	NA	✓	✓
5D Wastewater handling	5 D2 Industrial wastewater	NA	✓	NA

✓ *- indicates that emissions from this sub-sector have been estimated*

7.2 SOLID WASTE DISPOSAL ON LAND (CRF SECTOR 5A)

7.2.1 SOURCE CATEGORY DESCRIPTION

Treatment like disposal of municipal, industrial and other solid waste produces significant amounts of methane (CH_4). CH_4 produced at SWDS contributes approximately 3 to 4 percent to the annual global anthropogenic greenhouse gas emissions (IPCC 2001). In this report CH_4 is addressed.

The methodology used to estimate emissions from waste management activities requires country-specific knowledge on waste generation, composition and management practice. The main parameters that influence the estimation of the emissions from landfills, apart from the amount of the disposed waste, are: the waste composition, fraction of methane in landfill gas and amount of landfill gas that is collected and treated. These parameters are strictly dependent on the waste management policies throughout the waste streams which start from waste generation through collection and transportation, separation for resource recovery, recycling and energy recovery and terminate at landfill sites. The improvements of quality and quantity of data are visible in last couple of years. Effort was done in order to evaluate and compile data coming from different sources and adjust them to recommended IPCC methodology which is used for GHGs emissions estimation. At present in our country are used country specific data, where they are available. Default values are used when such data are not available.

Legislation and development planning processes in the field of waste management in Bulgaria:

After the global economic and political change and regime change of government in our country start to lay the groundwork for approval of plans and strategies outlining guidelines on sustainable management.

At the beginning of the nineties years in the country began to develop practices for separate collection of household waste and their subsequent recycling.

During the last couple of years the measures in national legislation aimed at decreasing CH_4 emissions from landfills - limiting the disposal of municipal waste, measures for closure and rehabilitation of municipal landfills with terminated operation; coverage of all household waste in a managed system of waste treatment, including all waste to be disposed of in managed landfills and capturing, utilizing or flaring of landfill gas.

New waste management law 2012 - separate bio-waste collection (yards, park and garden wastes, green wastes must be treated via composting or anaerobic digestion); reducing the amount of biodegradable waste, sent to landfills).

National strategic plan for diversion of biodegradable waste going to landfills (2010-2020)

National strategic plan on sewage sludge management (2012-2020)

Ordinance for the treatment of bio-waste and separate bio-waste collection (2016)

Third National Action Plan on Climate Change (2013-2020)

National Waste Management Plan (2014-2020)

Bulgarian legislation introduce the specific quantitative targets for separate collection, recycling and recovery of municipal bio waste as well as targets for diverting biodegradable municipal waste from landfills. The provisions of the Waste Management Act require that by 31 December 2020 there shall be limiting the amount of biodegradable municipal waste to 35 percent of the total of those wastes in the Republic of Bulgaria in 1995. This is compliant with the requirements of the European directive on the landfill of waste.

The effect of the legislative measures will be visible in the future. Currently, some positive tendencies are observing, concerning SWD on the managed and unmanaged disposal sites.

Since 2000 the share of population, land filling on unmanaged sites decreases and the share of population, which dispose of wastes on managed sites is increasing.

The landfills are classified as managed and unmanaged (see below: Activity data).

As the main criteria for whether landfills are managed and unmanaged, is considered the fact if the landfills meet the requirements laid down in EU Directive 1999/31/EC on the landfill of waste.

7.2.2 EMISSION TREND

Methane emissions are shown in the Table 232, Table 240 and Figure 112 CH4 Emissions from SWDS from managed and unmanaged sites.

Total CO_2 eqv from Solid waste disposal for 2017 are 2832.50 Gg CO_2 eqv. In 2017 emissions decrease with 5.79% in comparison with previous year.

Landfilling as a method of waste disposal still holds the biggest share in the management of municipal waste, but there is a steady decline in this indicator in recent years (the percentage of waste disposed in landfills drop from 95% in 1990 to 60% in 2017). Recyclable waste collection, which was a scarce practice at the beginning of the nineties, has been increased. In 2013, legislation on bio-waste management was promulgated, which combined with the existing economic instruments as well as the introduced in 2011 landfill tax per ton led to the present positive trends.
The total amount of municipal waste generated in Bulgaria in 2017 is 2945 kt which is in average 1.14 kg per capita/per day. The total amount of municipal waste generated in the country is following a positive trend towards permanent decrease.
The amounts of separately collected fractions from municipal waste are gradually increasing. Since 2009, collection schemes have been improved for management of six special waste categories - packaging waste, waste oils, end-of-life vehicles, waste electrical and electronic equipment, waste tires, batteries and accumulators. This resulted in increased quantities of collection and recovery of those waste streams and decrease in per capita waste generation. Bulgaria is among the member-states with close to the average level of recycling in recent years.

In the country exist regional systems for waste management where before land filling the waste is subjected to pre-treatment (separation) as recyclable fractions such as paper and cardboard, metals, glass, plastics and wood are sent to recycling facilities. This practice reduces the amount of waste which going to landfills, additionally development of composting activities concerning the decreased land filled degradable fraction of MSW.

The emissions from SWDS are emitted from MSW (including AMSW-assimilated municipal solid waste and sludge from wastewater treatment plant) which are landfilled. MSW are disposed of on managed and unmanaged disposal sites as from 2000 the share of population, landfilling waste on unmanaged is decreasing and the share of population, landfilling on managed MSW sites is increasing.

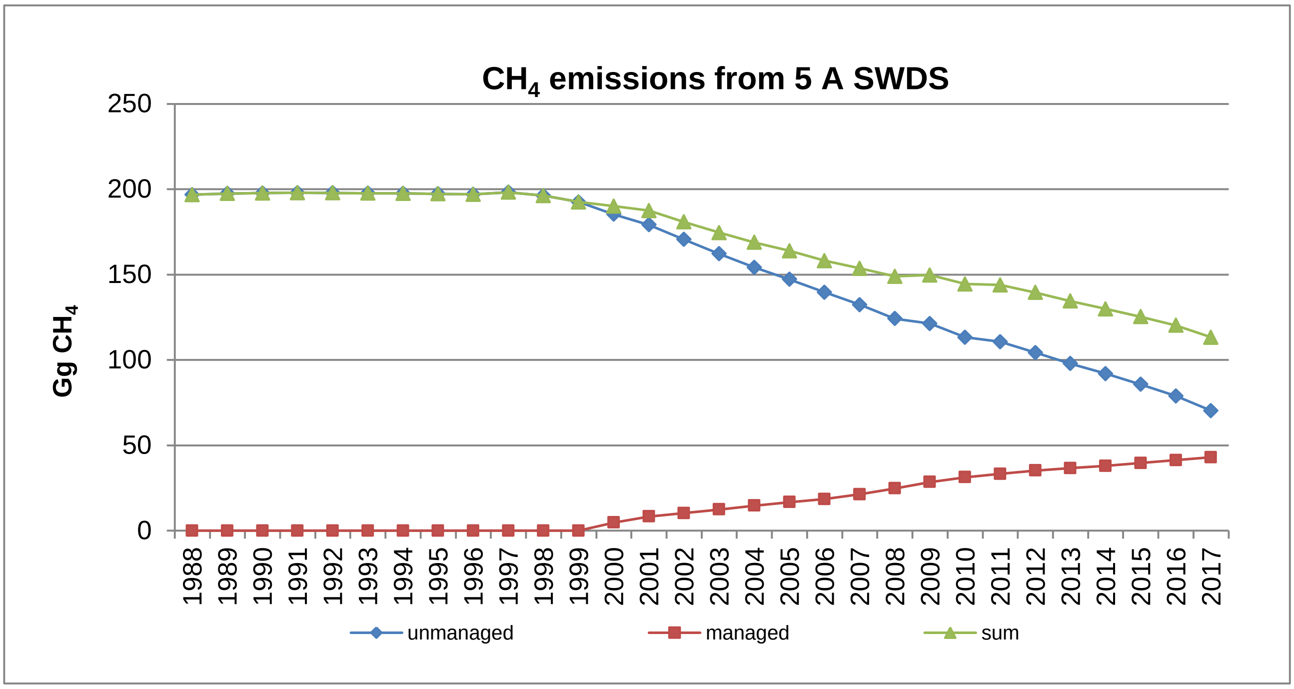

Figure 112 CH_4 Emissions from SWDS

7.2.3 METHODOLOGICAL ISSUES

7.2.3.1 Methodology

A. Choice of method:

Emissions from solid waste disposal on land have been calculated using the First Order Decay (FOD) method, the IPCC Tier 2 method given in the 2006 IPCC Guidelines.

The choice of a good practice method will depend on national circumstances.

B. Basics:

- IPCC FOD Tier 2;
- Multi –phase model (based on waste composition);
- Starting year 1950;
- Managed and unmanaged type of site;
- Source AD: NSI, MOEW, ExEA.

C. Influencing factors/ data required:

- Waste amounts deposited / waste generated (starting year 1950)
- Waste treatment (deposition, composting, incineration, recycling)
- Management practices at landfill sites (MCF)
- Conditions at landfill sites + Composition of waste deposited
- Organic carbon in landfill sites (DOC)
- Methane generation rate constant (k)
- Landfill gas recovery, Oxidation
- National waste management policy

7.2.3.2 Activity data and emission factors

The main source of activity data is NSI. Data on Municipal Solid Waste generation rate and on the quantity of MSW disposed to SWDSs and etc. are country specific data. On the basis of generated waste from 1999-2010 and total population of the country are calculated generated waste for the period 1950-1998.

Waste generation rate is based on the evaluation of the collected MSW in the country including recycled waste with origin from population.

Concerning disposed MSW, questionnaires, verified by Eurostat are sending to the municipalities in which they fill the data about the quantities of land filled municipal solid waste.

Detail information about AMSW (assimlilated municipal solid waste) data collection will be provided later from National Statistical Institute.

Sludge from wastewater treatment plants

Sludge from wastewater treatment plants has also been considred, because it can be disposed of at the same landfills as municipal solid waste, once it meets a specific requirements. The fraction of sludge, disposed at ladfill sites has been estimated to be 17.9 Gg in 2004 (extrapolated value) decreasing to 6.95 Gg in 2017 (decrased by 61.17%).

On the basis of its characteristics, sludge from wastewater treatment plants is also used in agriculture, in compost production with red Californian worms, landfilled or temporarily stored on special platforms.

Source of information about sludge from wastewater treatment plants is National Statistical Institute. Information about sludge is available from 2005 (Regulation EC No 2150/2002 on waste statistics). For 2004 values are extrapolated.

Information from NSI is ensured by conducting the following annual statistical surveys included in National statistical programme:

- Water supply, sewage and treatment – exhaustive survey. Data are collected from public water supply companies, dealing with water collection, treatment, water supply and wastewater collection, discharge and treatment (water supply companies/urban wastewater treatment plants operators and irrigation systems).

Another source of information is Executive Environment Agency through National legislation (Ordinance on the way of recovery of sludge from wastewater treatment through its use in agriculture; Ordinance No 1 on the procedures and forms for providing information about waste management activities and the procedure for keeping public records).

Table 235 Time series of sewage sludge production and landfilling is reported

Year	2004	2005	2006	2007	2008	2009
Sewage sludge production Gg	40,38	41,70	38,00	39,90	42,90	39,40
Sewage sludge landfilled Gg	17,90	23,40	16,40	20,80	17,80	11,10

Year	2010	2011	2012	2013	2014	2015	2016	2017
Sewage sludge production Gg	49,80	51,40	59,30	60,30	54,94	57,36	65,76	68,88
Sewage sludge landfilled Gg	13,97	7,05	6,64	10,49	8,47	8,54	6,15	6,95

Information about sludge is available at Eurostat.

Industrial waste

Industrial waste assimilated to municipal solid waste (AMSW) could be disposed of to the same landfills as MSW. It originate from commercial establishments and related handicraft activities, recreation and entertainment; from professional services, hotels, restaurants, schools and etc.

The description of methodology for collecting information about industrial (AMSW) waste in the country is provided by National Statistical Institute(NSI).

- ✓ Methodology for collecting information about industrial (AMSW) waste:

A source of waste data from the economy is NSI statistical surveys. Since 2004, information on non-hazardous waste from the production activity has been collected through a sample representative of economically active economic entities in the country. After weighing, the data from the sample is transferred to the national level and supplemented with data from the National Environmental Monitoring System of the Executive Environment Agency. Dangerous waste data is entirely from NEMS.The methodology has been developed in accordance with the requirements of EU Regulation No 2150 of 25.11.2002 on waste statistics. A "European Waste Catalogue" nomenclature is used, which corresponds to the "Waste List".

Table 236 Represents the trend in AMSW, disposed of to landfills.

Year	2013	2014	2015	2016	2017
Assimilated municipal solid waste dsposed in landfills (Gg)	408.98	443.41	398.80	370.20	353.06

The table below presents the summarized sources of initial activity data.

Table 237 Source of Activity data by year

Year	Parameters										
	generated waste	Source of information	waste generation rate	Source of information	land filling waste	Source of information	waste composition	Source of information	type of landfill		Source of information
									managed	unmanaged	
1950-1998	CS	NSI (proportional to the population)	CS	NSI	CS	NSI	D	IPCC 2006	not defined as such	all unmanaged	IPCC 2006
1998-2000	CS	NSI	CS	NSI	CS	NSI	D	IPCC 2006	not defined as such	all unmanaged	IPCC 2006
2000-2002	CS	NSI	CS	NSI	CS	NSI	D	IPCC 2006	CS	CS	MOEW

Year	Parameters										
	generated waste	Source of information	waste generation rate	Source of information	landfilling waste	Source of information	waste composition	Source of information	type of landfill		Source of information
									managed	unmanaged	
2002-2017	CS	NSI	CS	NSI	CS	NSI	CS	MOEW	CS	CS	MOEW

The emissions of methane on basis of the activity data are calculated for the entire period 1950-2016, and the plan for calculation depending on the time of reallocated activity data. The quantity of CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. The main reason for the choice of the period for composition of waste calculation is the fact that in 2002 is done a study at the national level for determine the morphology of the waste. This waste composition is set later in the Implementation Program for Directive 1999/31/EC. A major feature of the study is to determine the rate of accumulation of different types of waste based on distribution and population in different settlements. (Program for the implementation of Directive 1999/31/EC on the landfill of waste, p.21) Table 238 shows the morphological composition of the waste allocated according to distribution of population.

Table 238 Waste composition

Population	until 3 000	from 3 000 to 25 000	from 25 000 to 50 000	over 50 000
A	Organic waste, %			
Food	4.86	12.56	20.85	28.80
Paper	3.87	6.55	10.45	11.10
Paperboard	1.30	0.70	1.63	9.70
Plastics	5.21	8.98	9.43	12.00
Textiles	3.48	4.70	3.40	3.20
Rubber	1.15	0.45	1.10	0.60
Leather	1.36	1.35	2.10	0.70
Garden waste	14.12	14.00	5.53	6.80
Wood waste	2.14	2.28	1.58	1.30
B	Non-organic waste, %			
Glass	8.85	3.40	8.75	9.90
Metals	2.88	1.30	2.83	1.70
C	Other waste, %			
Inert waste	50.78	43.73	32.35	14.20

For country specific biodegradable organic fraction of waste calculations is implemented a model, based on human settlements and distribution of population in them, with the percentage composition of different types of waste and total waste generated for a specific year. Using this model, respectively, the composition of waste is calculated, mainly in following groups:

A – paper, paperboard;

B - garden and park waste;

C - food (kitchen) waste;

D - wood waste.

E – textile;
F – rubber and leather
S – sludge (from wastewater treatment plants)

DOC is calculated according Equation 3.7 (2006 IPCC, Vol.5: Waste p. 3.13):

$$\boldsymbol{DOC} = \sum_i (\boldsymbol{DOC_i} \bullet \boldsymbol{W_i})$$

Where:

DOC – fraction of degradable organic carbon in bulk waste, Gg C/Gg waste

DOC_i – fraction of degradable organic carbon in waste type i

W_i – fraction of waste type i by waste category

Default values for DOC in different MSW component are used in calculations (2006 IPCC, Vol.5: Waste, Table 2.4, p.2.14). For paper and paperboard – DOC content 40%; for food waste – DOC content 15%; for wood waste – DOC content 43% and for garden and park waste – DOC content 20%; for rubber and leather – DOC content 39 %; for textile – DOC content 24% and for sludge – DOC content 50%.

With the above equation is calculated the value of the decomposed organic structure of the waste for the country for 2017 as a whole:

DOC = 12.68 %

DOC was estimated by using country-specific data on waste composition and quantities based on compiled data from 2002 to 2016 for managed disposal sites. From 1950 to 2001 for unmanaged disposal sites for DOC calculations country used a default morphology (table 2.3, p.2.13, 2006 IPCC) and default DOC values for each waste component to derive DOC of bulk waste using the approach in the 2006 IPCC Guidelines. **DOC** for unmanaged disposal sites is **18.13 %.**

The default waste composition is used for 1950-2001: Paper/paperboard-**21.80%**; Food waste-**30.10%**; Wood waste-**7.50%**; Textile**-4.70%**; Rubber/leather-**1.40%.** The default value for DOC**-0.18134,** is used for 1950-2001 for all waste composition

Table 239 Components of waste composition 2002-2017

Year	Waste composition	%	Degradable waste, %	DOC
2002	paper/paperboard	12.94%	48.44%	0.1228
	garden and park waste	10.22%		
	food waste	18.05%		
	wood waste	1.76%		
	textile	3.58%		
	rubber and leather	1.90%		
2003	paper/paperboard	12.95%	48.45%	0.1229
	garden and park waste	10.22%		
	food waste	18.05%		
	wood waste	1.75%		
	textile	3.58%		
	rubber and leather	1.90%		
2004	paper/paperboard	12.96%	49.08%	0.1259
	garden and park waste	10.23%		
	food waste	18.07%		
	wood waste	1.76%		
	textile	3.58%		

Year	Waste composition	%	Degradable waste, %	DOC
	rubber and leather	1.89%		
	sludge	0.58%		
2005	paper/paperboard	13.00%	49.29%	0.1268
	garden and park waste	10.21%		
	food waste	18.11%		
	wood waste	1.75%		
	textile	3.58%		
	rubber and leather	1.89%		
	sludge	0.75%		
2006	paper/paperboard	13.04%	49.23%	0.1263
	garden and park waste	10.19%		
	food waste	18.18%		
	wood waste	1.75%		
	textile	3.58%		
	rubber and leather	1.89%		
	sludge	0.60%		
2007	paper/paperboard	13.04%	49.35%	0.1268
	garden and park waste	10.21%		
	food waste	18.17%		
	wood waste	1.75%		
	textile	3.58%		
	rubber and leather	1.88%		
	sludge	0.70%		
2008	paper/paperboard	13.05%	49.19%	0.1260
	garden and park waste	10.17%		
	food waste	18.21%		
	wood waste	1.75%		
	textile	3.58%		
	rubber and leather	1.89%		
	sludge	0.53%		
2009	paper/paperboard	13.03%	48.97%	0.1249
	garden and park waste	10.15%		
	food waste	18.23%		
	wood waste	1.75%		
	textile	3.58%		
	rubber and leather	1.90%		
	sludge	0.33%		
2010	paper/paperboard	13.08%	49.17%	0.1258
	garden and park waste	10.13%		
	food waste	18.28%		
	wood waste	1.75%		
	textile	3.58%		
	rubber and leather	1.90%		
	sludge	0.46%		
2011	paper/paperboard	13.26%	49.32%	0.1257
	garden and park waste	10.04%		
	food waste	18.55%		
	wood waste	1.74%		
	textile	3.57%		
	rubber and leather	1.88%		
	sludge	0.28%		
2012	paper/paperboard	13.30%		

Year	Waste composition	%	Degradable waste, %	DOC
	garden and park waste	10.02%	49.37%	0.1258
	food waste	18.60%		
	wood waste	1.73%		
	textile	3.57%		
	rubber and leather	1.88%		
	sludge	0.26%		
2013	paper/paperboard	13.34%	49.64%	0.1270
	garden and park waste	10.01%		
	food waste	18.64%		
	wood waste	1.73%		
	textile	3.57%		
	rubber and leather	1.88%		
	sludge	0.48%		
2014	paper/paperboard	13.30%	49.47%	0.1264
	garden and park waste	9.99%		
	food waste	18.61%		
	wood waste	1.73%		
	textile	3.56%		
	rubber and leather	1.89%		
	sludge	0.38%		
2015	paper/paperboard	13.31%	49.52%	0.1267
	garden and park waste	9.99%		
	food waste	18.60%		
	wood waste	1.73%		
	textile	3.56%		
	rubber and leather	1.89%		
	sludge	0.44%		
2016	paper/paperboard	13.35%	49.47%	0.1263
	garden and park waste	9.97%		
	food waste	18.66%		
	wood waste	1.73%		
	textile	3.56%		
	rubber and leather	1.89%		
	sludge	0.39%		
2017	paper/paperboard	13.38%	49.22%	0.1268
	garden and park waste	9.98%		
	food waste	18.69%		
	wood waste	1.73%		
	textile	3.56%		
	rubber and leather	1.88%		
	sludge	0.40%		

The Methane Correction Factor (MCF) reflects the way in which MSW is managed and the effect of management practices on CH_4 generation.

MCF accounts for the fact that unmanaged SWDS produce less CH_4 from a given amount of waste than anaerobic managed SWDS.

The methodology requires countries to provide data or estimates of the quantity of waste that is disposed of to each of categories of solid waste disposal sites. 2006 IPCC Guidelines gives a default values for MCF (2006 IPCC, Vol.5: Waste Table 3.1, p.3.14).

To determine the quantity of managed and unmanaged landfills at the national level is applied the method of expert judgment, assessment by leading experts in the field of waste from the structure of MOEW (2006 IPCC Guidelines, Vol.1 General Guidance and Reporting). As the main criteria for whether landfills are managed and unmanaged, is considered the fact if the landfills meet the requirements laid down in the EU Directive 1999/31/EC on the landfill of waste. For managed SWDS country uses MCF=1 and for unmanaged (deep) - MCF=0.8.

The CH_4 generation potential (Lo), (Gg CH_4 generated) depends upon the composition of waste, on waste disposal practices and on the physical characteristics of the SWDS. For calculation of CH_4 generation potential Equations 3.2 and 3.3 (2006 IPCC Vol.5: Waste p. 3.9) are used.

For 2017 inventory year the values are:

$$\mathbf{Lo}_{\text{managed landfills}} = 0.04226 \text{ Gg } CH_4$$

$$\mathbf{Lo}_{\text{unmanaged landfills}} = 0.03381 \text{ Gg } CH_4$$

Methane generation rate constant (k)

k=0.09 (1/yr)

The methane generation rate constant (k) in the FOD method is related to the time necessary for DOC in waste to decay to half of its initial mass (the "half life or t½) and depends on large number of factors associated with the composition of waste and conditions at the site.

For calculation of methane generation rate (k), Bulgaria used default k value=0.09 for bulk waste for estimation of CH_4 emissions from Solid waste disposal after ERT recommendation in country review in November 2016. Due to consistency, recalculations have been made for the period 2002-2015 for managed solid waste disposal sites and for unmanaged - from 1950 to 2001.

Besides the following parameters are chosen:

Fraction of DOC dissimilated (DOC_f) is an estimate of the fraction of carbon that is ultimately degraded and released from SWDS, and reflects the fact that some organic carbon does not degrade, or degrades very slowly, when deposited in SWDS. It is also good practice to use a value of 0.5 (including lignin C) as the default (2006 IPCC). For calculations of DOC_f Bulgaria uses a default value of 0.5.

Fraction of CH_4 in landfill gas (F): Landfill gas consists mainly of CH_4 and carbon dioxide (CO_2). The CH_4 fraction F is usually taken to be 0.5 by default according to the 2006 IPCC Guidelines.

Methane recovery (R): The country reports methane recovery since 2010 when the installation was brought to exploitation. Before that is zero (2006 IPCC Guidelines).

The calculation of CH_4 from landfills is based on regulatory basis of obtaining information about waste - Ordinance No 1 on the Procedures and forms for providing information about waste management activities and the procedure for keeping public records (published in State Gazette No 51 from 20.06.2014).The operators of installations are obliged to report on annual basis. In the reporting formats under the Ordinance there is information about methane, stored in reservoirs, burned in a flare and utilized methane. The amount of gas collected and utilized, measured at SWDS is reported to RIEW (Regional Inspectorate of Environment and Water). Reporting is based on the metering of gas recovered for energy utilization and flaring. These data are country specific.

For 2017 the recovered methane is 0.0976 Gg. The resulting emissions (CO_2, CH_4 and N_2O) are estimated in Energy sector and are included in Sector 1.A – Fuel combustion, Subcategory 1.A.4 – Gaseous fuels,gaseous biomass.

The quantities of recovered methane are given in Table 240.

Sofia landfill is equipped with gas collection system, system for CH_4 utilization and flaring system. The system for methane utilization is co-generation system (CHP-combined heat and power) for heat and electricity production. The system is operating since 2010. Landfill near Silistra does not collect the landfill gas. It has a flaring system (SIMENS installation).

Oxidation factor (OX). Country uses OX=0.1 for managed and OX=0 for unmanaged landfills.

Table 240 Parameters in Tier 2 for Solid waste Disposal Sites

Year	Total population	Waste generation rate	Fraction of MSW disposed	Fraction DOC in MSW	CH_4 oxidation factor	CH_4 fraction in landfill gas	CH_4 generation rate constant	Time lag	CH_4 emissions	CH_4 recovery
	1000s	kg/person/day						yr	Gg/yr	Gg/yr
1988	8986.636	1.38	0.950	0.1813	0; 0.1	0.5	0.090	38	196.897	NO
1989	8767.308	1.38	0.950	0.1813	0; 0.1	0.5	0.090	39	197.466	NO
1990	8669.269	1.38	0.950	0.1813	0; 0.1	0.5	0.090	40	197.792	NO
1991	8595.465	1.38	0.950	0.1813	0; 0.1	0.5	0.090	41	197.944	NO
1992	8484.863	1.38	0.950	0.1813	0; 0.1	0.5	0.090	42	197.865	NO
1993	8459.763	1.38	0.950	0.1813	0; 0.1	0.5	0.090	43	197.742	NO
1994	8427.418	1.38	0.950	0.1813	0; 0.1	0.5	0.090	44	197.566	NO
1995	8384.715	1.38	0.950	0.1813	0; 0.1	0.5	0.090	45	197.320	NO
1996	8340.936	1.38	0.950	0.1813	0; 0.1	0.5	0.090	46	197.008	NO
1997	8283.200	1.38	0.950	0.1813	0; 0.1	0.5	0.090	47	198.253	NO
1998	8230.371	1.38	0.950	0.1813	0; 0.1	0.5	0.090	48	196.340	NO
1999	8190.876	1.64	0.651	0.1813	0; 0.1	0.5	0.090	49	192.564	NO
2000	8149.468	1.68	0.654	0.1813	0; 0.1	0.5	0.090	50	190.136	NO
2001	7891.095	1.66	0.670	0.1813	0; 0.1	0.5	0.090	51	187.519	NO
2002	7845.841	1.65	0.676	0.1228	0; 0.1	0.5	0.090	52	180.844	NO
2003	7801.273	1.65	0.681	0.1229	0; 0.1	0.5	0.090	53	174.628	NO
2004	7761.049	1.63	0.669	0.1259	0; 0.1	0.5	0.090	54	168.902	NO
2005	7718.750	1.60	0.698	0.1268	0; 0.1	0.5	0.090	55	163.938	NO
2006	7679.290	1.57	0.627	0.1263	0; 0.1	0.5	0.090	56	158.113	NO
2007	7640.238	1.50	0.714	0.1268	0; 0.1	0.5	0.090	57	153.671	NO
2008	7606.551	1.62	0.749	0.1260	0; 0.1	0.5	0.090	58	148.961	NO
2009	7563.710	1.61	0.770	0.1249	0; 0.1	0.5	0.090	59	149.776	NO
2010	7504.868	1.48	0.748	0.1258	0; 0.1	0.5	0.090	60	144.519	0.251
2011	7327.224	1.34	0.719	0.1257	0; 0.1	0.5	0.090	61	143.979	0.246
2012	7284.552	1.22	0.797	0.1258	0; 0.1	0.5	0.090	62	139.600	0.223
2013	7245.677	1.19	0.705	0.1270	0; 0.1	0.5	0.090	63	134.507	0.223
2014	7202.198	1.21	0.694	0.1264	0; 0.1	0.5	0.090	64	129.922	0.127
2015	7153.784	1.15	0.662	0.1267	0; 0.1	0.5	0.090	65	125.349	0.096
2016	7101.859	1.11	0.642	0.1263	0; 0.1	0.5	0.090	66	120.263	0.092
2017	7050.034	1.14	0.599	0.1268	0;0.1	0.5	0.09	67	113.300	0.098

7.2.4 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

To ensure consistency over time, it is good practice (2006 IPCC Guidelines) a time series should be developed using the same methods. For entire time series we apply the same FOD methods for emission calculation.

Table 241 Activity data and emission factors Uncertainty Range

Total Municipal Solid Waste (MSWT)	30%
Fraction of MSWT sent to SWDS (MSWF)	±30%
Emission factor uncertainty	80%
Total uncertainty of Waste composition	±30%
Degradable Organic Carbon (DOC) (default)	20%
Degradable Organic Carbon (DOC) (country-specific values)	±10%

Fraction of Degradable Organic Carbon Decomposed (DOCf) (IPCC default value (0.5))		± 20%
Methane Correction Factor (MCF) (IPCC default value)	= 1.0	–10%, +0%
	= 0.8	±20%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5 (default)		±5%
Methane Recovery (R)		±110%
Oxidation Factor (OX)		-
half-life (t1/2) (default)	7	17% /-22%
Combined uncertainty		85%

7.2.5 SOURCE-SPECIFIC QA/QC AND VERIFICATION

During the preparation of the inventory submission activities related to quality control were mainly focused on completeness and consistency of emission estimates and on proper use of notation according to QA/QC (Improvement) plan.

Regarding to Tier 2 activities, emission factors and activity data were checked for key source categories. Solid waste disposal on land represent key source category in Waste sector. CH_4 emissions from solid waste disposal on land were estimated using Tier 2 method which is a good practice.

The next basic QA/QC activities were implemented and national circumstances was taken into account:

- Check activity data, emission factors and other parameters (value, record and archive);
- Check for errors in data input and references;
- Check that emissions and parameters are calculated correctly;
- Check completeness;
- Trends checks and etc.

7.2.6 SOURCE-SPECIFIC RECALCULATION

There are no source specific recalculations in this subsector.

7.2.7 SOURCE-SPECIFIC IMPROVEMENT PLAN

There is no plan improvement.

7.3 BIOLOGICAL TREATMENT OF WASTE (CRF CATEGORY 5B)

7.3.1 SOURCE CATEGORY DESCRIPTION

The category includes calculation of CH_4 and N_2O emissions in the atmosphere from biological treatment of solid waste (composting). Calculation of the emissions depends on the quality of collected data, amount and type of solid waste, treated biologically and the choice of emission factors respectively.

Composting is a waste management practice for reducing the volume of land filled organic waste and reducing CH_4 emissions respectively. This activity was not well developed in the country until 2011. With adoption of new Waste management law in 2012 composting is regulated as a practice for reducing the share of biodegradable waste sent to SWDS. In this period three composting facilities have been built.

CH_4 and N_2O emissions from composting are decreasing in 2014 due to decreasing amount of waste composted. The reason for the small amount of composted waste is the quality of incoming raw materials for compost production. After biological treatment of waste, organic fraction gets a very low quality and it has been used in landfills as a soil covering material.

7.3.1.1 Methodological issues

Methodology for calculation of CH_4 and N_2O emissions from composting.

The estimation and calculations of the emissions from biological treatment of waste are based on the methodology, proposed in the 2006 IPCC Guidelines.

For the emissions estimation from biological treatment of solid waste country uses TIER 1 with default emission factors.

Default emission factors for CH_4 and N_2O emissions from biological treatment of waste

Type of biological treatment	CH_4 Emission Factors (g CH_4/kg waste treated)		N_2O Emission Factors (g N_2O/kg waste treated)	
	on a dry weight basis	on a wet weight basis	on a dry weight basis	on a wet weight basis
Composting	10 (0.08-20)	4 (0.03-8)	0.6 (0.2-1.6)	0.24 (0.06-0.6)

7.3.1.2 Activity data

The source of activity data is National Statistical Institute.

The emissions from composting are given in the table below

Table 242 CH_4 and N_2O emissions from composting

Year	Total annual amount treated by biological treatment facilities (Gg)	CH4 emissions (kt)	N2O emissions (kt)
2011	83.686	0.335	0.0201
2012	92.000	0.368	0.0221
2013	106.492	0.426	0.0256
2014	58.628	0.235	0.0141
2015	311.000	1.244	0.0746
2016	263.000	1.052	0.0631
2017	238.000	0.952	0.0571

7.3.1.3 Emission factors

Default emission factors (on wet weight basis) are used for emission estimation of CH_4 and N_2O from composting. Country specific emission factors or plant specific emission factors are not available at the moment.

7.3.2 UNCERTAINTY AND TIME – SERIES CONSISTENCY

The uncertainty in CH_4 emissions from compost production is estimated to be about 30% concerning activity data, 30% for N_2O emission factor used and 400% for CH_4 EF used.

7.3.3 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The category is covered by the general QA/QC procedures.

7.3.4 SOURCE-SPECIFIC RECALCULATIONS

The are no recalculations for this category.

7.3.5 SOURCE-SPECIFIC IMPROVEMENT PLAN

Investigation of anaerobic digestion of organic waste in the country and subsequent calculation of CH_4 emissions from this type of biological treatment.

7.4 WASTE INCINERATION (CRF CATEGORY 5C)

7.4.1 OVERVIEW OF THE SECTOR

Emissions from waste incineration without energy recovery have to be reported in the Waste sector, while emissions from incineration with energy recovery should be reported in the Energy sector. According to the 2006 IPCC Guidelines incineration of waste produces emissions of CO_2, CH_4 and N_2O. Normally, emissions of CO_2 from waste incineration are significantly greater than CH_4 and N_2O emissions. Except this type of emissions in the atmosphere are released non-greenhouse gasses like NOx, NH_3, NMVOCs and etc. Emissions of CH_4 are not likely to be significant and these emissions are much dependent on the continuity of the incineration process, the incineration technology and management practices.

For the purpose of this inventory are calculated emissions of CO_2 from waste incineration (significantly greater than N_2O emissions) N_2O and CH_4 emissions.

Incineration of waste is not a key category in the country. For estimation of CO_2, N_2O and CH_4 emissions TIER 1 method is applied. This report includes emissions from incineration of clinical and hazardous waste that are incinerated in the country.

7.4.1.1 Emission trend

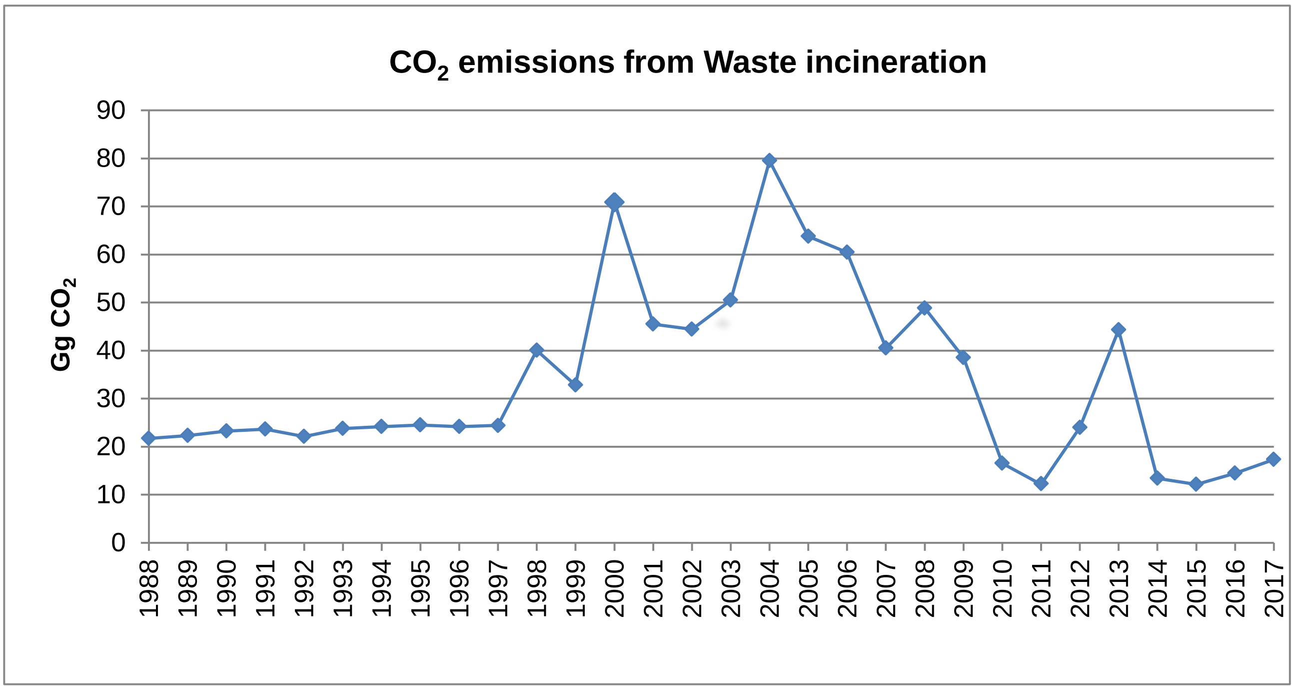

Figure 113 CO2 emissions from waste incineration

Table 243 Quantity of incinerated type of waste and CO_2, CH_4 and N_2O emissions from waste incinerations hows in systematic way the quantity of incinerated type of waste and respectively emissions of CO_2, N_2O and CH_4, according to activity data and type of waste for different years

Year	Clinical waste				Hazardous waste			
	Clinical waste Gg/yr	CO_2 emissions	CH_4 emissions	N_2O emissions	Hazardous waste Gg/yr	CO_2 emissions	CH_4 emissions	N_2O emissions
1988	0.976	2.146	5.854E-06	4.878E-05	10.70	19.62	0.0000642	0.005
1990	0.977	2.149	5.86E-06	4.884E-05	11.50	21.08	0.0000690	0.005
1995	1.070	2.354	6.419E-06	5.349E-05	12.10	22.18	0.0000726	0.005
2000	1.124	2.472	6.742E-06	5.618E-05	37.33	68.43	0.000224	0.017
2005	2.353	5.177	1.412E-05	0.0001177	31.97	58.62	0.0001918	0.014
2006	2.579	5.673	1.547E-05	0.0001289	29.88	54.78	0.0001793	0.013
2007	2.035	4.478	1.221E-05	0.0001018	19.66	36.03	0.0001179	0.009
2008	1.440	3.168	8.64E-06	7.2E-05	24.93	45.70	0.0001496	0.011
2009	1.301	2.862	7.805E-06	6.504E-05	19.48	35.70	0.0001169	0.009
2010	1.285	2.827	7.71E-06	6.425E-05	7.47	13.69	4.481E-05	0.003
2011	1.244	2.738	7.466E-06	6.222E-05	5.22	9.57	3.132E-05	0.002
2012	1.355	2.982	8.133E-06	6.777E-05	11.45	21.00	6.871E-05	0.005
2013	0.892	1.963	5.353E-06	4.461E-05	23.10	42.35	0.0001386	0.010
2014	0.744	1.638	4.466E-06	3.722E-05	6.430	11.788	3.858E-05	0.003
2015	0.751	1.651	4.504E-06	3.753E-05	5.722	10.490	3.433E-05	0.003
2016	0.715	1.573	4.290E-06	3.575E-05	7.056	12.94	4.23E-06	0.003
2017	0.788	1.734	4.728E-06	3.940E-05	8.499	15.58	5.10E-05	0.004

Reduced incineration of hazardous waste in the installation of Luk Oil Neftochim for 2010 is due to the reduced quantity of processed sludge which is connected with decrease of the quantity of wastewaters in wastewater treatment plant. For 2011 except reduced quantity of processed sludge, a repair of the three-phase centrifuge for oil middling slime processing took place for a long time. For 2012 the quantity of incinerated hazardous waste in the installation increase in comparison with preceding years (doubled quantity of the incinerated waste in comparison with 2011) and that lead to emissions increase respectively.

Reduced incineration of hazardous waste in the installation of Luk Oil Neftochim for 2014 is due to the frequent shutdowns of the furnaces for repair. In 2014 the construction of installations for purifying flue gases from kiln incinerators is completed. Furnaces have a system for continuous measurements of pollutants in flue gases.

Concerning clinical waste, before 2006 in country were working considerable number of furnaces for clinical waste incineration, located on the territory of the hospitals throughout the country. Following the adoptions of more stringent requirements of Directive 2000/76/EC transposed into Regulation No 6/28.04.2004 that has led to the closure of the operation of all this type of furnaces and emissions reduction respectively.

7.4.2 INCINERATION OF CLINICAL WASTE (CRF CATEGORY 5C)

7.4.2.1 Category description

Currently waste incineration is a practice to manage clinical waste. There are two incinerators for incineration of clinical waste at the EMEPA and Medicom, located in Sofia. Concerning activity data, we have regulatory basis for obtaining information about waste -Ordinance No 1 on the Procedures and forms for providing information about waste management activities and the procedure for keeping public records (published in State Gazette No 51 from 20.06.2014). The operators of installations are obliged to report on annual basis. In the reporting formats under the ordinance the quantities of treated waste are included. They contain information about:

- Type of incineration plant
- Capacity of installation
- Year of commissioning the installation
- Reconstruction of the installation (change, year and etc.)
- Quantity of incinerated waste
- Characteristics of incinerated waste

7.4.3 METHODOLOGICAL ISSUES

The choice of a good method for emission calculations depend on national circumstances, including whether incineration of waste is a key category and to what extent country and plant-specific information is available. Concerning waste incineration, most adequate and correct results are going to be completed if the information about type of waste and incineration technology are available. The methods for estimating CO_2, N_2O and CH_4 emissions from incineration differ because of the different factors that influence emission levels. For this reason they are described separately.

7.4.3.1 Choice of method for estimating CO_2 emissions from clinical waste incineration

TIER 1 method is used for estimation of CO_2 emissions from incineration of clinical waste, because it is not a key category. CO_2 emissions have been calculated using the methodology, proposed by the

2006 IPCC Guidelines, by multiplying the incinerated waste with default values for dry matter content in the waste, fraction of carbon in dry matter, fraction of fossil carbon and oxidation factor.

Equation 5.1 (2006 IPCC, Vol.5: Waste p.5.7) is used for estimating CO_2 emissions.

7.4.3.2 Choice of method for estimating N_2O emissions from clinical waste incineration

For N_2O emission calculations equation 5.5 is used (2006 IPCC, Vol.5: Waste p.5.14, TIER 1, non key category)

7.4.3.3 Choice of method for estimating CH_4 emissions from clinical waste incineration

For CH_4 emission calculations equation 5.4 is used (2006 IPCC, Vol.5: Waste p.5.12, TIER 1, non key category)

7.4.4 CHOICE OF EMISSION FACTORS

In the annual reports from operators of incinerators lacks sufficient information for specifying characteristics of waste as carbon content in the waste, fraction of fossil carbon, dry matter content, etc.

For estimation of CO_2 emissions from clinical waste incineration, country used 60 % total carbon content in % of dry weight; 40 % fossil carbon fraction in % of total carbon content and 100 % oxidation factor (2006 IPCC,Vol.5:Waste, p.5.18, Table 5.2)

7.4.4.1 Choice of emission factors for N_2O estimations

If site-specific emissions factors are not available, default factors can be used.

In country incineration plants are type heart or grate. There is no a default EF N_2O for such type of installation. For estimation of N_2O emissions from incineration of clinical waste we choose EF N_2O 50g N_2O/t waste for continuous and semi-continuous incinerators (2006 IPCC, Vol.5: Waste, p.5.22, Table 5.6)

7.4.4.2 Choice of emission factors for CH_4 estimations

For calculation of CH_4 emissions from clinical waste incineration, default EF is used - 6 kg/Gg incinerated waste for semi-continuous incineration (2006 IPCC, Vol.5: Waste, p.5.20, Table 5.3)

7.4.5 INCINERATION OF HAZARDOUS WASTE (CRF CATEGORY 5C)

7.4.5.1 Category description

In the installation of Luk Oil Neftochim are incinerated hazardous waste, mainly sludge and other waste contaminated with oil.

Concerning activity data, we have regulatory basis for obtaining information about waste-Ordinance No 1 on the Procedures and forms for providing information about waste management activities and the procedure for keeping public records (published in State Gazette No 51 from 20.06.2014). The operators of installations are obliged to report on annual basis. In the reporting formats under the ordinance the quantities of treated waste are included.

7.4.5.2 Choice of method for estimating CO_2 emissions from hazardous waste incineration

TIER 1 method is used for estimation of CO_2 emissions from hazardous waste incineration, because it is not a key category.

Equation 5.1 (2006 IPCC, Vol.5: Waste p.5.7) is used for estimating CO_2 emissions

7.4.5.3 Choice of method for estimating N_2O emissions from hazardous waste incineration

TIER 1 method is used for estimation of N_2O emissions from hazardous waste incineration. The calculation of N_2O emissions is based on the waste input to the incinerators and default emission factor.

For N_2O emission calculations equation 5.5 is used (2006 IPCC, Vol.5: Waste p.5.14)

7.4.5.4 Choice of method for estimating CH4 emissions from hazardous waste incineration

The calculation of CH_4 emissions is based on the amount of waste incinerated and on the related emission factor for TIER 1 - Equation 5.4 (2006 IPCC, Vol.5: Waste p.5.12).

7.4.6 CHOICE OF EMISSION FACTORS

For calculation of CO_2 emissions from incineration of hazardous waste default parameters have been used (2006 IPCC, Vol.5: Waste, p.5.18, Table 5.2)

For estimation of CO_2 emissions from hazardous waste incineration, country used 50% total carbon content in % of dry weight; 90% fossil carbon fraction in % of total carbon content and 100 % oxidation factor.

7.4.6.1 Choice of emission factors for N_2O estimations

For calculation of N_2O emissions from hazardous waste incineration we used EF N_2O of 450 g N_2O/t waste (2006 IPCC, Vol.5: Waste, p.5.21, Table 5.5)

7.4.6.2 Choice of emission factors for CH_4 estimations

For calculation of CH_4 emissions from hazardous waste incineration we used EF CH_4 of 6 kg/Gg waste incinerated on a wet weight basis for semi-continuous incineration (2006 IPCC, Vol.5: Waste, p.5.20,Table 5.3).

7.4.7 UNCERTAINTY AND TIME – SERIES CONSISTENCY

Emission factor uncertainty from waste incineration is estimated to be about 100 % - default factors are used, concerning AD uncertainty - 10 % due to higher uncertainty of clinical waste.

Emissions from waste incineration are calculated using the same method and data set consistently for every year in the time series.

7.4.8 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The category is covered by the general QA/QC procedures.

7.4.9 SOURCE-SPECIFIC RECALCULATIONS

Source specific recalculations are not planned.

7.4.10 SOURCE-SPECIFIC IMPROVEMENT PLAN

Improvements are not planned.

7.5 WASTEWATER HANDLING (CRF SECTOR 5 D)

7.5.1 OVERVIEW OF THE SECTOR

This sector includes CH_4 emissions from wastewater when treated or disposed anaerobically and indirect N_2O emissions for the period 1988-2017. CO_2 emissions from wastewater are not considered in the 2006 IPCC Guidelines.

The calculation of the emissions is separated in two sub categories:

5D1 – Domestic/commercial wastewater treatment;

5D2 – Industrial wastewater treatment

7.5.2 EMISSION TREND

Total CO_2 equivalents from wastewater handling for 2017 are 894.59 Gg CO_2 eq. In 2017 emissions decrease with 12.03% in comparison with 2016.

TIER 2 is applied in the calculation of the CH_4 emissions from Domestic and Industrial wastewater handling.

Methane emissions from wastewater treatment are shown on the figure below. We divide the emission by domestic and industrial origin.

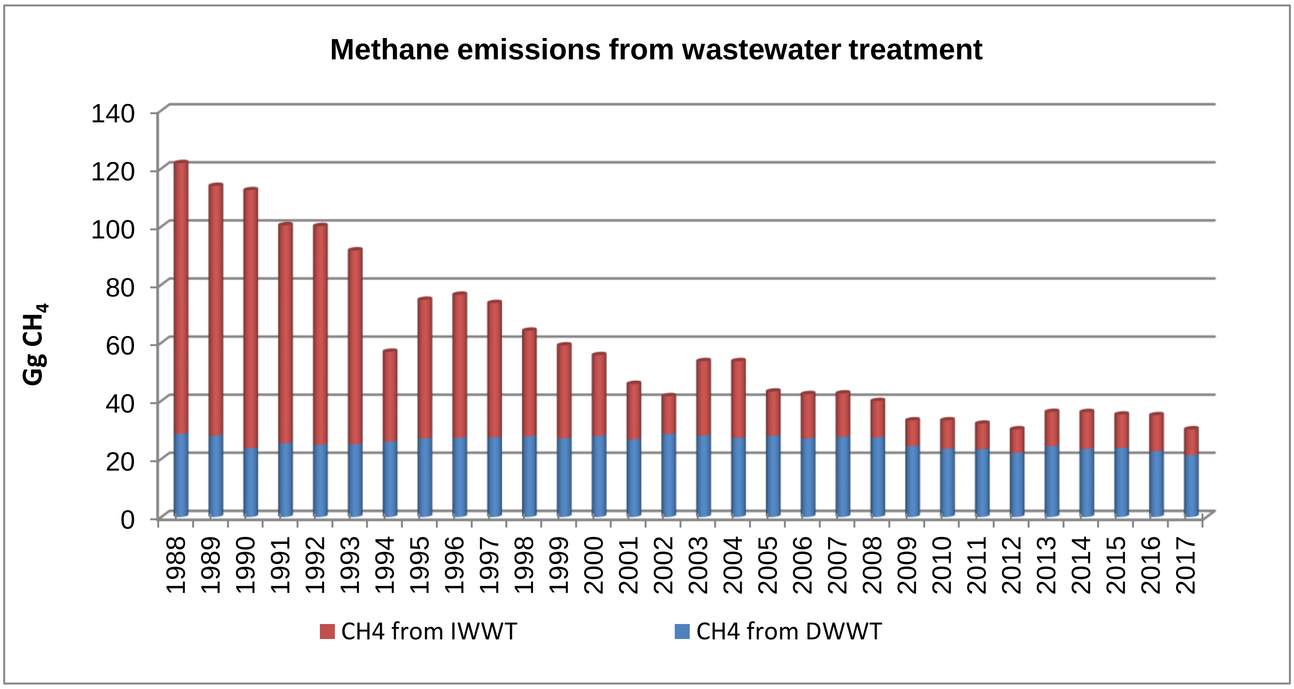

Figure 114 CH4 emissions from wastewater handling

7.5.3 DOMESTIC WASTEWATER HANDLING (CRF CATEGORY 5D1)

7.5.3.1 Category description

This category is a key category.

The source of information about treatment and discharge pathways or systems in the country, quantities of wastewater, treated in each treatment system and generated and treated domestic/industrial wastewater is National Statistical Institute.

According to NSI data, domestic wastewater has been treated in centralized aerobic treatment plants, septic systems, latrines and discharged into water bodies (sea, river, lakes). In 2017 about 63.42 % of the population is connected to centralized aerobic treatment plants, 12.61 % is connected to the public sewerage, but without treatment (sea, river, lake) and 23.91 % of the country population use septic systems and latrines (detail information at: www.nsi.bg).

In Bulgaria, 73,5% of the population is classified as urban income group and 26.5 % - as rural income group (NSI data). Degree of utilization (T) of treatment and discharge pathways for each income group are shown in Table 246.

Total methane emissions from domestic wastewater treatment for 2017 are 21.26Gg. Significant contribution to these emissions have septic systems – 4.73 Gg.

7.5.3.2 Methodological Issues

7.5.3.2.1 Methodology for calculation of the methane emissions from domestic/commercial wastewater handling (5D1)

The 2006 IPCC Guidelines describe methodology for the calculation of the methane emissions in the atmosphere during the processes of domestic wastewater treatment. The decision tree, which describes the steps and the algorithm for calculating methane emissions, is shown on Figure 6.2, page.6.10 / 2006 IPCC.

The methodology for the calculation of the methane emissions from domestic wastewater handling consists of three components: 1) definition of the total organically degradable material in domestic wastewater (TOW); 2) definition of emission factor for each domestic wastewater treatment/discharge pathway or system and 3) emission estimation.

The first step in the calculations is to define the total organically degradable material in domestic wastewater (TOW), which is the AD for this source category. TOW is expressed in the term of biochemical oxygen demand (kg BOD/year). Based on the demographic data acquired by the National Statistical Institute for the respective inventory years, we calculate TOW with the following equation:

$$TOW = P \bullet BOD \bullet 0.001 \bullet I \bullet 365$$

Where:

TOW – total organics in the wastewater in inventory year, kg BOD/yr

P – country population in inventory year

BOD – country specific per capita BOD in inventory year, g/person/day

Default value = 60 g/person/day

0.001 - conversion from grams BOD to kg BOD

I - correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, used in calculations)

Table 244 Total organically degradable material (TOW) in domestic wastewater

Year	Total organic product	Year	Total organic product	Year	Total organic product
	kg BOD/year		kg BOD/year		kg BOD/year
1988	246009161	**1998**	225306406	**2008**	208229334
1989	240005057	**1999**	224225231	**2009**	207056561
1990	237321239	**2000**	223091687	**2010**	205445762
1991	235300854	**2001**	216018726	**2011**	200582757
1992	232273125	**2002**	214779897	**2012**	199414611
1993	231586012	**2003**	213559848	**2013**	198350408
1994	230700568	**2004**	212458716	**2014**	197160170
1995	229531573	**2005**	211300781	**2015**	195834837
1996	228333123	**2006**	210220564	**2016**	194413390
1997	226752600	**2007**	209151515	**2017**	192994681

The next step of the calculation is to define the Emission factor.

The emission factor for wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (Bo) and methane correction factor (MCF) for wastewater treatment and discharge system.

The Equation for calculation of EF is:

$$\boldsymbol{EF_j = B_0 \bullet MCF_j}$$

Where:

EF_j – emission factor, kg CH_4/kg BOD

j – each treatment/discharge pathway or system

Bo – maximum CH_4 producing capacity, kg CH_4/kg BOD

MCF_j– methane correction factor (fraction)

2006 IPCC Guidelines provides the default value for domestic wastewater:

Bo = 0,60 kg CH_4 /kg BOD

The first step for the definition of MCF is to characterize the systems for wastewater treatment in the country.

Following the 2006 IPCC Guidelines, table 6.3, page.6.13, the type of wastewater treatment system and the discharge pathways are defined for the whole country. Based on the data by the National Statistical Institute, we point out four categories of methane emissions sources.

Category 1 - waters without treatment discharged in the water sources (sea, rivers and lakes).

Category 2 - waters discharged trough sewer systems into centralized aerobic wastewater treatment plant. In the general case they are amortized.

Category 3 – waters treated in septic systems.

Category 4 – waters treated in latrines

We use the *methane correction factor* as follows:

Category 1 - waters without treatment discharged in the water sources (sea, rivers and lakes) MCF = 0.1

Category 2 - waters discharged trough sewer system into centralized aerobic wastewater treatment plant – MCF = 0.3

Category 3 – waters treated in septic systems – MCF = 0.5

Category 4 – waters treated in latrines – MCF = 0.1

The same data from National Statistical Institute are used for wastewater distribution among different treatment systems. The data are country specific.

Table 245 Domestic wastewater distribution among different treatment systems

	Discharged into sea, river, lake	Centralized, aerobic not well managed treatment plant	Septic systems	Latrines
MCF	**0.1**	**0.3**	**0.5**	**0.1**
1988	43.07%	32.30%	13.35%	11.28%
1989	43.07%	32.30%	13.61%	11.02%
1990	56.14%	17.54%	14.82%	11.51%
1991	49.36%	18.95%	18.16%	13.53%
1992	51.23%	21.28%	16.04%	11.45%
1993	51.02%	22.79%	15.53%	10.65%
1994	48.08%	25.07%	16.18%	10.66%
1995	44.25%	28.99%	16.39%	10.37%
1996	43.30%	28.51%	17.54%	10.65%
1997	42.54%	29.82%	17.46%	10.18%
1998	41.54%	32.69%	16.53%	9.24%
1999	43.72%	32.19%	15.69%	8.40%
2000	40.61%	32.75%	17.61%	9.04%
2001	42.28%	33.14%	16.48%	8.10%
2002	35.52%	37.27%	18.58%	8.63%
2003	37.23%	37.10%	17.85%	7.82%
2004	40.16%	37.66%	15.70%	6.48%
2005	37.38%	40.18%	16.16%	6.28%
2006	40.27%	38.60%	15.48%	5.65%
2007	38.36%	40.52%	15.74%	5.38%
2008	38.96%	41.33%	14.93%	4.78%
2009	41.41%	40.28%	14.10%	4.21%
2010	41.20%	41.55%	13.50%	3.75%
2011	39.26%	42.55%	14.47%	3.73%
2012	38.08%	45.35%	13.38%	3.19%
2013	34.82%	43.41%	17.85%	3.92%
2014	33.50%	45.25%	17.68%	3.56%
2015	30.93%	44.16%	21.04%	3.87%
2016	30.24%	54.97%	12.68%	2.11%
2017	32.11%	56.13%	10.22	1.53%

After determination of TOW, wastewater treatment systems and discharge pathways and respective MCF, we can calculate the CH_4 emissions from domestic wastewater as follows:

$$CH_4\ Emissions = \left[\sum_{i,j}(U_i \bullet T_{i,j} \bullet EF_j)\right](TOW - S) - R$$

Where:

CH_4 emissions – CH_4 emissions in inventory year, kg CH_4/yr

TOW – total organics in wastewater in inventory year, kg BOD/yr

S – organic component removed as sludge in inventory year, kg BOD/yr

R – amount of CH4 recovered in inventory year, kg CH_4/yr

U_i – fraction of population in income group i in inventory year

$T_{i,j}$ – degree of utilization of treatment/discharge pathway or system, j, for each income group fraction i in inventory year

i – income group: rural, urban high income and urban low income

j – each treatment/discharge pathway or system

EF – emission factor, kg CH_4/yr

CH_4 emissions from domestic wastewater treatment and discharge for the period 1988-2017 are shown in figure below

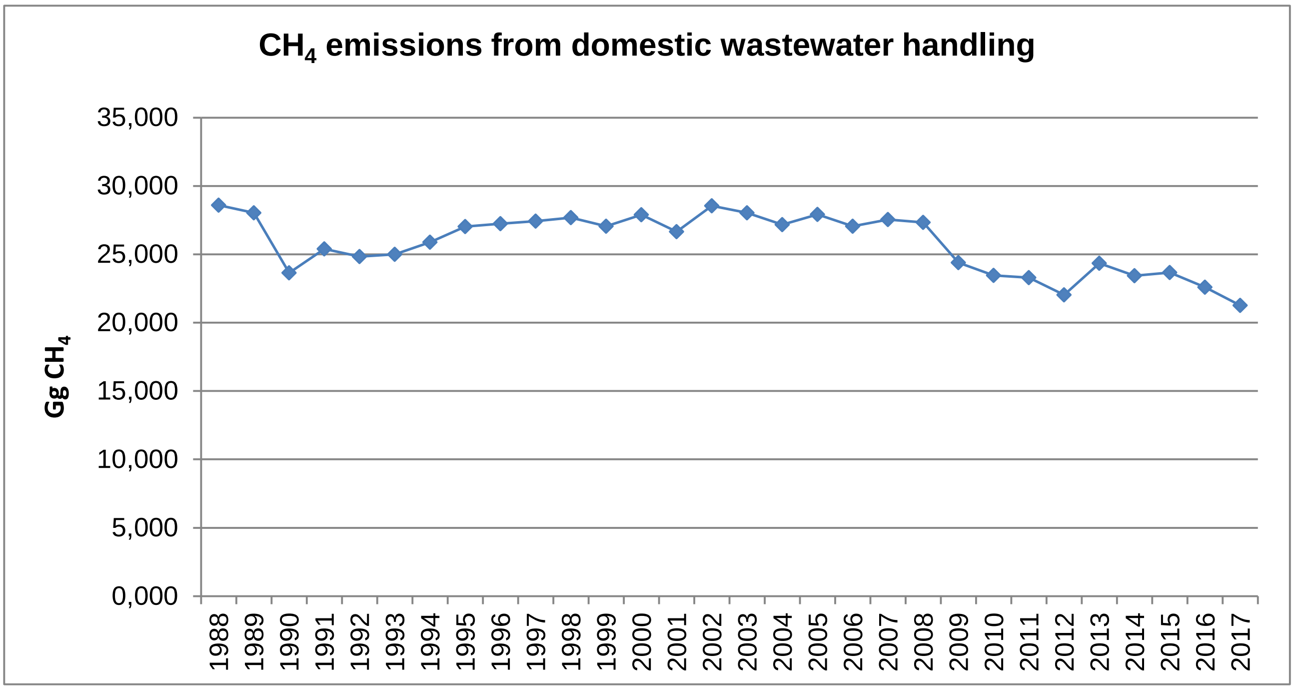

Figure 115 CH4 emissions from domestic wastewater handling

Emission increase in 2013 is due to a technical problems with methane tanks in one of the biggest wastewater treatment plant in the country.

Decreased emissions from domestic wastewater treatment in 2017 is due to decreased quantity of wastewater, treated in septic system and latrines , according to the Activity Data, provided by National Statistical Institute.

The source of information about degree of urbanization in the country is National Statistical Institute. The population is separated into two main fractions: urban and rural as the dominating is the urban population.

The degree of utilization of each treatment system is calculated for urban and rural population.

The following table summarizes the results

Table 246 Degree of utilization of treatment systems (T) for each income group (U)

Income group	Type of treatment and discharge pathways	Treatment utilization (%)
Urban population	Discharge into the sea,river, lake	24
	Centralized aerobic treatment plant	41
	Septic systems	8
Rural population	Discharge into the sea,river, lake	9
	Centralized aerobic treatment plant	15
	Septic systems	3
	Latrines	2

7.5.3.3 Choice of emission factors and parameters

For CH_4 emission estimation, default 2006 IPCC Guidelines were used.

Wastewater treatment and discharge pathways

The source of activity data about treatment and discharge pathways or systems in the country, quantities of wastewater, treated in each treatment system and generated and treated domestic/industrial wastewater is National Statistical Institute.

Degradable organic component indicator (BOD)

For domestic wastewater, biochemical oxygen demand (BOD) is the recommended parameter used to measure the degradable organic component in wastewater. The BOD concentration indicates the amount of carbon that is aerobically biodegradable. The IPCC default value of 60 g BOD/person/day or 21900 kg BOD/1000 person/yr was used for emission calculations (2006 IPCC,Vol.5: Waste, p. 6.14).

Correction factor for additional industrial BOD discharged into sewers (I)

The factor expresses the BOD from industries and establishments that is co-discharged with domestic wastewater. The IPCC default value of 1.25 was used for emission calculations (2006 IPCC, Vol.5: Waste, p. 6.14, Table 6.4). The factor I is applied only for the wastewater, treated by WWTP.

Maximum methane producing capacity (B_0)

The IPCC default of 0.6 kg CH_4/kg BOD was used for emission calculations (2006 IPCC, Vol.5: Waste, p. 6.12, Table 6.2).

Methane correction factor (MCF)

Determination of methane correction factor depends on the available systems for wastewater treatment in the country. The defaults MCF, used in calculations are as follows:

a) waters without treatment discharged in the water sources (sea, rivers and lakes) MCF = 0.1
b) waters discharged trough sewer system into centralized aerobic wastewater treatment plant – MCF = 0.3
c) waters treated in septic systems – MCF = 0.5
d) waters treated in latrines – MCF =0.1

Methane recovery (R)

The calculation of CH_4 recovery from wastewater handling is based on regulatory basis of obtaining information about waste - Ordinance No 1 on the Procedures and forms for providing information about waste management activities and the procedure for keeping public records (published in State Gazette No 51 from 20.06.2014).).The operators of installations are obliged to report on annual basis. In the reporting formats under the Ordinance there is information about the type of plant treatment system for CH_4 utilization (e.g. gas holder system, methane tanks and gas burning system); quantity of total captured CH_4, CH_4 stored in reservoirs, utilized and flared methane) and year of commissioning of the installation for CH_4 utilization. Reporting is based on the metering of gas recovered for energy utilization and flaring. These data are country specific.

For 2017 the quantity of recovered methane is 6.095 Gg. The resulting emissions (CO_2, CH_4 and N_2O) are estimated in Energy sector and are included in Sector 1.A – Fuel combustion, Subcategory 1.A.4 – Gaseous fuels,gaseous biomass.

Organic component removed as sludge (S). For sludge removal from the wastewater default IPCC value of zero was used for emission calculations (2006 IPCC, Vol.5: Waste, p.6.9).

For the last couple of years there is an improvement in the sludge management practices – as sludge is stabilized in methane tanks. Information about the quantities of treated sludge and type of treatment is obtained through Ordinance No 1 on the Procedures and forms for providing information about waste management activities and the procedure for keeping public records (published in State Gazette No 51 from 20.06.2014). For 2017 nearly 70% of the sludge in the country is treated anaerobically. All wastewater treatment plants with anaerobic sludge stabilization utilise biogas for generation of heat and/or electricity. Sludge, which will be used in agriculture, need to be treated in a proper way to ensure safety in terms of microbiological and parasitological parameters. According Ordinance on the way of recovery of sludge from wastewater treatment through its use in agriculture for 2017 the quantity of sludge, used in agriculture is 22702.36 t; 3810.86 t sludge are composted with red Californian warms; 12357.84 t are used for reclamation of disturbed areas; 6951.26 t of sludge are land filled and respective emissions are reported in sector 5 A - Solid waste disposal and 23241.89 t of sludge are temporarily stored.

7.5.3.4 Methodology for calculation of the methane emissions of industrial wastewater handling (CRF 5D2)

Industrial wastewater can be treated on site or discharged into centralized sewer. Emissions from industrial wastewater discharged into centralized sewer, are included in emissions from domestic wastewater.

The source of activity data about treatment and discharge pathways or systems in the country, quantities of wastewater, treated in each treatment system and generated and treated domestic/industrial wastewater is National Statistical Institute.

In this sub-category we calculate the methane emissions from industrial wastewater treated on site.

Based on the data acquired by the National Statistical Institute we determine the percentage on industrial wastewater treated on site.

Table 247 Industrial wastewater treated on site

Year	Total industrial wastewater	Treated on site		Non treated on site	
	thou.m^3	thou.m^3	%	thou.m^3	%
1988	1 075 286	610 746	56.80%	464 540	43.20%
1989	1 008 789	572 976	56.80%	435 812	43.20%
1990	1 127 165	610 252	54.14%	516 913	45.86%
1991	900 404	460 803	51.18%	439 601	48.82%
1992	766 131	368 586	48.11%	397 545	51.89%
1993	608 420	304 300	50.01%	304 120	49.99%
1994	526 760	291 347	55.31%	235 413	44.69%
1995	587 085	361 591	61.59%	225 494	38.41%
1996	577 742	352 879	61.08%	224 863	38.92%
1997	489 706	298 698	61.00%	191 008	39.00%
1998	418 679	250 707	59.88%	167 972	40.12%
1999	377 265	206 549	54.75%	170 716	45.25%
2000	328 497	158 273	48.18%	170 224	51.82%
2001	274 475	121 677	44.33%	152 797	55.67%
2002	225 023	136 029	60.45%	88 994	39.55%
2003	666 142	558 201	83.80%	107 941	16.20%
2004	657 812	555 546	84.45%	102 267	15.55%
2005	180 648	102 945	56.99%	77 703	43.01%
2006	227 422	121 008	53.21%	106 414	46.79%
2007	219 057	119 621	54.61%	99 436	45.39%
2008	204 462	109 484	53.55%	94 978	46.45%
2009	172 156	80 950	47.02%	91 206	52.98%
2010	171 890	84 462	49.14%	87 428	50.86%
2011	153 581	69 733	45.40%	83 848	54.60%
2012	146 536	69 526	47.45 %	77 011	52.55%
2013	154 477	74 043	47.93 %	80 433	52.07 %
2014	146 283	74 743	51.09%	71 540	48.91%
2015	110 519	66 812	60.45%	44 543	40.30%
2016	117 862	76 683	65.06%	41 178	34.94%
2017	113 822	75 257	66.12%	38 565	33.88%

2006 IPCC Guidelines describe a method for calculating methane emissions from industrial wastewater in the atmosphere, similar to methodology for calculation of the emissions from domestic/commercial wastewater.

As the first step, it is necessary to determine the total amount of organically degradable material in the wastewater (TOW). It is expressed in terms of chemical oxygen demand (kg/COD/yr). The equation for calculation of TOW for particular industrial sector is:

$$TOW_i = P_i \bullet W_i \bullet COD_i$$

Where:

TOW – total organically degradable material in wastewater for industry i, kg COD/yr

Pi – total industrial product for industrial sector i, t/yr

Wi – wastewater generated, m^3/t product

COD – degradable organic component in wastewater, kg COD/yr

i – industrial sector

Secondly, the emission factors for each industrial wastewater treatment and discharge pathways have to be estimated (2006 IPCC, Vol.5: Waste, p.6.21, eq.6.5). The emission factor is function of the maximum CH_4 producing potential (Bo) and methane correction factor (MCF).

$$\boldsymbol{EF_j = B_0 \bullet MCF_j}$$

Where:

EF_j – emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD

Bo – maximum CH_4 producing capacity, kg CH_4/kg COD

MCF – methane correction factor

j – each treatment/discharge pathway or system

To determine the methane correction factor, the type of wastewater treatment systems and discharge pathways are defined for the whole country by National Statistical Institute:

a) waters, discharged into sea, river, lake - MCF= 0.05

b) waters, discharged trough sewer system into centralized aerobic treatment plant – MCF= 0.3;

c) waters, treated in stagnant sewer – MCF= 0.5

These methane correction factors are used in estimation of CH_4 emissions from industrial wastewater treatment.

In the end, the total emission of methane from industrial wastewater is estimated. The equation for calculation of annual CH_4 emissions is as follows:

$$CH_4\ emission = \sum_i [(TOW_i - S_i)EF_i - R_i]$$

Where:

CH_4 emissions – CH_4 emissions in inventory year, kg CH_4/kg COD

TOW – total organically degradable material in wastewater in industry I in inventory year, kgCOD/yr

i – industrial sector

EF – emission factor for industry i, kg CH_4/kg COD for treatment/discharge pathway or system

Ri – amount of CH_4 recovered in inventory year.

CH_4 emissions from industrial wastewater treatment for the period 1988-2016 are shown in figure below.

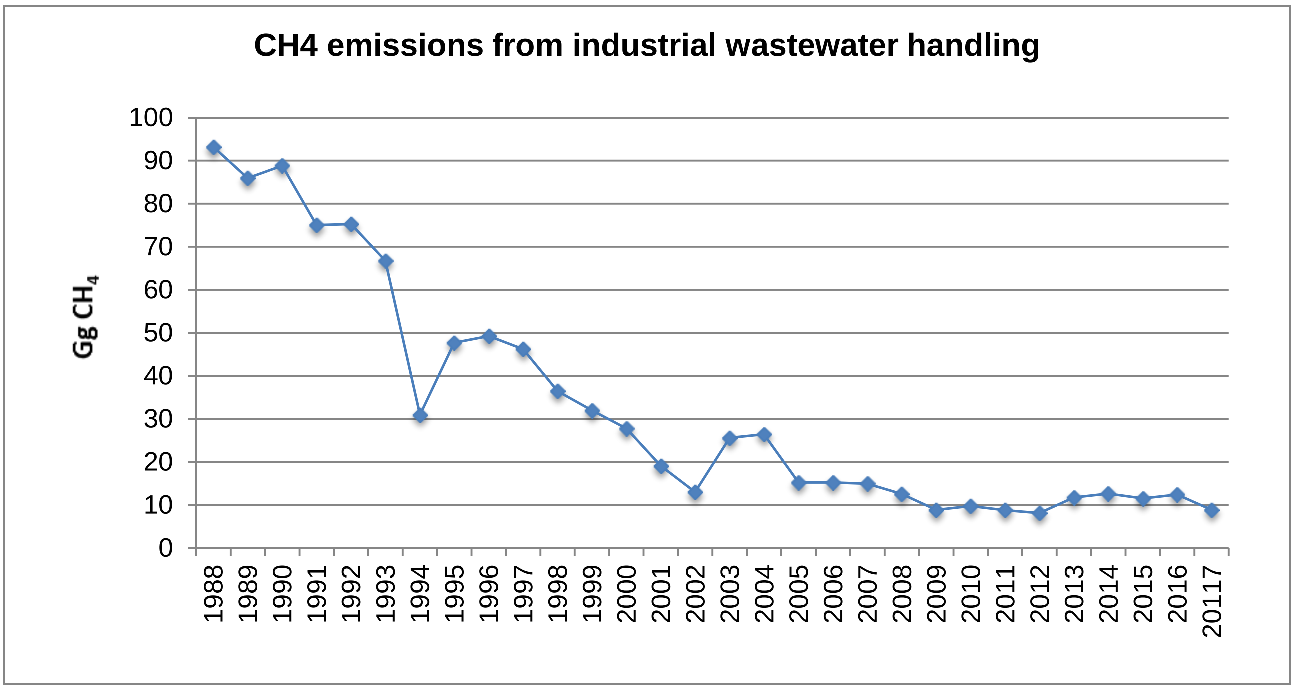

Figure 116 CH4 emissions from industrial wastewater handling

After the crisis in 1989 in the country and changes in economy in that period a decline in total generated wastewater from industry is observed (1990-1994). This trend is characteristic for paper and pulp production, production of food and beverage, organic chemicals, textile and textile products and affect the emissions in that period.

In 2002 again a decline in total generated wastewater could be observed from industry: food and beverage, paper and pulp production, organic chemicals and textile. This is connected with the next stage of the economy restructuring in the country – privatization of enterprises (part of them are sold, closed or changed their functions).

During 2003-2004 a significant growth of generated industrial wastewater is observed, formed by discharged wastewater from preceiding years (discharge of several big tailing ponds of mining companies in the country) with permission of the Ministry of Environment and waters which gives rise of the emissions from industrial wastewater treatment.

In 2017 the quantity of generated industrial wastewater is less than 2016 with 3.4%.

Table 248 The total organically degradable material in industrial wastewater (total organic product-TOW)

Year	Total organic product	Aggregate Emission Factor	Net methane emissions
	kg COD/year	kg CH_4/kg COD	Gg CH_4
1988	1770357161	0,05	93,23
1989	1660875637	0,05	85,96
1990	1768925993	0,05	88,86
1991	1335720988	0,06	75,03
1992	1068413305	0,07	75,31
1993	882068686	0,08	66,78
1994	844522069	0,04	30,99
1995	1048137030	0,05	47,73
1996	1022883720	0,05	49,25
1997	865830274	0,05	46,23
1998	675249732	0,05	36,42

Year	Total organic product	Aggregate Emission Factor	Net methane emissions
	kg COD/year	kg CH_4/kg COD	Gg CH_4
1999	560226105	0,06	32,01
2000	453700479	0,06	27,81
2001	335359951	0,06	19,14
2002	366472888	0,04	13,03
2003	1393752184	0,02	25,61
2004	1384385079	0,02	26,46
2005	366112919	0,04	15,25
2006	396185055	0,04	15,23
2007	405429790	0,04	14,97
2008	342864487	0,04	12,58
2009	214454606	0,04	8,85
2010	250936231	0,04	9,80
2011	223019186	0,04	8,82
2012	218531125	0,04	8,10
2013	246893557	0,05	11,79
2014	260715532	0,05	12,66
2015	239732348	0,05	11,57
2016	286189398	0,04	12,42
2017	241114483	0.04	8.90

The quantity of methane from industrial wastewater streams depends on the concentration of the biodegradable organic component in wastewater, the wastewater volume and type of treatment (aerobic or anaerobic).

Using these criteria, we determine the industries with the greatest potential for release of methane emissions, namely:

- Production of food and beverage
- Production of Paper and pulp
- Production of Organic chemicals
- Production of textiles and textile products

These four sectors are generating a large amount of wastewater with high content of degradable organic component.

<u>Quantity of wastewater</u>

Annual amount of the wastewater output for different industrial sectors comes from the National Statistical Institute. Data are collected through statistical questionnaires in electronic and paper format (with instruction for filling, definition and some formulas). Respondents send completed questionnaires to the Regional Statistical Offices for data validation and then to the Central NSI office. Data on the wastewater volume are calculated by combination the survey data and estimations. Statistical questionnaires require detail data on wastewater, generated and discharged by origin of water flows, by place of discharge and by technology of treatment.

Table below shows the wastewater distribution among different treatment systems (Source-NSI).

Table 249 Industrial wastewater distribution among different treatment systems

Year	Discharged into sea, river, lake	Centralized, aerobic, not well managed treatment plant	Stagnant sewer
1988	42,29%	49,53%	8,18%
1989	43,40%	48,85%	7,76%
1990	45,98%	46,08%	7,94%
1991	38,80%	50,34%	10,85%

Year	Discharged into sea, river, lake	Centralized, aerobic, not well managed treatment plant	Stagnant sewer
1992	8,62%	89,63%	1,75%
1993	6,05%	84,98%	8,97%
1994	66,33%	27,37%	6,30%
1995	49,64%	47,24%	3,13%
1996	46,00%	50,20%	3,80%
1997	36,92%	60,16%	2,92%
1998	36,37%	60,29%	3,34%
1999	31,27%	65,38%	3,35%
2000	24,07%	73,28%	2,66%
2001	31,71%	64,52%	3,77%
2002	65,22%	32,14%	2,65%
2003	90,84%	8,85%	0,30%
2004	89,93%	9,42%	0,64%
2005	54,87%	43,21%	1,92%
2006	60,82%	36,28%	2,90%
2007	62,49%	35,55%	1,96%
2008	64,55%	31,40%	4,05%
2009	57,15%	38,86%	3,98%
2010	59,94%	37,04%	3,02%
2011	58,31%	39,67%	2,02%
2012	62,28%	35,73%	1,99%
2013	44,82%	53,67%	1,51%
2014	43,98%	53,90%	2,12%
2015	44,39%	53,62%	1,99%
2016	51,41%	47,54%	1,05%
2017	62,22%	36,18%	1.59%

7.5.3.5 Choice of emission factors and parameters

For CH_4 emission estimation, default IPCC 2006 values were used.

Industrial degradable organic component indicator (COD)

The principal factor in determining the CH_4 generation potential of wastewater is the amount of degradable organic material in the wastewater. Common parameter used to measure the organic component of the industrial wastewater is Chemical Oxygen Demand (COD). The COD measures the total material available for chemical oxidation.

In the 2006 IPCC Guidelines are set default values for the degradable organic component of COD (kg/m^3) for the different types of industries (2006 IPCC, Vol.5: Waste, p. 6.22,Table. 6.9).

Based on these data and data provided by the National Statistical Institute about the quantity of wastewater, we define degradable organic components for the different types of industry.

For food and beverage industry, the used value for COD (kg/m^3) is 2.8, which is a default value. For other industries: paper and pulp COD (kg/m^3)=9.0; organic chemicals COD (kg/m^3)=3.0; textile COD (kg/m^3)=0.9

Maximum methane producing capacity (B_0)

It is good practice for the maximum CH_4 producing capacity B_0 to use country specific data from measurements made of various wastewaters. If there is no such specific data, IPCC provides for B_0 to take a default value for industrial wastewater B_0 = 0,25 kg CH_4 / kg COD, used in calculations (2006 IPCC,Vol.5: Waste, p. 6.12,Table 6.2).

Methane correction factor (MCF)

Determination of methane correction factor depends on the available systems for wastewater treatment in the country. The present calculations of CH_4 emissions from industrial wastewater treatment are based on the project, which defines wastewater treatment systems and discharge pathways in the country and respective MCF for each treatment/discharge pathway or system. The MCF, used in calculations is as follows:

a) for waters, discharged into sea, river, lake - MCF= 0.05 ;

b) for waters, discharged trough sewer system into centralized aerobic treatment plant – MCF= 0.3;

c) for waters, treated in stagnant sewer - MCF= 0.5

Organic component removed as sludge (S)

For sludge removal from the waste water default IPCC value of zero was used for emission calculations (2006 IPCC, p.5.20, pg.6.9).

Methane recovery (R)

For amount of methane recovered default IPCC value of zero was used for emission calculations (2006 IPCC, Vol.5: Waste, p.6.9).

7.5.4 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Table 250 Uncertainty of sub-sector Wastewater handling

CRF categories	Key Category	GHG	AD uncertainty	EF uncertainty	Combined uncertainty
5 D1	Domestic Wastewater Handling	CH_4	39	42	67.42
5 D1	Domestic Wastewater Handling	N_2O	20	50	53,9
5 D2	Industrial Wastewater Handling	CH_4	55	30	51.61

7.5.5 SOURCE-SPECIFIC QA/QC AND VERIFICATION

It is recommended to carry out the following basic procedures for checking the quality of data and calculations:

Review and detailed analysis of natural indicators;
Analysis of trends in emissions of greenhouse gases emitted in the treatment of wastewater
Evaluation of the emission factors;
Overview of all archived documents and data necessary for the inventory

7.5.6 SOURCE-SPECIFIC RECALCULATIONS

There are no source specific recalculations fot this sector.

7.5.7 SOURCE-SPECIFIC IMPROVEMENT PLAN

There is no plan improvement.

7.5.8 NITROUS OXIDE EMISSIONS FROM WASTEWATER

7.5.8.1 Methodological Issues

For estimation of N_2O from domestic wastewater effluent, 2006 IPCC Guidelines suggest a single methodology for calculations with no higher TIERS and decision tree provided.

7.5.8.2 Choice of method

Nitrous oxide emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea. This section addresses indirect N_2O emissions from wastewater treatment effluent that is discharged into aquatic environments. 2006 IPCC Guidelines suggests a methodology for calculation of N_2O emissions.

The calculations of the emissions follow the general equation 6.7 (p.6.25):

Equation 6.7:

$$N_2O \text{ Emissions} = N_{Effuent} \bullet EF_{Effluent} \bullet 44/28,$$

Where:

N_2O emissions - N_2O emissions in inventory year, kg N_2O/yr

$N_{Effluent}$ - nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{Effluent}$ - emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

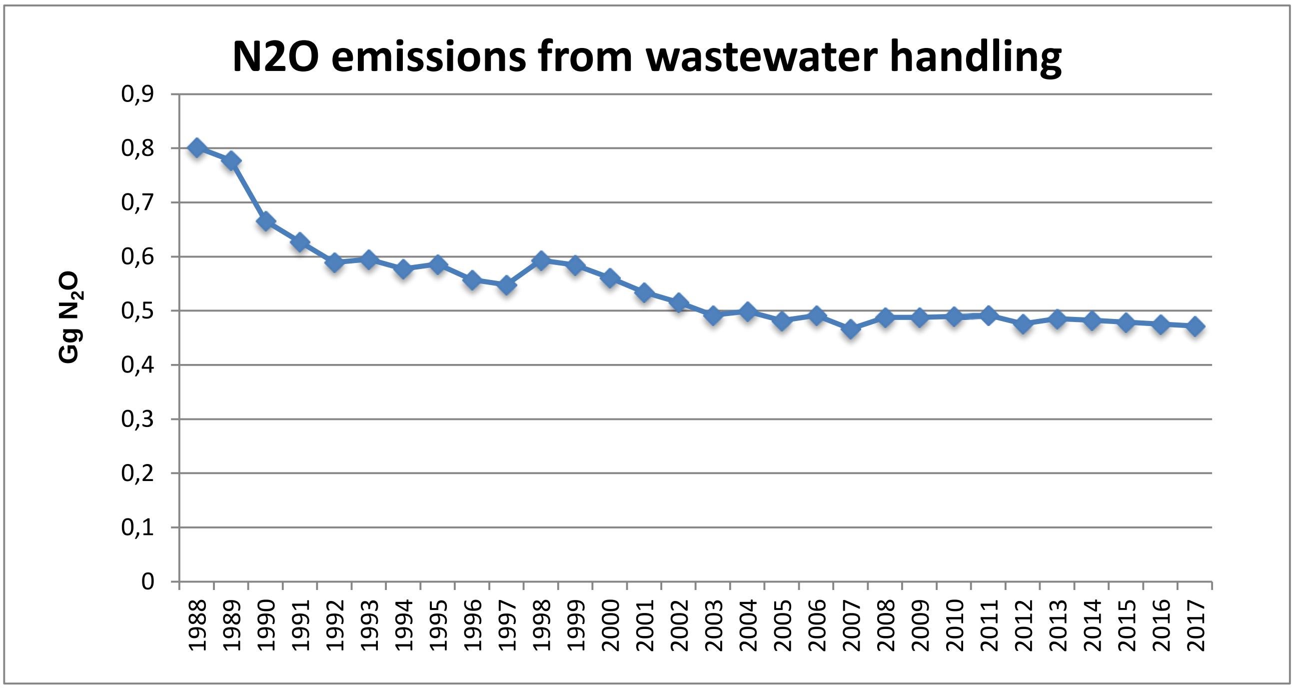

Figure 117 N2O emissions from wastewater handling

7.5.8.3 Choice of emission factors

The default IPCC emission factor for N_2O emissions from domestic wastewater nitrogen effluent is 0.005 (0.0005-0.25) kg N_2O-N/kg N.

7.5.8.4 Choice of Activity data

The activity data that are needed for estimating N_2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr). Per capita protein generation consists of intake (consumption) of protein, available at FAO statistics, multiplied by factors to account for additional "non-consumed" protein and for industrial protein discharged into the sewer system. The total nitrogen in the effluent is estimated, using equation 6.8 (p. 6.25) :

Equation 6.8:

$$N_{Effluent} = (P \bullet Protein \bullet F_{NPR} \bullet F_{NON\text{-}CON} \bullet F_{IND\text{-}COM}) - N\ sludge,$$

Where:

$N_{Efflent}$ - total annual amount of nitrogen of the wastewater effluent, kg N/yr

P- human population (country specific)

Protein - annual per capita protein consumption, kg/person/yr

F_{NPR} – fraction of nitrogen in protein, default = 0.16 kg N/kg protein

$F_{NON\text{-}CON}$ – factor for none-consumed protein added to the wastewater (1.4)

$F_{IND\text{-}COM}$ – factor for industrial and commercial co-discharged protein into the sewer system (1.25)

N_{Sludge} – nitrogen removed with sludge (default = zero), kg N/yr

Table 6.11 (IPCC 2006, p.6.27) summarizes N_2O methodology default data

7.5.9 UNCERTAINTIES AND TIME SERIES CONSISTENCY

Large uncertainties are associated with IPCC default emission factors for N_2O from effluent.

Calculations of the N_2O emissions with new emission factors are made for whole time series.

7.5.10 SOURCE-SPECIFIC RECALCULATIONS

There are no recalculations.

7.5.11 SOURCE-SPECIFIC IMPROVEMENT PLAN

Improvements are not planned.

8 OTHER (CRF SECTOR 7)

This sector from the IPCC classification is designated to submit all GHGs emission sources, which for one or another reason have not been categorized at one of the six preceding sectors.

The Bulgarian inventory has no such specific sources to be reported in this sector.

9 INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

Indirect CO_2 and nitrous oxide emissions have been reported at the relevant chapters of the report.

9.1 DESCRIPTION OF SOURCES OF INDIRECT EMISSIONS IN GHG INVENTORY

Please see the relevant chapters of the report.

9.2 METHODOLOGICAL ISSUES

Please see the relevant chapters of the report.

9.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Please see the relevant chapters of the report.

9.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION,

Please see the relevant chapters of the report.

9.5 CATEGORY-SPECIFIC RECALCULATIONS

Please see the relevant chapters of the report.

9.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Please see the relevant chapters of the report.

10 RECALCULATIONS AND IMPROVEMENTS

10.1 EXPLANATIONS AND JUSTIFICATIONS FOR RECALCULATIONS, INCLUDING IN RESPONSE TO THE REVIEW PROCESS

Recalculations of previously submitted inventory data are performed following the 2006 IPCC Guidelines, chapter 7 with the purpose to improve the GHG inventory. Specific sectoral information on recalculations made are given in Chapters 3-7 dedicated to source/sink categories.

10.1.1 GHG INVENTORY

The GHG emission recalculations for the period 1988-2016 (emission data 1988-2016) were made because of update and revision of activity data, EF and other parameters used for all sectors.

The main reason for recalculations is implementation of recommendations of the Expert Review Team as set out in the annual review report.

Table 251 Summary of GHG emission recalculations in submission 2019

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
1. Energy			
A. Fuel combustion (sectoral approach)	All subcategories	The national energy balances were updated by the NSI, correcting NCVs and reallocating consumption between categories. Additionally, following ERT recommendation were reallocated the emissions from hydrogen production and petroleum coke used in refineries under fugitive emissions.	More detailed explanations are provided in Chapter 3.3.10.2.1
2. Manufacturing industries and construction			
3. Transport	Revised EF	An updated COPERT 5.2.2 model was introduced, which corrects some errors in the applied emission factors and emission calculations.	More detailed explanations are provided in Chapter 3.3.12.3.8 (Road Transport)
4. Other sectors			
5. Other			
B. Fugitive emissions from fuels			
1. Solid fuels			
2. Oil and natural gas			
C. CO2 transport and storage			
2. Industrial processes and product use			
A. Mineral industry	Revised all (AD and EF)	Changes of glass production data for 2015 and 2016 which are due to technical errors.	For more information please see relevant chapter – Glass production 2.A.3
B. Chemical industry			
C. Metal industry	Revised all (AD and EF)	Recalculations have been performed based on submitted annual emissions report (after the deadline for 2013) by one of the ETS operator and missed report for 2016 of the same ETS operator.	For more information please see relevant chapter - Iron and steel production 2.C.1.A.
D. Non-energy products from fuels and solvent use	Revised EF	An updated COPERT 5.2.2 model was introduced, which corrects some errors in the applied emission factors and emission calculations.	For more information please see relevant chapter – 2.D.3.d Urea use
E. Electronic Industry			
F. Product uses as ODS substitutes			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
G. Other product manufacture and use	Revised all (AD and EF)	Recalculations are made on the basis of new data.	For more information please see relevant chapter – 2.G.3.b Propellant for pressure and aerosol product.
	Revised all (AD and EF)	The recalculations are made on the basis of the quantities of used creosote and water soluble wood preservatives and the respective EF from EMEP/EEA guidebook 2016.	For more information please see relevant chapter – 2.G.4.i Other product use.
H. Other			
3. Agriculture			
A. Enteric fermentation	Revised activity data .	Emissions for 2016 have been recalculated due to revised activity data for sheep population.	For more information please see Chapter Agriculture/ Enteric fermentation.
B. Manure management	Revised activity data .	Emissions for 2016 have been recalculated due to revised activity data for sheep population.	For more information please see Chapter Agriculture/ Enteric fermentation.
C. Rice cultivation			
D. Agricultural soils	Revised activity data .	Emissions for 2016 have been recalculated due to revised activity data for sheep population.	For more information please see Chapter Agriculture/ Enteric fermentation.
F. Field burning of agricultural residues			
G. Liming			
H. Urea application			
I. Other carbon-containing fertilizers			
J. Other			
4. Land use, land-use change and forestry			
A. Forest land	Revised AD and EF	Revised stratification level at which estimations of emissions and removals are calculated. This affect the callculations of CSC in living biomass of both subcategories – FlrFL and LUCs to FL. For category FlrFl changes in biomass are estimated at level of tree species and then grouped for the reporting into forest types - coniferous and deciduous. More detailed data is used, and more specific emission factors are applied accordingly. For category LUC to FL, the annual average biomass growth has been recalculated as the expansion and conversion factors have been recalculated. Moved from higher tier back to tier 1 in calculating the changes in carbon stock in DOM and Soil for subcategory FLrFL	More information about these changes is presented in Chapter 6.3.2 More information is provided in 6.3.1
B. Cropland			
C. Grassland			
D. Wetlands			
E. Settlements			
F. Other land			
G. Harvested wood products	Revised AD and EF	A complete new calculation in HWP, t0=1987	More information is provided in Chapter LULUCF, HWP
H. Other			
5. Waste			
A. Solid waste disposal			
B. Biological treatment of solid waste			
C. Incineration and open burning of waste			
D. Waste water treatment and discharge			
E. Other			
6. Other (as specified in summary 1.A)			

10.2 IMPLICATIONS FOR EMISSION LEVELS

10.2.1 GHG INVENTORY

As a result of the continuous improvement of Bulgaria's GHG inventory, emissions of some sources have been recalculated on the basis of updated data or revised methodologies, thus emission data for 1988 to 2016 which are submitted this year differ slightly from data reported previously.

Table 252 Recalculation Difference of National Total GHG Emissions.

Year	National Total GHG emissions without LULUCF		
	Submission 2018 [Gg CO_2e]	Submission 2019 [Gg CO_2e]	Recalculation Difference [%]
1988*	116753.3	116754.2	0.00
1989	114320.7	114322.4	0.00
1990	103989.2	101849.1	-2.10
1991	82330.6	83417.0	1.30
1992	77701.6	77785.6	0.11
1993	76674.4	76758.9	0.11
1994	73075.0	73099.2	0.03
1995	74567.1	74605.8	0.05
1996	74749.9	74771.3	0.03
1997	71350.5	71788.1	0.61
1998	67261.0	67934.0	0.99
1999	60495.4	60690.2	0.32
2000	59568.9	59566.6	0.00
2001	62677.4	62677.6	0.00
2002	59717.2	59718.3	0.00
2003	64191.6	64192.9	0.00
2004	63342.8	63341.7	0.00
2005	63906.7	63906.8	0.00
2006	64484.8	64485.1	0.00
2007	68358.6	68359.2	0.00
2008	66952.2	66953.7	0.00
2009	57970.7	57970.0	0.00
2010	60548.0	60549.8	0.00
2011	65849.7	65851.9	0.00
2012	60779.4	60779.2	0.00
2013	55533.7	55512.8	-0.04
2014	58581.6	58527.6	-0.09
2015	61748.0	61708.7	-0.06
2016	59114.1	59085.2	-0.05

**Base year is 1988 for all gases*

10.3 IMPLICATIONS FOR EMISSION TRENDS, INCLUDING TIME SERIES' CONSISTENCY

10.3.1 GHG I INVENTORY AS CAN BE SEEN IN TABLE 252 AND FIGURE 118 BULGARIA'S GREENHOUSE GAS EMISSIONS AS REPORTED IN THE UNFCCC SUBMISSION 2019 ARE DIFFERENT COMPARED TO THE VALUES REPORTED LAST YEAR DUE TO RECALCULATIONS.

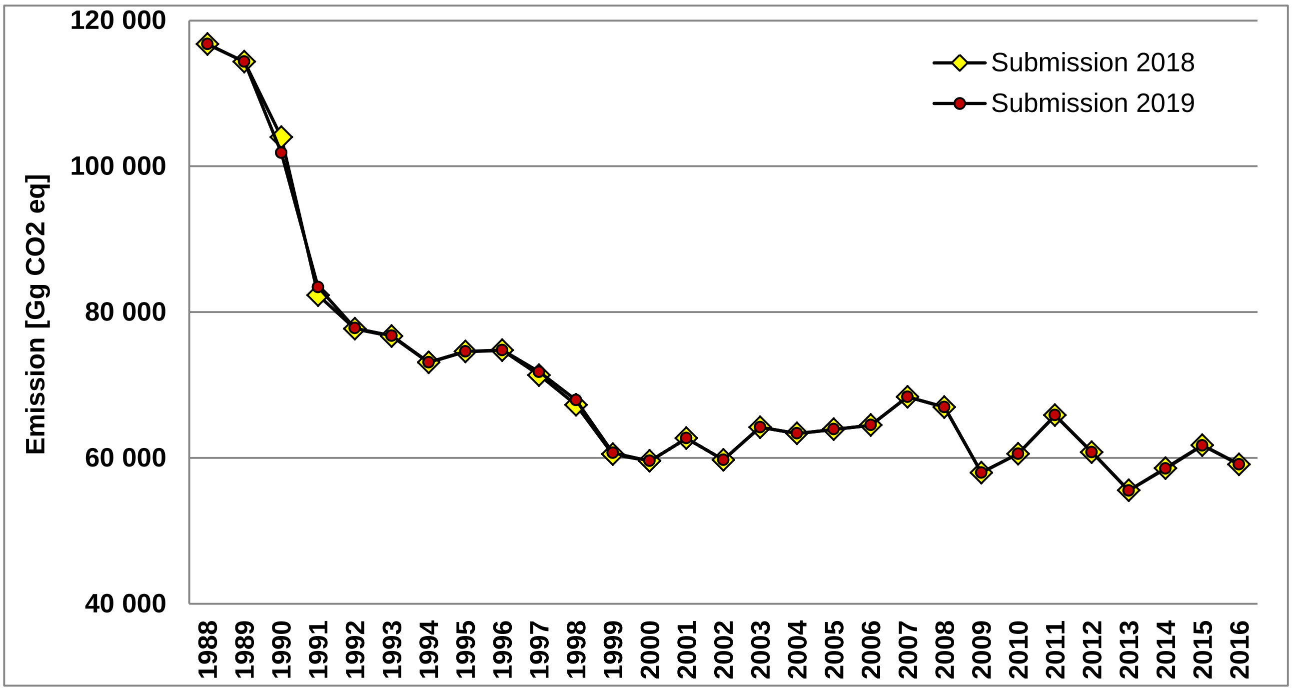

Figure 118 Emission estimates of the submission 2019 and recalculated value

10.4 PLANNED IMPROVEMENTS, INCLUDING RESPONSE TO THE REVIEW PROCESS

Many recalculations have baeen carried out in resopone to recommendations proposed in review reports.

The following general improvements are planned for the next submissions

Update and revision of activity data, emission factors and related parameters;

Conduct further studies for verification of emission factos and assumptions;

Improvement of uncertainty assessment;

Improvement of the relation with Branch Business Associations;

Executive Environment Agency (ExEA) Communication & Information Centre (Data management);

Further collaboration with external organizations;

QA/QC activities and audit;

Documentation and archiving.

All improvements will be conducted to increase TACCC.

For planned improvements please refer to respective chapters "planned improvements" for each source category.

11 KP-LULUCF

11.1 GENERAL INFORMATION

Bulgaria reports emissions/removals from afforestation, reforestation and deforestation under Article 3.3. of Kyoto Protocol and from Forest Management under Article 3.4 of Kyoto Protocol. The estimates of the emissions/removals related to art. 3.3. and 3.4. follow the guidance of the 2013 Revised Supplementary Methods and Guidance Arising from the Kyoto Protocol (2013 KP Supplement) and are consistent with the UNFCCC Decisions (15/CMP.1, 16/CMP.1, 2/CMP.6, 2/CMP.7).

11.1.1 DEFINITION OF FOREST AND ANY OTHER CRITERIA

For defining forest, Bulgaria uses the definition in the Bulgarian Forest Act (last amendment 2019):

"Area over 0.1 ha, covered with forest tree species higher than 5 meters and tree crown cover over 10% or with trees which can reach these parameters in natural environment".

Areas of natural forest regeneration outside urban areas with a size of more than 0.1 ha also represent "forest". City parks with trees, forest shelter belts, and single row trees do not fall under the category "forests.

According to their functions, forests are divided in: forests for timber production, protective and recreation forests and forests in protected areas.

All forests in Bulgaria, are managed.

Forests are also:

- areas which are in a process of recovering and are still under the parameters, but it is expected to reach forest crown cover over 10% and tree height 5 meters;
- areas, which as the result of anthropogenic factors or natural reasons are temporarily deforested, but will be reforested;
- protective forest belts, as well as tree lines with an area over 0.1 ha and width over 10 meters;
- cork oak stands."

For reaching the targets of KP the minimal figures of the defined range of parameters for tree height, tree crown cover an, minimum area have been chosen by Bulgaria:

Minimum forest area – 0.1 ha;

Tree crown cover – 10%;

Tree height – 5 meters.

In accordance with Article 7 of the Kyoto Protocol the country will report in the National Inventories the following activities, following the definitions of the forest related activities, as given in **Decision 16/CMP.1 Land use, land-use change and forestry:**

"Afforestation" as a direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources

"Reforestation" as a direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989.

"Deforestation" as a direct human-induced conversion of forested land to non-forested land

Forest Management is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner

11.1.2 ELECTED ACTIVITIES UNDER ARTICLE 3, PARAGRAPH 4, OF THE KYOTO PROTOCOL

Bulgaria has decided not to elect any of the activities under Article 3, paragraph 4, in the first commitment period. For the second commitment period the accounting of emissions/removals from Forest Management is manadatory. Bulgaria decided to account for this activity in the end of the commitment period.

11.1.3 DESCRIPTION OF HOW THE DEFINITIONS OF EACH ACTIVITY UNDER ARTICLE 3.3 AND EACH ELECTED ACTIVITY UNDER ARTICLE 3.4 HAVE BEEN IMPLEMENTED AND APPLIED CONSISTENTLY OVER TIME

Bulgaria has chosen to account for each activity under Article 3, paragraph 3 at the end of the commitment period.

The base year for reporting ARD activities is 1990. The area units reported as Afforestation/Reforestation (AR) and Deforestation (D) have the same basis as the area of land-use change to and from forest under the UNFCCC GHG inventory reporting taking into account the different time frame. All LUC from and to forests are considered to be direct human induced. Afforestation/Reforestation (AR) activities are reported together.

All forests in Bulgaria are managed, therefore all activities which are carried out in the forests are considered human-induced. Therefore, all emissions and removals of all lands which were forests in 1.1.1990 are accounted as Forest Management emissions and removals, except the emissions and removals of the ARD lands since 1.1.1990 which are accounted under the Art. 3.3 activity ARD

The Forest Inventory (FI) and the information from the Forest Management Plans (FMP) are the main sources of information for the ARD units of land (see chapter 11.2.1).

11.2 LAND-RELATED INFORMATION

11.2.1 SPATIAL ASSESSMENT UNIT USED FOR DETERMINING THE AREA OF THE UNITS OF LAND UNDER ARTICLES 3.3 AND 3.4

The Forest Inventory (NFI) and the information from the Forest Management Plans (FMP) are the main sources of information for the ARD units of land. The FI in Bulgaria covers assessments for the entire country territory in 10 years' cycles. In other words all forest stands are surveyed once in every 10 years. Forest inventory presents collection of qualitative and quantitative data about the investigated area. The management planning gives recommendations about the silvicultural operations and activities for the next 10 years period. The process of forest inventory and planning is stable and consistent over time. The measurements of the forest inventory are carried out for all sub-compartments in each and every State Forest Enterprises (SFE). The area of one sub-compartment or forest management unit is from 1-25 ha, when forested. The area of the non-forested unit is 0,1 ha. The territory of one SFE may include the territory of one or several municipalities.

11.2.2 METHODOLOGY USED TO DEVELOP THE LAND TRANSITION MATRIX

Reporting of AR units of land:

The reporting of the AR units of land since reported 2012 represents extrapolation of the results of the completed project (in 2014) for assessment of the AR units of land. The project has been launched following the the plan for improvement of the estimation of AR units of land as accepted by the ERT team as answer to the related Saturday paper issue of the 2011 review. The plan has been implemented in stages starting in Submission 2012 and completed for the Submission 2014.

Due to financial and technical (incomplete data from NFI) constraints and taking into account that Bulgaria accounts at the end of the CP, It decided that it is not necessary to carry out such an assessment for each year. It is planned to have two assessments of the AR units of lands up to the end of the CP – one partial assessment for the Submission 2020 and one just before the end of CP2. In the meanwhile Bulgaria would report preliminary estimates based on extrapolation of the data available.

For transparency issue below it is describe the steps of the AR assessment.

According to this plan the following improvement steps have been implemented in order to fulfil the reporting requirement set out in paragraph 8 (a) of the annex to decision 15/CMP.1.

Bulgaria examined the Forest Management Plans (FMPs – see below) for all State Forest Enterprises (SFE), which were inventoried for the period 1991-2012. Like this all changes since 1992 in forest area for each and every SFE has been traced and identified. For those SFE, where there is an increase in the forest area since 1990, the increase is derived into:

a. New forest areas which are included in the forest total, but which were forested before 1990, so new forests with stands of older age classes.
b. And the new forested areas with stands of the youngest age class, which are due to afforestation and reforestation activities (planting and seeding) on barren areas or afforestation and reforestation activities (planting, manual and natural seeding) on grassland or on croplands.

These improvement steps have been performed by the experts from Executive Forest Agency, by using the following sources of information:

- Forest Inventory and FMPs[40];

[40] Forest Inventory and FMPs are carried out for each State Forest Enterprise. The inventory aims measurement and processing of the following main data:

1) Forest area and its changes
2) Tree composition, origin, age, management purpose
3) Tree height and diameter,
4) Annual increment, bonitat, density of the stands
5) Tree growing stock

- Forestry Fund Reporting Form 1FF[41] (forest area) for the 1990;
- Forest maps

The results (up to 2012) from the revision of the FMPs are given in the table below. The observed increase in forest area due to AR activities for every single SFEs is given for two periods - 1992-2000 and since 2000. The amount of the "new" forest areas since 1.1.1990 which were forested before 1990 (point a) was added to the total forest area in 1991 and the years after according to Forestry Fund Reporting Form 1FF (forest area). The new forest areas between 2012 and 1992 according to point b represent the **net increase** in forest due to planting or seeding (manually or naturally) activities. Changes in forest area for the years 1990, 1991 are based on extrapolation using the same forest change as in the year 1992.

Table 253 Results from the revision of the FMPs for all SFEs for the period 2001-2012, representing the net AR activities since 1992 till 2012

State Forest Enterprises	Forest area in ha for 1991	Forest area in ha for 2012.	Planted or manually seeded in ha 1992-2000	Planted or manually seeded in 2001-2012	AR due to natural seeding in ha. 1992-2000	AR due to natural seeding in ha 2001-2012	Forest area forested before 1990
I. DISTRICT VIDIN							
1. Vidin	27 483	32 070	-	21	1 438	3 884	-
2. Belogradjik	27 730	27 826	620	6	-	2 128	906
3. Midjur	16 510	23 943	-	-	70	2 548	495
Total	**71 723**	**83 839**	**620**	**27**	**1 508**	**8 560**	**1 401**
II. DISTRICT MONTANA							
1. Montana	28 136	14 950	-	27	242	20	184
2. Chiprovtsi	-	16 506	1	2	19	316	818
3. Berkovitsa	24 346	26 344	59	-	196	1 392	20
4. Lom	4 868	6 237	-	50	110	573	608
5. Govejda	15 862	16 456	-	2 264	-	-	22
6. Burziya	6 919	6 644	-	-	-	-	83
Total	**80 131**	**87 137**	**60**	**2 343**	**567**	**2 301**	**1 735**
III. DISTRICT OF VRATSA							
1. Vratsa	20 591	24 588	-	-	288	627	1 068
2. Mezdra	26 816	30 140	757	670	2 109	1 260	300
3. Oryahovi	4 628	4 433	-	-	-	47	-
Total	**52 035**	**59 161**	**757**	**670**	**2 397**	**1 934**	**1 368**
IV. DISTRICT OF PLEVEN							
1. Pleven	23 002	31 441	973	-	4 767	3 001	1 320
2. Nikopol	9 645	13 559	-	40	-	198	2 054
Total	**32 647**	**45 000**	**973**	**40**	**4 767**	**3 199**	**3 374**
V. DISTRICT OF LOVECH							
1. Lovech	21 902	26 393	35	3 658	-	4 061	408
2. Teteven	19 589	19 728	119	54	11	589	992

6) Data about main rock, soil type and soil bonitat and other important habitat characteristics.

The measurements of the Forest Inventory are carried out for each and every SFE once in every 10 years.

[41] The reporting forms 1FF to 7 FF represent the forest fund reporting forms. The data gathered during the forest inventories is used as data base for preparation of the reporting forms of the forest fund

State Forest Enterprises	Forest area in ha for 1991	Forest area in ha for 2012.	Planted or manually seeded in ha 1992-2000	Planted or manually seeded in 2001-2012	AR due to natural seeding in ha. 1992-2000	AR due to natural seeding in ha 2001-2012	Forest area forested before 1990
3. Ribaritsa	15 491	20 096	-	18	-	76	2
4. Cherni Vit	9 113	13 735	-	4	314	352	863
5. Troyan	31 280	25 262	35	8	-	1 407	368
6. Rusalka, Apriltsi	11 501	12 863	-	-	334	356	84
7. Cherni Osam	12 900	13 437	-	2	1	312	68
8. Borima	-	7 779	-	3	-	-	-
9. Lesidren	19 729	32 583	159	118	-	1 186	-
10. Lukovit	14 374	-	-	-	-	-	-
Total	**155 879**	**171 876**	**348**	**3 865**	**660**	**8 339**	**2 785**
VI. DISTRICT OF GABROVO							
1. Gabrovo	25 447	28 568	35	11	-	3 228	10
2. Sevlievo	20 059	22 538	-	-	1 525	297	11
3. Rositsa	14 341	14 757	-	7	-	350	90
4.Plachkovtsi	20 969	27 291	-	-	1 327	5 370	77
Total	**80 816**	**93 154**	**35**	**18**	**2 852**	**9 245**	**188**
VII. DISTRICT OF VELIKO TARNOVO							
1. Bolyarka, V.Tarnovo	36 091	42 925	504	841	-	9 440	-
2. Svishtov	3 646	4 874	-	746	13	-	404
3. Gorna Oryahovitsa	17 123	20 587	211	12	4	738	94
4. Elena	30 461	33 418	-	7	-	2 736	284
5. Buinovtsi	14 366	16 507	-	33	-	123	434
Total	**101 687**	**118 311**	**715**	**1 639**	17	**13 037**	**1 216**
VIII. DISTRICT OF ROUSSE							
1. Dunav, Rousse	16 257	20 774	-	192	-	1 784	2 019
2. Byala	15 874	20 176	-	3 381	-	859	584
Total	**32 131**	**40 950**	**-**	**3 573**	**-**	**2 643**	**2 603**
IX. DISTRICT OF TARGOVISHTE							
1.Tyrgovishte	15 437	17 272	-	-	16	127	1 005
2. Omurtag	26 170	30 857	3	320	-	1 117	1 998
3. Cherni Lom, Popovo	24 753	28 561	900	484	1 848	654	1 858
Total	**66 360**	**76 690**	**903**	**804**	**1 864**	**1 898**	**4 861**
X. DISTRICT OF SHUMEN							
1. Shumen	16 299	17 395	479	1	760	156	866
2. Preslav	17 391	16 696	184	-	-	737	384
3. Varbitsa	15 489	18 856	221	-	-	515	212
4. Smyadovo	17 467	19 217	-	-	91	537	404
5. Palamara, Venets	30 773	34 025	588	40	-	1 779	816
Total	**97 419**	**106 189**	**1 472**	**41**	**851**	**3 724**	**2 682**
XI. DISTRICT OF RAZGRAD							
1. Razgrad	20 767	22 244	775	1 235	-	446	252
2. Seslav	28 411	30 484	-	-	-	219	623

State Forest Enterprises	Forest area in ha for 1991	Forest area in ha for 2012.	Planted or manually seeded in ha 1992-2000	Planted or manually seeded in 2001-2012	AR due to natural seeding in ha. 1992-2000	AR due to natural seeding in ha 2001-2012	Forest area forested before 1990
3. Iri-Hisar	13 553	13 553	-	-	-	-	-
Total	**62 731**	**66 281**	**775**	**1 235**	**-**	**665**	**875**
XII. DISTRICT OF SILISTRA							
1. Silistra	25 550	24 433	-	665	-	914	4 066
2. Karakuz	17 221	25 395	311	59	-	615	452
3. Tutrakan	8 785	10 584	30	922	158	85	579
Total	**51 556**	**60 412**	**341**	**1 646**	**158**	**1 614**	**5 097**
XIII. DISTRICT OF DOBRICH							
1. Dobrich	24 691	16 981	1 199	286	123	246	2 466
2. Balchik	12 239	15 655	778	176	-	224	1 045
3. Tervel	11 096	14 264	586	51	-	519	2 321
4. General Toshevo	-	14 120	2 268	108	26	143	429
Total	**48 026**	**61 020**	**4 831**	**621**	**149**	**1 132**	**6 261**
XIV. DISTRICT OF VARNA							
1. Varna	30 611	31 075	-	-	456	-	768
2. Suvorovo	11 626	12 104	30	25	-	179	294
3. Provadiya	20 067	12 406	394	13	-	270	173
4. Tsonevo	12 168	22 653	644	650	417	70	120
5. Sherba	12 391	14 160	-	30	-	461	864
6. Staro Oryahovo	23 501	23 822	-	-	-	-	-
Total	**110 364**	**116 220**	**1 066**	**718**	**873**	**980**	**2 219**
XV. DISTRICT OF BOURGAS							
1. Bourgas	21 967	18 084	428	278	162	406	1 427
2. Nesebar	30 131	35 362	25	104	189	503	2 168
3. Aytos	40 749	42 187	252	128	251	932	1 242
4. Karnobat	6 965	26 047	70	-	-	144	795
5. Sungurlare	36 297	20 413	136	50	775	80	
6. Sredets	34 613	39 885	17	39	294	1 890	3 389
7. Ropotamo	9 696	15 419	88	12	88	77	522
8. Novo Panicharevo	19 542	20 593	133	8	-	226	39
9. Tsarevo	27 844	28 228	-	1	-	609	-
10. Gramatikovo	19 445	20 654	-	-	34	128	1 234
11. Kosti	12 650	12 994	57	-	79	248	-
12. Malko Tarnovo	30 845	20 776	3	2	162	134	3 985
13. Zvezdets	-	19 752	-	18	-	1 394	3 834
Total	**290 744**	**320 394**	**1 208**	**640**	**2 034**	**6 996**	**18 772**
XVI. DISTRICT OF YAMBOL							
1. Tundja, Yambol	19 384	20 376	-	33	18	110	907
2. Elhovo	26 857	31 289	194	703	214	721	2 524
Total	**46 241**	**51 665**	**194**	**736**	**232**	**831**	**3 431**
XVII. DISTRICT OF SLIVEN							
1. Sliven	43 370	44 827	513	38	-	300	294

State Forest Enterprises	Forest area in ha for 1991	Forest area in ha for 2012.	Planted or manually seeded in ha 1992-2000	Planted or manually seeded in 2001-2012	AR due to natural seeding in ha. 1992-2000	AR due to natural seeding in ha 2001-2012	Forest area forested before 1990
2. Kotel	37 776	40 771	40	2	-	565	1 079
3. Tvarditsa	27 279	27 140	-	3	-	236	60
4. Nova Zagora	9 921	10 352	83	-	-	99	436
5. Ticha	12 505	12 983	-	12	568	73	638
6. Stara reka	7 536	8 155	-	21	-	67	713
Total	**138 387**	**144 228**	**636**	**76**	**568**	**1 341**	**3 220**
XVIII. DISTRICT OF STARA ZAGORA							
1. Stara Zagora	34 935	36 986	1 008	75	120	143	89
2. Chirpan	21 877	24 646	46	20	572	375	1 174
3. Mazalat	27 878	35 082	171	99	-	147	1 207
4. Gurkovo	21 668	22 493	-	-	-	356	-
5. Maglij	25 675	24 317	19	122	54	539	131
6. Kazanlak	28 956	24 410	14	37	-	-	427
Total	**160 989**	**167 934**	**1 258**	**353**	**746**	**1 560**	**3 028**
XIX. DISTRICT OF HASKOVO							
1. Haskovo	77 076	81 839	-	1 896	567	1 644	121
2.Topolovgrad	20 955	21 574	146	172	240	369	275
3. Svilengrad	25 647	28 067	607	276	354	1 807	178
4. Ivaylovgrad	44 385	48 956	104	65	244	1 685	1 623
Total	**168 063**	**180 436**	**857**	**2 409**	**1 405**	**5 505**	**2 197**
XX. DISTRICT OF KARDJALI							
1. Kardjali	35 637	22 310	4	5	-	-	29
2. Jenda	3 517	16 964	-	7	-	3	36
3.Momichilgrad	54 424	24 698	21	8	-	-	16
4. Kirkovo	-	29 155	-	2	-	-	-
5. Krumovgrad	42 794	43 205	18	2	-	24	34
6. Ardino	18 339	18 623	9	1	9	16	-
Total	**154 711**	**154 955**	**52**	**25**	**9**	**43**	**115**
XXI. DISTRICT OF SMOLYAN							
1. Smolyan	22 570	29 438	27	46	148	2 143	493
2. Zlatograd	33 180	32 409	-	-	80	27	-
3. Smilyan	30 858	32 028	-	-	11	1 028	-
4. Slaveyno	27 126	29 005	-	-	39	459	-
5. Pamporovo	8 796	-	-	-	-	-	-
6. Chepelare	11 075	-	-	-	-	-	-
7. Hvoyna	11 588	27 280	37	273	895	125	63
8. Shiroka Laka	8 206	9 124	-	-	1	569	347
9. Mihalkovo	13 802	15 430	-	7	356	633	981
10. Izvora	2 255	17 699	12	3	43	569	826
11. Devin	12 879	-	-	-	-	-	-
12. Trigrad	7 731	10 044	256	36	628	595	784
13. Borino	10 476	12 597	-	4	837	160	1 031
14. Dospat	19 421	20 577	5	35	138	461	457
Total	**219 963**	**235 631**	**337**	**404**	**3 176**	**6 769**	**4 982**
XXII. DISTRICT OF PLOVDIV							
1. Plovdiv	25 618	23 715	543	144	-	945	5 255

State Forest Enterprises	Forest area in ha for 1991	Forest area in ha for 2012.	Planted or manually seeded in ha 1992-2000	Planted or manually seeded in 2001-2012	AR due to natural seeding in ha. 1992-2000	AR due to natural seeding in ha 2001-2012	Forest area forested before 1990
2. Hisar	23 815	26 157	1 078	50	283	456	651
3. Klisura	7 216	20 731	52	61	-	-	516
4. Rozino	12 472		-	-	-	-	-
5. Karlovo	28 649	30 590	49	55	148	1 130	668
6. Chekeritsa	12 849	31 691	28	26	609	455	901
7. Parvomai	9 796	9 706	112	23	-	177	-
8. Asenovgrad	24 633	28 076	86	285	125	1 670	988
9. Kormisosh, Laki	19 347	21 365	200	34	1 099	612	144
10. Krichim	7 978	-	-	-	-	-	-
Total	**172 373**	**192 031**	**2 148**	**678**	**2 264**	**5 445**	**9 123**
XXIII. DISTRICT OF PAZARDJIK							
1. Pazardjik	24 922	26 158	-	27	-	149	483
2.Panagurishte	38 617	39 095	371	50	-	-	207
3. Belovo	22 307	23 375	44	52	357	199	663
4. Yundola	4 977	4 933	-	1	-	-	-
5. Alabak	26 606	26 001	107	121	-	238	457
6. Chepino	2 573	19 504	-	-	18	136	135
7. Chehlyovo	15 078	-	-	-	-	-	-
8. Selishte	15 677	16 126	80	14	-	122	211
9. Shiroka Polyana	15 539	10 942	-	-	-	86	148
10. Rodopi	2 651	19 966	-	1	-	121	181
11. Beglika	12 601	-	-	-	-	-	-
12. Borovo	14 747	15 348	-	-	-	104	478
13. Batak	9 627	10 026	-	-	-	99	238
14. Rakitovo	18 771	19 614	92	109	70	15	379
15. Peshtera	18 873	19 676	476	118	21	17	203
Total	**243 566**	**250 764**	**1 170**	**493**	**466**	**1 286**	**3 783**
XXIV. DISTRICT OF BLAGOEVGRAD							
1. Blagoevgrad	24 418	29 001	16	131	345	2 490	2 559
2. Simitli	31 387	34 172	422	235	301	1 080	388
3. Kresna	21 625	23 062	-	-	92	235	431
4. Strumyani	18 780	21 015	-	3	-	148	970
5. Parvomay	18 629	17 970	252	43	-	442	-
6. Petrich	10 899	11 451	-	-	-	260	79
7. Sandanski	22 412	22 543	242	-	57	290	107
8. Katuntsi	26 629	28 193	-	-	62	48	910
9. Gotse Delchev	28 955	29 327	46	42	129	176	-
10. Dikchan, Satovcha	18 115	18 640	60	91	-	-	-
11. Garmen	24 907	27 039	40	8	-	62	-
12. Mesta	16 925	11 567	49	82	1	6	-
13. Dobrinishte	12 116	18 984	29	80	359	639	429
14. Eleshnitsa	16 607	16 814	179	132	-	546	1 065
15. Yakoruda	20 161	21 635	1 162	688	-	-	-
16. Belitsa	10 591	11 265	100	269	-	218	907
17. Razlog	18 269	19 596	112	54	461	-	-
Total	**341 425**	**362 284**	**2 709**	**1 858**	**1 807**	**6 640**	**7 845**

State Forest Enterprises	Forest area in ha for 1991	Forest area in ha for 2012.	Planted or manually seeded in ha 1992-2000	Planted or manually seeded in 2001-2012	AR due to natural seeding in ha. 1992-2000	AR due to natural seeding in ha 2001-2012	Forest area forested before 1990
XXVI. DISTRICT OF KUSTENDIL							
1. Osogovo	46 737	58 598	-	-	868	5 990	3 175
2. Nevestino	21 703	23 166	407	525	510	497	516
3. Dupnitsa	46 798	48 973	-	-	-	450	2 561
Total	**115 238**	**130 737**	**407**	**525**	**1 378**	**6 937**	**6 252**
XXVII. DISTRICT OF PERNIK							
1. Radomir	25 248	20 589	3 834	216	-	124	135
2. Zemen	15 506	18 484	28	53	740	764	1 743
3. Breznik	8 939	10 415	153	110	-	980	176
4. Tran	30 547	33 947	956	2	797	713	421
5. Vitoshko-Studena	-	8 878	-	-	-	-	128
Total	**80 240**	**92 313**	**4 971**	**381**	**1 537**	**2 581**	**2 603**
XXVIII. DISTRICT OF SOFIA							
1. Sofia	45 229	55 423	-	2 383	-	3 223	3 175
2. Svoge	46 447	45 198	-	405	240	266	221
3. Vitinya	9 179	17 295	-	-	-	-	-
4. Botevgrad	40 797	33 957	-	111	-	1 425	307
5. Godech	10 182	11 107	-	5	14	243	626
6. Etropole	20 994	22 779	144	11	-	1 335	264
7. Pirdop	43 526	45 228	-	46	-	824	883
8. Elin Pelin	25 157	22 129	25	74	150	629	22
9. Aramliets		7 534	-	27	-	3	-
10. Ihtiman	26 682	25 622	-	56	214	625	1 275
11. Kostenets	19 409	21 228	14	208	316	409	265
12. Samokov	65 481	68 994	-	-	192	2 607	14
13. Iskar	3 297	3 470	-	-	-	-	128
Total	**356 380**	**379 964**	**183**	**3 326**	**1 126**	**11 589**	**7 360**
Total for the Country	3 531 825	3 849 576	29 026	29 144	33 411	116 794	109 376

Therefore, the net increase in forest areas plus the annual deforestation areas must represent the annual AR areas:

$$AR_x = FL_x - FL_{x-1} + D_{SMx}$$

Where,

AR – AR area

X - year

FL – forest area

D_{SM} – D area for settlements

The assessment of the former land use of the identified AR units of land was made by using an expert judgment. Land use (cropland, grassland, other land) typically follows ecological site condition. The forestry experts know the dominating land uses in the SFE region or at the region of identified AR lands, so they made an expert judgment of former land use on basis of likelihoods. For example, there are regions where grassland (GL) dominates, because growth/site conditions are not good enough for cropland (CL) plants or CL management or, site conditions are so good that CL dominates. Similarly, other land (OL) can be found in extreme site conditions where CL, GL cannot grow.

Reprting of D units of land:

All changes of designation of forests are registered in Executive Forest Agency for every single year since 2001. The registry contains administrative information in relation with the orders issued for excluding of forests. For the years before 2001 data on forest loss is available for the period 1990-1994. The information is provided by the experts from ExFA and is gathered from specific books, where all changes of designation of forest for these years were written up. There is no activity data on forest loss for the years 1995-2000, so the forest loss for these years is estimated as an average from the forest loss for the period 1990-1994. Since Bulgaria uses the national boundary as a geographical boundary for reporting of activities under Article 3.3 of KP the total amount of changes in designation of forests and lands from forest fund was used as data source for D reporting. All changes of designation of forests are associated with conversion from forest land to settlement (SM) and are reported as such. In its previous submission Bulgaria reported forest loss also for WL due to probability reasons. It was assumed that the observed increase in WL suggested also a deforestation for WL. The assumed D for WL was estimated as a share of forest land in the totals of forest land, cropland plus grassland (it was supposed that the wetlands increase comes from such lands). Actually the reported D area to WL in the previous submissions of Bulgaria represented an overestimation of D activity since all the information for forest loss due to changes in designation of forest was reported under D to SM. Since the improvements in area representation made for the Submission 2014 LUCs from FL to WL were not calculated. According to experts from the ExFA, the changes of designation of forest in the years 1990-2012 are associated with conversion only to SM. There is only one new dam lake (Tsankov kamak) which was built up in recent years but the forest loss associated with its construction works has been already reported in the 70's. Therefore, Bulgaria reports all information provided by the ExFa for forest loss across the time series (3.76 kha) as D activity associated with conversion to SM.

Reporting of FM area

All forests are managed, so to get FM area we used data for total forest area in 1990 and then for the years after we substracted the cumulative areas of ARD.

11.2.3 MAPS AND/OR DATABASE TO IDENTIFY THE GEOGRAPHICAL LOCATIONS, AND THE SYSTEM OF IDENTIFICATION CODES FOR THE GEOGRAPHICAL LOCATIONS

The database used to identify the geographical locations of the ARD activities is the NFI in Bulgaria. All measurements gathered in accordance with the forest inventory and FMP are mapped. Forest Inventory and FMP are carried out for each State Forest Enterprise. The SFE is divided into compartments and sub-compartments. The forest maps in Bulgaria are carried out for each State Forest Enterprise (SFE) as a result of the Forest Inventory (therefore, the maps are updated every 10th years for each SFE). The country territory is divided into almost 180 State Forest Enterprises. The territory of one SFE may include the territory of one or several municipalities. The area of one sub-compartment or forest management unit is between 1-25 ha, when forested. The area of the non-forested unit is 0,1 ha. The sub-compartments are defined based on uniformity of stands by species, age class structure, etc. The forest maps have unified consecutive numbering in the adopted geodesic coordinating system (BG, 2000), and contain information on areas or parts of them with permanent use as forests according to the Forest act. Forest maps are maintained separately by Forestry enterprises according to their FMP.

The forest maps give detailed data on:

- state boundary and all administrative boundaries in the scope of the particular map
- the boundaries of the urbanized areas
- the boundaries of the transportation areas
- the boundaries of the agricultural lands
- the boundaries of the State forestry enterprises and State game management areas and their subdivisions (forestry compartments and subcompartments)
- main and secondary watersheds
- roads, track and underground line facilities, within the boundaries of the forestry departments

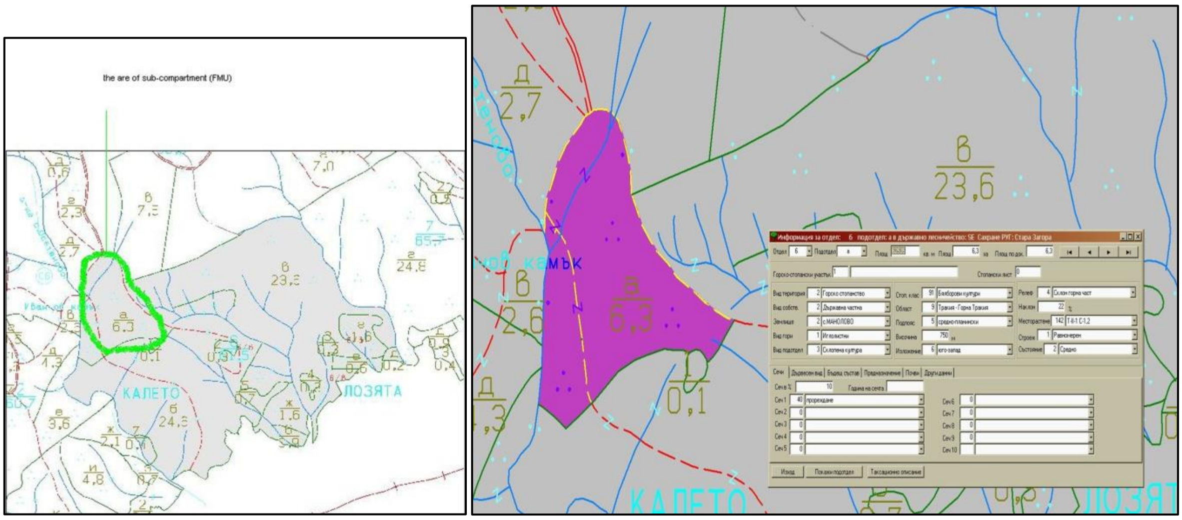

Figure 119 A map of one SFE (on left side), showing a forest land compartment (in grey colour and) and a sub-compartment (green line). On the right side - the area of sub-compartment and its details in the table.

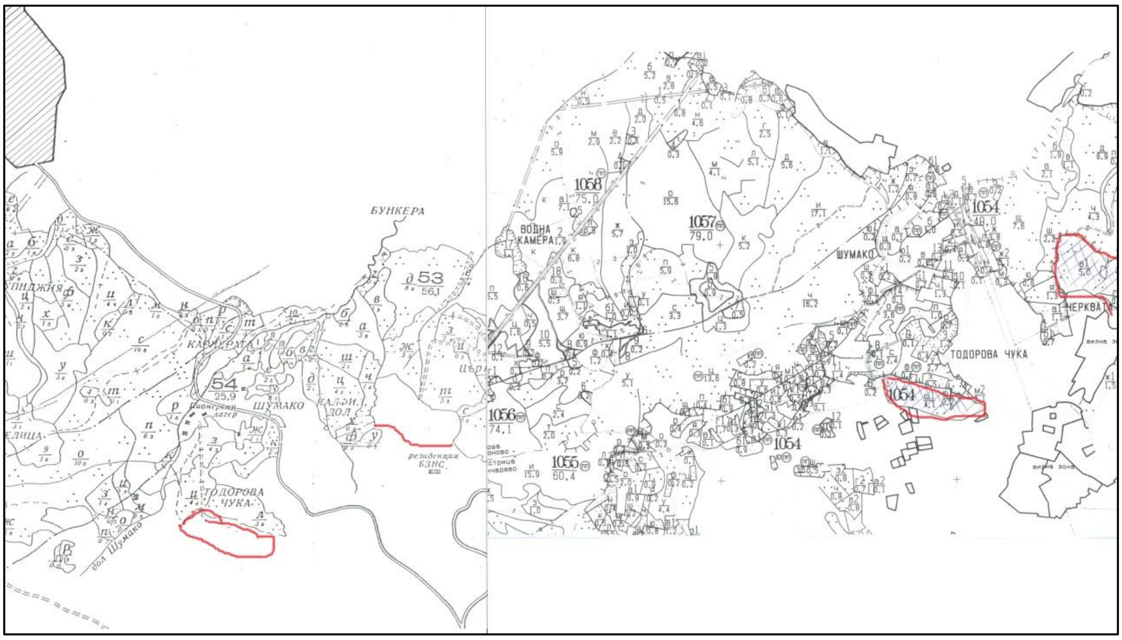

Figure 120 A map of the area of one SFE before (left) and now (right), which trace the changes in the forest land (in red).

11.3 ACTIVITY-SPECIFIC INFORMATION

11.3.1 METHODS FOR CARBON STOCK CHANGE AND GHG EMISSION AND REMOVAL ESTIMATES

11.3.1.1 Description of the methodologies and the underlying assumptions used

The methodologies and assumptions used for the reporting under the Kyoto Protocol Art. 3.3. follow completely those for the areas of LUCs from and to forests (see Chapter0 Lands converted to Forest Land).

The emission factors were estimated in the following manner:

11.3.1.2 Biomass

For FM

Bulgaria follows IPCC Guidelines 2006 and applies the stock-difference method when defining carbon stock changes in living biomass. Conversion coefficients used are specific for Bulgaria and the ones given in the IPCC 2006 tables. The main database includes: forest area by type (coniferous and deciduous), forested area by tree species and age-class structure, and the volume stock (stem wood and branches) by forest type and tree species obtained from the reporting forms (1, 2 and 3 RFs). To calculate the changes in the carbon stock of the living biomass Method 2 is used.

The emissions and removals associated with FM activities are reported for coniferous and deciduous forests, but the reported figures are the sum of the most common tree species from these forest types. Thus, the strata used in the calculations is as follow:

3. Coniferous:
    - Scots pine
    - Norway spruce
    - Black pine
    - Silver fir
    - Other conifers
4. Deciduous:
    - Oak
    - Beech
    - Poplar
    - Others

This stratification reflects the main tree species distribution in Bulgaria. The reason to put the poplars into a separate stratum is that these forests are fast growing forests and are managed in a completely different way from the rest of the broadleaved forests.

The methods for estimating the carbon stock changes follow those used in FLrFL category. For more information on biomass conversion and expansion factors used, refer ro Chapter 5 on LULUCF, Forest land category.

The annual stock changes in biomass pool are obtained by estimating the difference between the years for which biomass stock by tree species is estimated divided by 5 (1990,1995, 2000, 2005, 2010, 2015). Then the stock changes by tree species are multiplied by their area on FM in order to estimate the annual emissions/removals from the pool for this activity.

For ARD activities

To determine the annual increase in carbon stock in biomass due to growth on lands converted to FL (ΔC_G), data on growing stock (stemwood and branches) for the first age class (1-20 years) has been used. The growing stock of the stands of I[st] and II[nd] age classes for coniferous and deciduous forests was divided by the average age of 10 years. This was done for all years when data on volume per age-class and area (RF2 and RF3) are available – 1995, 2000, 2005, 2010, 2015. Once we obtained the weighed mean by forest type (coniferous and deciduous) for these years an average of them equals to 6.03 m^3/ha/y for the stands of Ist age class and 11.89 m^3/ha/y, which represents the average current increment. In order to convert the average annual increment for these age classes to an average annual biomass growth, biomass conversion and expansion factors have been used as shown in the table below. To estimate the carbon stock, the coefficient for carbon content as shown in the table has been used.

Table 254 Expansion and conversion factors used to convert the average annual increment of stands of Ist age class into average annual biomass growth for Ist age class

	BEF2		D		R		CF	
Age class	0-20 y	21-40 y	0-20 y	21-40 y	0-20 y	21-40 y	0-20 y	21-40 y
coniferous	1.09	1.13	0.48	0.48	0.40	0.40	0.51	0.51
deciduous	1.02	1.04	0.62	0.61	0.46	0.46	0.48	0.48
weighted mean	1.07	1.10	0.52	0.52	0.42	0.42	0.50	0.50

BEF_2 coefficient adds the biomass of the leaves and needles. The values of BEF_2 for coniferous and deciduous forests are estimated as a weighted mean considering the volumes of different coniferous and deciduous species. To estimate the average $BEF_{2,}$ data from literature sources on results from ecosystem studies for Spruce, Scots pine, Beech and Oaks for the I[st] and II[d] age classes were used (compiled in Korner et al.1993).

Basic wood densities for the Ist and II age class of coniferous and deciduous forests are estimated as a weighted mean considering the share of the volume of coniferous and deciduous species for these age classes. Country-specific data on the basic wood density of the main tree species were used (compiled by Bluskova, G., 1994; Enchev, E., 1984).

The coefficient for the ratio of the below-ground biomass to above-ground biomass is estimated as a weighted mean considering the share of the volume of coniferous and deciduous forests. The estimates are based on the default values for R (table 4.4 2006 IPCC GIs) for the biomass stock <50 tonnes d.m per ha for coniferous and <75 tonnes d.m per ha for hardwoods.

The carbon fraction is again estimated as a weighted mean.

Like this, the calculated the biomass growth equals to 2.39 tC/ha for the stands of first age class and 4.84 tC/ha for stands in second age class. The average biomass growth for the first age class (2.39 tC//ha/yr) is applied for forest cohorts up to 20 years, while the average biomass growth for the second age class (4.84 tC/ha/yr) is applied for forest cohorts greater than 21 years.

The biomass stock on lands before the conversion depends on the type of land and its vegetation. The average biomass stock for the respective land types converted to FL is:

- Annual cropland – 3 tC/ha
- Perennial cropland – 63 tC/ha
- Grassland – 6.07 tC/ha
- Other land – 4.5 tC/ha

More information on how the average biomass stocks of these lands have been estimated can be found in the respective chapters in LULUCF sector of NIR.

For estimating biomass loss associated with deforestation, data from NFI on volume stock over barck was used. The data on volume stocks over the five years period since 1990 was expanded and converted with the related country specific (or default) expansion/conversion factors: wood density (0.43 t/m3 for coniferous, 0.60 t/m3 for deciduous), stemwood plus branches expanded to the whole aboveground tree biomass (1.08 for coniferous, 1.03 for deciduous), root-to-shoot ratios (0.29 for coniferous, 0.24 for deciduous) and C-content (0.51 t C/t d.m. for coniferous and 0.48 t C/t d.m for deciduous). Then it was estimated the share of the coniferous and deciduous stocks in the total biomass stock for the respective years. Like this the weighted means for tree biomass stock were calculated. The means were used for estimating biomass loss from deforestation for the years across the time series.

Table 255 Living forest biomass stocks which are used to calculate emissions from deforestation

		1990	1995	2000	2005	2010	2015 – 2017
Weighted mean tree biomass stocks	tC/ha	43.14	48.31	53.87	55.67	59.38	61.20

For the biomass growth on settlements after deforestation the following values were taken: 2.00 $tCha^{-1}y^{-1}$ and 0.68 $tCha^{-1}y^{-1}$ for annual and perennial plants respectively. Growth of annual plants is accounted only in the year of D, while the growth of the perennial plants at the D areas continues.

11.3.1.3 Dead wood

Due to the young age of the forests at the AR areas it is assumed that there is no dead wood and there is no change in this carbon stock at AR areas. If there was any in the young forests of AR areas it would represent a C stock increase due to the lack of dead wood in the previous land uses. So, the assumption is conservative.

For estimating changes in DW stock due to deforestation activity it was assumed that the dead wood stocks is equal to 5% of the standing biomass stock of the Bulgarian forests. This is a percentage magnitude for dead wood that is frequently reported for managed forests in Europe. The resulting values are given in the table below.

Table 256 Dead wood stocks used for estimating the changes in DW pool after deforestation

		1990	1995	2000	2005	2010	2015 - 2016
DW stock	tC/ha	2.2	2.4	2.7	2.8	3.0	3.1

11.3.1.4 Litter

According to IPCC definition litter pool includes all non-living biomass in a various state of decomposition, so this means – litter layer (fresh dead plant material), fumic and humic layers. As it was explained in chapter Forest remaining forest, changes in carbon stock in soil the source of information in order to estimate a country specific value for the carbon stock in litter is EEA-MOEW. The database resulted from the implementation of the ICP "Assessment and Monitoring of Air Pollution Effects on Forests"-UN/ECE Convention on Long Range Transboundary Air Pollution.

When analysing carbon content in litter Bulgaria follows ICP Forests Manual methodological approach http://www.icp-forests.org/pdf/FINAL_soil.pdf (see Annex 7 Soil horizon designation p.195) where litter definition is:

OL-horizon (Litter, Förna): this organic horizon is characterised by an accumulation of mainly leaves/needles, twigs and woody materials (including bark), fruits etc. This sublayer is generally indicated as litter. It must be recognized that, while

the litter is essentially unaltered, it is in some stage of decomposition from the moment it hits the floor and therefore it should be considered as part of the humus layer. There may be some fragmentation, but the plant species can still be identified. So most of the original biomass structures are easily iscernible. Leaves and/or needles may be discoloured and slightly fragmented. Organic fine substance (in which the original organs are not recognisable with a naked eye) amounts to less than 10 % by volume.

According to IPCC definition this represents the "litter layer" (a horizon consisting of relatively fresh dead plant material). For Bulgaria there is no data gathered for the carbon content in this layer during the soil surveys. However, since the changes in biomass fully account for all leaves and needles (the tree biomass estimates accounts for these pools) that represent the material of the litter layer within one year. Any further accounting of this material would end in double accounting.

OF-horizon (fragmented and/or altered) is a zone immediately below the litter layer. This organic horizon is characterised by an accumulation of partly decomposed (i.e. fragmented, bleached, spotted) organic matter derived mainly from leaves/needles, twigs and woody materials. The material is sufficiently well preserved to permit identification as being of plant origin (no identification of plant species).The proportion of organic fine substance is 10% to 70% by volume. Depending on humus form, decomposition is mainly accomplished by soil fauna (mull, moder) or cellulose-decomposing fungi. Slow decomposition is characterised by a partly decomposed matted layer, permeated by hyphae.

OH-horizon (humus, humification): characterised by an accumulation of well-decomposed, amorphous organic matter. It is partially coprogenic, whereas the F horizon has not yet passed through the bodies of soil fauna. The humified H horizon is often not recognized as such because it can have friable crumb structure and may contain considerable amounts of mineral materials. It is therefore often misinterpreted and designated as the Ah horizon of the mineral soil and not as part of the forest floor as such. To qualify as organic horizon, it should fulfil the FAO requirement, as described above. The original structures and materials are not discernible. Organic fine substance amounts to more than 70% by volume. The OH is either sharply delineated from the mineral soil where humification is dependent on fungal activity (mor) or partly incorporated into the mineral soil (moder).

According to the ICP Forests Manual samples are taken separately for the different depth. OH and OF layers should be sampled together (see Table 5, p. 15 ICP Forests Manual). The data is available for each depth

The estimation for the model carbon stock in litter pool is based on data for carbon content in OFH layers available for the years 2000 – 2002. According to the data available it was estimated that the carbon stock in litter is 5.38 tC/ha.

11.3.1.5 Soil

Emissions/removals of carbon stock in the mineral soils due to AR were evaluated through the annual change in the carbon stock at the AR areas using the equation:

$$\Delta \boldsymbol{C}_{\boldsymbol{LFmineral}} = \frac{\left[\left(\boldsymbol{SOC}_{\boldsymbol{ref}} - \boldsymbol{SOC}_{\boldsymbol{non-frest\ land}}\right) \cdot \boldsymbol{A}_{\boldsymbol{aff}}\right]}{\boldsymbol{T}_{\boldsymbol{aff}}}$$

where:

$\Delta C_{LFmineral}$ - annual change in the carbon stock in mineral soils in the year of assessment, tonnes C/yr

SOC_{ref} – stable carbon stock in forests for a certain soil type, tonnes C/ ha

$SOC_{non-frest\ land}$ - stable carbon stock in the soil of the previous type of land-use (croplands, grasslands and other lands), tonnes C/ ha

A_{aff} - total af-/reforestated area after the conversion, ha

T_{aff} - duration of the transition from SOC Non forest Land to SOCref, yr

The used transition period was 20 years according to IPCC GPG.

For the stable stock of organic carbon in soils (0-40 cm) from forest ecosystems (SOCref) a country specific value is used = 78.3 t C/ha.

For the stable stock of organic carbon in soils (0-40 cm) of previous types of land-use the country specific values obtained for annual or perennial cropland, grassland and other land are used:

- annual crops: 89.9 t C/ha
- perennial crops: 76.5 t C/ha
- grasslands: 103.57 t C/ha
- other land: 69 t C/ha

Following the recommendation from the ERT Bulgaria re-estimated the reference organic carbon stock in soils under other land use. This has been done by using the default SOC reference level as described in table 2.3 in 2006 IPCCC Guidelines. In order to choose the most appropriate default SOC reference level Bulgaria did the following:

According to "Classification scheme for default climate regions" (IPCC, 2006) Bulgaria is in the "warm temperate dry" (appr. 60%), "cool temperate dry" (appr. 20%) and "cool temperate moist" (appr. 20%) regions (please see the map from the link below).

http://forest.jrc.ec.europa.eu/media/cms_page_media/122/BGR_Climate_1.pdf

Concerning the soil type, more than 80% of the territory is under high activity clay soils (please see the map from the link below).

http://forest.jrc.ec.europa.eu/media/cms_page_media/123/BGR_Soil.pdf

Therefore, Bulgaria estimated a weighted mean value for the SOC reference level in soils taking into account the SOC reference levels for HAC soils (table 2.3 from the2006 IPCC Guidelines) for the respective climate regions. The result for the 0-30 cm depth is 51.8 tC/ha. Bulgaria in its inventory estimates the CSC in mineral soils for 0-40 cm depth. Therefore, the value of 51.8 tC/ha had to be corrected for consistency reason. The final result is 69 tC/ha for 0-40 cm.

For C stock changes in soils of D areas the same approach and values as for AR areas were used, but with an appropriate reverse equation. The soil C stock (0-40 cm) used for settlements is:

- Settlements: 19.7 t C/ha

A descripiton of the methods of deriving all these soil C stocks can be found in the respective chapters of these subsectors.

11.3.1.6 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

No carbon pool is omitted.

Deadwood is assumed not to occur on AR areas. Due to the young age of the forests at AR areas (since 1990) and the assumed lack of dead wood at areas of all other land uses it is assumed that a stock change of dead wood does not occur at AR areas. If there was any in the young forests of AR areas it would represent a C stock increase due to the lack of dead wood in the previous land uses. So, the assumption is conservative.

There is no practice of biomass burning at ARD areas in Bulgaria. Furthermore, forests are not fertilised and liming does not exist in Bulgaria. So, fertilisation at AR areas and liming at ARD areas do not occur.

11.3.1.7 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Emissions have been estimated for all situations where C losses in mineral soils occur (according 2006 IPCCC Guidelines), based on equations 11.1, 11.2, 11.8.

The ratio C/N in the mineral soils is default from 2006 IPCCC Guidelines – 15. N_2O emissions from N mineralization associated with a loss of soil organic matter are presented in the table below.

Table 257 N_2O emissions in ARD land from N mineralization associated with a loss of soil organic carbon

	AR (Annual CL to FL)	AR (GL to FL)	D (FL to SM)
1990	0.0006	0.0079	0.0002
1991	0.0011	0.0158	0.0610
1992	0.0017	0.0239	0.2738
1993	0.0023	0.0318	0.4561
1994	0.0028	0.0397	0.7084
1995	0.0034	0.0475	0.8853
1996	0.0039	0.0553	1.0622
1997	0.0045	0.0631	1.2409
1998	0.0051	0.0710	1.4436
1999	0.0056	0.0789	1.9246
2000	0.0062	0.0868	2.4080
2001	0.0070	0.1011	2.6951
2002	0.0078	0.1154	3.3754
2003	0.0086	0.1297	3.9522
2004	0.0095	0.1441	4.6070
2005	0.0103	0.1585	5.8028
2006	0.0111	0.1729	6.9397
2007	0.0119	0.1875	8.8975
2008	0.0128	0.2027	13.9867
2009	0.0136	0.2170	15.3435
2010	0.0139	0.2237	17.7172
2011	0.0141	0.2301	18.3868
2012	0.0144	0.2365	19.1364
2013	0.0146	0.2434	22.9231
2014	0.0149	0.2499	24.4586
2015	0.0152	0.2570	30.0027
2016	0.0154	0.2640	34.9044
2017	0.0157	0.2540	38.6018

11.3.1.8 Changes in data and methods since the previous submission (recalculations)

Recalculations reflects the changes made in estimation of the average biomass growth of stands from first and second age classes as the expansion and conversion factors have been recalculated.

The losses of biomass and dead wood due to deforestation have been recalculated as an technical error in its previous estimations have been found.

N_2O Emissions from N mineralization associated with a loss of soil organic matter have been estimated and reported.

11.3.1.9 Uncertainty estimates

We plan to update the uncertainty assessment for the next Submission.

11.3.1.10 Information on other methodological issues

The methods used to estimate emissions/removals from ARD and FM activities are of the same tier method as those used for the UNFCCC reporting.

11.3.1.11 The year of the onset of an activity, if after 2008

Bulgaria reports all area subject to the activities under 3.3 and FM since 1990. This information is available in the CRF tables in NIR-2 table.

Concernig FM all forests in Bulgaria are managed, therefore all activities which are carried out in the forests are considered human-induced and those activities were already in place before the starting of the first commitment period of the Kyoto Protocol.

11.4 ARTICLE 3.3

11.4.1 INFORMATION THAT DEMONSTRATES THAT ACTIVITIES UNDER ARTICLE 3.3 BEGAN ON OR AFTER 1 JANUARY 1990 AND BEFORE 31 DECEMBER 2012 AND ARE DIRECT HUMAN-INDUCED

Changes in forest area are traced only after a forest inventory has been performed. Bulgaria reports the following AR activities that occurred on or after 1990:

- Planted or seeded on grasslands and croplands(97% from the total AR units of land due to planting and seeding on GL and around 1% on CL)
- Planted or seeded on other land for protective purposes (i.e erosive lands – around 2% from the total AR units of land due to planting and seeding)
- Abandoned lands – cropland and grassland which are naturally regrown as forest (20% from the total AR units of land due to regrowth on croplands and 80% - regrowth on GL

Table 258 Identified net AR units of land for the period 1992-2012 for each district in Bulgaria[42]

District	Regrowth in ha. 1992-2000	Regrowth on CL	Regrowth on GL	Regrowth in ha 2001-2012.	Regrowth on CL	Regrowth on GL	Planted or manually seeded in ha 1992-2000	Planted, seeded on CL	Planted, seeded on GL	Planted, seeded on erosive areas	Planted or manually seeded in ha 2001-2012	Planted, seeded on CL	Planted, seeded on GL	Planted, seeded on erosive areas
Vidin	**1508**	257	1251	**8560**	2072	6488	**620**	-	496	124	**27**	-	27	-
Montana	**567**	186	381	**2301**	294	2007	**60**	-	56	4	**2343**	-	2313	30
Vrats	**2397**	330	2067	**1934**	121	1813	**757**	12	735	10	**670**	-	624	46
Pleven	**4767**	1656	3111	**3199**	576	2623	**973**	122	851	-	**40**	-	40	-
Lovech	**660**	85	575	**8339**	827	7512	**348**	-	321	27	**3865**	-	3841	24
Gabrovo	**2852**	973	1879	**9245**	2370	6875	**35**	-	35	-	**18**	-	18	-
Veliko Tarnovo	**17**	-	17	**13037**	1440	11597	**715**	15	689	11	**1639**	-	1597	42
Rousse	**-**	-	-	**2643**	303	2340	**-**	-	0	-	**3573**	-	3569	4
Targovishte	**1864**	566	1298	**1898**	431	1467	**903**	25	864	14	**804**	-	804	-
Shumen	**851**	33	818	**3724**	568	3156	**1472**	4	1421	47	**41**	-	41	-
Razgrad	**-**	-	-	**665**	45	620	**775**	5	770	-	**1235**	-	1213	22
Silistra	**158**	67	91	**1614**	209	1405	**341**	-	341	-	**1646**	-	1643	3
Dobrich	**149**	-	149	**1132**	138	994	**4831**	20	4767	44	**621**	-	621	-
Varna	**873**	398	475	**980**	257	723	**1066**	1	1031	34	**718**	-	714	4
Burgas	**2034**	469	1565	**6996**	1172	5824	**1208**	6	1175	27	**640**	-	636	4
Yambol	**232**	61	171	**831**	125	706	**194**	-	189	5	**736**	-	724	12
Sliven	**568**	214	354	**1341**	222	1119	**636**	-	622	14	**76**	-	76	-
Stara Zagora	**746**	174	572	**1560**	213	1347	**1258**	5	1218	35	**353**	-	344	9
Haskovo	**1405**	509	896	**5505**	480	5025	**857**	3	806	48	**2409**	-	2405	4
Kardjali	**9**	4	5	**43**	10	33	**52**	1	49	2	**25**	-	24	1
Smolyan	**3176**	644	2532	**6769**	843	5926	**337**	-	324	13	**404**	-	401	3
Plovdiv	**2264**	416	1848	**5445**	386	5059	**2148**	16	2058	74	**678**	-	670	8
Pazardjik	**466**	65	401	**1286**	88	1198	**1170**	9	1131	30	**493**	-	481	12
Blagoevgrad	**1807**	445	1362	**6640**	857	5783	**2709**	15	2669	25	**1858**		1795	63

[42] Data for AR units of lands by district for 2013, 2014 and 2015 is missing because the data for these years is extrapolated. The table with the data up to 2012 is provided for transparency reason.

District	Regrowth in ha. 1992-2000	Regrowth on CL	Regrowth on GL	Regrowth in ha 2001-2012.	Regrowth on CL	Regrowth on GL	Planted or manually seeded in ha 1992-2000	Planted, seeded on CL	Planted, seeded on GL	Planted, seeded on erosive areas	Planted or manually seeded in ha 2001-2012	Planted, seeded on CL	Planted, seeded on GL	Planted, seeded on erosive areas
Kustendil	**1378**	410	968	**6937**	614	6323	**407**	10	373	24	**525**	-	509	16
Pernik	**1537**	214	1323	**2581**	335	2246	**4971**	51	4859	61	**381**	-	358	23
Sofia	**1126**	234	892	**11589**	1694	9895	**183**	-	183	-	**3326**	6	3164	156
Total	**33411**	8410	25001	**116794**	16690	100104	**29026**	320	28033	673	**29144**	6	28652	486

Table 259 Total AR estimates for the period 1990-2012

Years	AR	FLx - FLx-1	Planted or manually seeded (kha)	Naturally seeded (kha)	Dx
2014	12.32	12.17	2.43	9.73	0.15
2013	12.63	12.17	2.43	9.73	0.46
1992-2012	211.94	208.38	58.17	150.21	3.57
1991	6.99	6.94	3.23	3.71	0.05
1990	7.08	6.94	3.23	3.71	0.15
Total	250.96		69.49	177.09	4.37

According to the Annex of Decision 16/CMP.1 art. 1 b) and c)[43] natural A/Rs occurred on abandoned arable lands have to be reported under art. 3.3. as this forest regeneration is based on a human induced promotion. Bulgaria reports these units of land consistent with the requirements. The re-growth in this case is the result of the direct human induced stop of the agricultural management at these lands, which in fact leads to a direct human induced natural seeding from the adjacent forests and (re-)growth of managed forests (all forests in Bulgaria are managed and reported as such).

It is good practice to provide documentation that all A/R activities included in the identified units of land are direct-human induced. "Relevant documentation includes forest management records or other documentation that demonstrates that a decision had been taken to replant or to allow forest regeneration by other means." This requirement is described in the Annex of Decision 15/CMP.1 art.8 a).

As it is described in the NIR on 11.2.2, all units of land subject to AR activities are identified from the revision of all Forest Management Plans for all State Forest Enterprises (SFE) in Bulgaria. The new forest area identified and reported as AR units is included in FMPs, which by itself is evidence that the AR area is direct-human induced. FMPs are considered by Bulgaria as documentations that demonstrate human induced activity. In addition to this, there is a specific administrative procedure when as a result of the forest inventory assessment an agricultural land (e.g CL and Gl) is identified as becoming a forest. The basics of this procedure is the owner's decision (please see art. 83 and 84 from the Forest Law 2011(last amendment 07.08.2012, SG №60). In the case when the new forest is less than 10 years old the land owner is informed on the risk of conversion of the agricultural land into forest land. If the land owner decides to keep the former agricultural land under agricultural use, he has to submit a declaration to the Executive director of the Executive Forest Agency. After the submission of the declaration, in 3 years term, the land owner is obliged to cut the re-grown forest vegetation and return the land into an active status of agricultural management. As a consequence of this procedure, it can be assumed that the lack of back conversion of such new forests into agricultural lands afterwards represents clear evidence for the nature of a land owner's decision of an intended land use change into forests.

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[43] *"Afforestation" is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources*
"Reforestation" is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1

According to the Forest Act 2011 this procedure is described in the following articles:

Art. 83. (1) Where as a result of the inventory of forest territories it is established, that the farm territories have acquired characteristics of a forest in the meaning of this law, the persons, who have performed the inventory shall produce to the Executive director of the a list of the properties upon the lands of the populated areas.

(2) The list under Para. 1 shall be published in one local and one central daily newspaper and shall be announced in public on the internet site of the relevant regional administration, Regional directorate of forests and the Executive Forest Agency.

(3) On the basis of the list under Para. 1, the Executive director of the Executive Forest Agency or an official, authorized by him shall invite in writing the owners of the relevant properties to declare if they wish to use their properties as farm or forest territories.

(4) ***Within 6-month term*** *from receiving the invitation under Para. 3, the owner,* ***who wishes to use his property as a farm territory*** *shall submit a declaration to the Executive director of the Executive Forest Agency.*

(5) If the owner fails to submit a declaration within the term under Para. 4, the Executive director of the Executive Forest Agency shall propose to the Minister of Agriculture and Food to issue an order for change of function of the properties as forest territory. The proposal shall describe the size of the properties, the type and origin of the forest and a plan of the property shall be attached from the map of the restored ownership or from the cadastre map and taxation characteristics.

(6) The order under Para. 5 shall be sent to the owner, to the relevant Regional directorate of forests, as well as to the relevant Office of geodesy, cartography and cadastre – for reflecting the change in the cadastre map and cadastre registers, or to the Municipal office of agriculture – for reflecting the change in the map of the restored ownership.

(7) The provisions of Para. 1 – 6 shall not apply to territories, provided to sites of the national security and defence.

Art. 84. (1) Where as a result of the inventory of the forest territories it is established, that farm territories have acquired the characteristics of a forest in the meaning of this law and the owner declares in writing before the Executive director of the Executive Forest Agency that he wishes to use his property as a farm territory within the term of 3 years from submitting the declaration he shall be obliged to clean his property from the forest timber vegetation.

(2) In case that within the term of Para. 1 the owner fails to clean his property from forest-timber vegetation, the provision of Art. 83, Para. 4 – 6 shall apply.

(3) Notwithstanding of the inventory under Para. 1, unfit for farm use territories may be included on the forest territories on the basis of a written application of the owner under Art. 83, Para. 5 and 6

When the new forest is older than 10 years, then this forested area belongs to the Forest Fund at once and the land owner cannot change the designation.

The old Forest Act did not contain specific procedure as the one described in the Forest Act 2011. However, under the old Forest act (1997-2011) the following have been taken into account:

The Forest Act (1997-2011) defines the term "Forest" (*"Art. 2. (1) (amend. SG 16/03) Forest, in the context of this law is the land occupied by forest ligneous plants with area not less than 1 decare*."). The Forest Act regulates the way of use and management of forests. The purpose of the law is ensuring the protection of the forest territory and increasing the area covered by forest. The subject of the Act includes only forest land and land within the Forest Fund and their management is done in accordance with the Forest management plans, programs and projects, as prescribed in Regulation № 6 on the structure of the forests and land included in the forest fund and the hunting reserves of Republic of Bulgaria. For the purpose of the management of the forests in the Forest management plans, programs and projects and the relevant reports that are integral part of them, all Afforestation and Reforestation activities in the Forest Fund are described in the Forest Act (1997-2011) (art.42(1)

Art. 42. (amend. SG 16/03) (1) (amend. – SG 64/07; amend. – SG 80/09) The afforestation in the forest fund shall be carried out according to the forest development projects, technical projects for fighting with the erosion and landslides, plans and programs under the conditions and by the order, determined with ordinance by the Minister of Agriculture and Food.

In cases when as a result of the natural regrowth agricultural land has become forest and has met definition of "forest" given by the Forest Act, this area should be managed as forest and is subject to forest inventory and therefore included in FMPs.

(*§ 9. (new – SG 28/92) Farm lands, in which the right of ownership has been restored by the order of art. 10 of this law and which are forests in the sense of the Law of the forests, shall be subordinated to the regime of the Law of the forests and the Law of the hunting economy(**LAW OF THE OWNERSHIP AND THE USE OF THE FARM LAND**)*)

As regards Deforestation activities, Forest Act clearly inscribes all cases in which forest is taken out of the Forest Fund (existing woods). This is followed by LUC and they are transformed from forested to non-forested lands. The procedure for taking out of the Forest Fund is given in the Forest Act (please see the respective articles below). **Therefore all changes in the function or designation of the forests are considered as deforestation and are reported as such.**

All forests in Bulgaria are protected by the Forest Act.

Art. 3. (1) Decreasing the existing woods shall not be allowed:

1. on the territory of the Republic of Bulgaria;

2. on the territory of Municipalities, in which the woods are under 10%.

Forest Act (2009):

*Art. 14. (amend. SG 16/03) (1) Forests and lands of the forest fund **shall be excluded at change of their designation for:***

1. plots for construction of power plants, dams and other hydro-technical and electric-technical facilities, obtaining of underground resources, graveyard parks, waste depots, re-loading stations;

2. tracks for linear sites;

a) located on the surface of the terrain – roads, railways, water canals, cable cars, draglifts and other facilities for technical infrastructure;

b) located under the surface of the terrain – oil pipelines, gas pipelines, heat conduits and water supply pipeline with cross section over 1500 mm;

3. creating of new or expansion of the construction boundaries of existing urbanized territories (settlements and settlement formations), as well as creating or expanding of the boundaries of separate regulated landed properties out of them;

4. (amend. – SG 64/07) creating of new or expanding of the construction boundaries of existing urbanized territories (settlements and settlement formations), as well as creating or expanding of the boundaries of separate regulated landed properties out of them in the cases when disposing actions with payment have been implemented with forests and lands of the state forest fund, in which till March 1, 2003 construction has been implemented in the sense of art. 12 of the Law of Spatial Planning;

5. creating of lands for agricultural use from land not producing timber in the state forest fund;

6. sites, connected with the national security, the defense of the country, the preservation and the reproduction of environment.

(2) The exclusion of forests and lands from the forest fund after fire shall be prohibited for a term of 20 years.

(3) Para 2 shall not be applied in the several cases:

1. when the change of the designation is connected with the defense or the security of the country;

2. when the change of the designation is connected with the fulfillment of investment projects, approved by the Council of Ministers.

Procedure for exclusion:

Art. 14d. (new – SG 16/03) (1) (amend. - SG 30/06, in force from 12.07.2006; amend. – SG 64/07; amend. – SG 54/08; amend. – SG 80/09) ***The Minister of Agriculture and Food upon proposal by the Executive director of the Executive Agency of Forests shall issue an order for excluding of the forests and the lands from the forest fund or propose to the Council of Ministers to take decision***

Forest Act 2011

Art. 73. (1) Change of the function of land properties in forest territories shall be admitted for:

1. grounds for construction of transport equipment (ports, airports, railway stations, bus-stations) production undertakings, extraction of ores and minerals, graveyards, waste depots, waste banks, depositories, electric power stations, damps, purifying stations for drinking or waste waters and other hydro-technical and electro-technical equipment, with the exception of the fundaments of the electric line posts;

2. permanent ways of line objects, placed on the surface of the ground – roads and railway lines, including the equipment to them, water canals;

3. creating new or expanding construction borders of existing urban territories in the cases where there are adopted general territorial plans of the Municipalities or parts of them, in which the properties are situated;

4. creating or expanding separate regulated land properties, which are not state ownership, for which there is an enforced general territorial plan;

5. national sites in the meaning of the Law on State ownership, sites, related to the national security and defence of the country, to the environment protection, for whose construction there is a Council of Ministers decision, as well as Municipal sites of first importance in the meaning of the law on the Territory Planning;

6. construction of posts for lifts and tow-lifts, as well as basic equipment of the wind-generators and photo-voltaic parks;

7. construction of ski-tracks.

Procedure for exclusion:

Art. 74. (1) ***Change of function of land properties in forest territories – public state ownership shall be done by a Council of Ministers decision upon proposal of the Minister of Agriculture and Food. The change of function of***

forest territories – public state ownership shall be done only for construction of sites, which are state or Municipal ownership.

(2) The change of function of land properties in forest territories apart from the ones, indicated in Para. 1 shall be done:

1. by a commission in the Regional directorate of forests – for land properties in forest territories with area up to 50 decares falling in the territorial scope of activity of the relevant Regional directorate of forests;

2. by a commission in the Executive Forest Agency – for land properties in forest territories apart from the ones, indicated in Para. 1 and in p. 1.

Art. 75. (1) ***For a change of the function of land properties in forest territories the owner or investor shall make a request for preliminary coordination before:***

1. The Minister of Agriculture and Food – for land properties in forest territories – public state ownership;

2. the relevant commission under Art. 74, Para. 2 – for land properties in forest territories apart from the ones, indicated in p. 1.

(2) The request for preliminary coordination for change of function of land properties in forest territories shall have attached the following documents:

1. a plan of the property from the cadastre map or from the map of the restored ownership, coordinated by the Relevant regional directorate of forests upon location of the property;

2. an approved task for development of a detailed territory plan, drawn up in compliance with the provisions of the Law on the Territory Planning;

3. a Municipal council decision – for land properties in forest territories – ownership of Municipalities.

11.4.2 INFORMATION ON HOW HARVESTING OR FOREST DISTURBANCE THAT IS FOLLOWED BY THE RE-ESTABLISHMENT OF FOREST IS DISTINGUISHED FROM DEFORESTATION

In KP LULUCF emission inventory for Bulgaria, we don’t use data coming from remote sensing technology. Harvesting and forest disturbance always occur on Forest Land, while deforestation is a permanent change of land use from Forest Land to other land-use categories.

According to the Forest Law (last amendment in 2019) all harvest activities in the forests and lands with forest are planned under the FMP.

Art. 101. (1) Felling shall be conducted for restoration, growing and improving the conditions of forests and for achieving the objectives, laid down in the forestry plans and programmes.

(3) The Minister of Agriculture and Food shall adopt an Ordinance, which shall determine:

Art. 102. Restoring felling shall be conducted at an age not smaller than:

1. 60 years in high-stem forests with the exception of birch and poplar trees, as well as the artificially created plantations out of their natural region of spreading;

2. 20 years and not bigger than 30 years in forests for sucker restoration;

3. 15 years for acacia forests.

Clear cuttings are forbidden by Law.

Art. 104. (1) It shall be prohibited:

1. conducting clear fell in all the forests with the exception of the poplar and low-stem forests;

When there is forest disturbance the owner of the forest should replant the area if it cannot be restored by naturally up to 7 years.

Art. 97. (1) Wood-cutting areas and burned out areas, which cannot be restored naturally up to 7 years after the timber cutting or burning during fire shall be planted by their owner up to 2 years after expiry the 7-year period.

(2) Where the forestry plan or programme envisages restoration in an artificial way, the forestation shall be done within the term of 3 years after cutting the plantation.

It is forbidden by the Law to convert burnt by wildfires area to other land use during the 20 years period after the damage, caused by wildfires.

The delimitation between deforestation[44] and harvesting and forest disturbance is taking into account when Bulgaria reports under the KP. As it was described above there are some obligations by the Law according to harvesting and replanting of the forest area in order to keep the forest fund stable. When there is a plan or a need to convert forest land to non-forest land – according to the Law the owner should exclude the forest area from the forest fund (see chapter 11.4.1).

11.4.3 INFORMATION ON THE SIZE AND GEOGRAPHICAL LOCATION OF FOREST AREAS THAT HAVE LOST FOREST COVER BUT WHICH ARE NOT YET CLASSIFIED AS DEFORESTED

In Bulgaria forests are managed and utilized based on forest management plans, projects or programs. According to this, all activities like felling are planned and described in detail. All felling activities are carried out under the Regulation for fellings. The regulation describes the type of fellings and specifies the conditions in which fellings are carried out.

Deforestation needs administrative steps as described above, so there are only two possibilities 1) Forest areas that have lost forest plant cover (e.g. clear cut areas, damaged areas): These areas remain forests by law, and there is no transition to non-forest situation of such areas allowed (obligations for replanting etc., Art. 97. (1) Forest act). 2) Deforestation areas that followed all administrative steps needed to get the permission for deforestation. Only such areas are accounted as D areas in Bulgaria.

The Regulation for felling sets up the following cuttings:

1) Renewable
    - Gradual
    - Selective
    - Clear
2) Thinning
3) Other

[44] (15/CMP.1 (par.8.b) "Deforestation" is the direct human-induced conversion of forested land to non-forested land.)

When any harvest is conducted the requirements for the density of the stand should be obeyed where the density is different with the different types of harvests, but no less than 0.4, which is within the framework of the Forest Definition of the KP and thus reported as Forest.

As regards clear cuts they are only done in the cases described down here and obligatory followed by afforestation:

Art. 104. (1) It shall be prohibited:

1. conducting clear fell in all the forests with the exception of the poplar and low-stem forests;

Art. 97. (1) Wood-cutting areas and burned out areas, which cannot be restored naturally up to 7 years after the timber cutting or burning during fire shall be planted by their owner up to 2 years after expiry the 7-year period.

(2) Where the forestry plan or programme envisages restoration in an artificial way, the forestation shall be done within the term of 3 years after cutting the plantation.

11.4.4 INFORMATION RELATED TO THE NATURAL DISTURBANCES PROVISION UNDER THE ARTICLA 3.3 OF THE KYOTO PROTOCOL

Since Bulgaria did not applied yet the provision, no additional information is needed and provided here.

11.4.5 INFORMATION ON HARVESTED WOOD PRODUCT UNDER ARTICLE 3.3 OF THE KYOTO PROTOCOL

Harvested Wood Products (HWPs) originating from *deforestation* activity are estimated assuming instantaneous oxidation. The share of HWP originating from D is estimated on the basis of the area under D and respective average biomass stock during the years. Emissions from HWPs originated from *afforestation/reforestation* activities have been included in the emissions estimated from HWPs from *forest management* activities following the recommendation of IPCC 2013 KP Supplement (IPCC 2014), where in case it is not possible to differentiate between the harvest from AR and FM, it is conservative and in line with good practice to assume that all HWP entering the accounting framework originate from FM.

11.5 ARTICLE 3.4

11.5.1 INFORMATION THAT DEMONSTRATES THAT ACTIVITIES UNDER ARTICLE 3.4 HAVE OCCURRED SINCE 1 JANUARY 1990 AND ARE HUMAN-INDUCED

All forests in Bulgaria are managed, therefore all activities which are carried out in the forests are considered human-induced. Therefore, all emissions and removals of all lands which were forests in 1.1.1990 are accounted as Forest Management emissions and removals, except the emissions and removals of the ARD lands since 1.1.1990 which are accounted under the Art. 3.3 activity ARD.

11.5.2 INFORMATION RELATING TO FOREST MANAGEMENT

Bulgaria has a long tradition in Forest Management which is characterized by a long-term forestry policy that takes also issues of biodiversity conservation into account. The forest management policy is based on the principles of sustainable forest resources management, which balance the ecological, economic and social functions of the forest. This is ensured with Forest Act (2011). The Forest Act and associated Ordinances define all measures which have to be taken in order to manage, protect and sustain the Bulgarian forests. This includes regulations connected with harvest (e.g. limitations for harvest in stands below the legal minimum age for the rotation period), provisions for natural and artificial regeneration, regulations around deforestation (e.g. principal ban of deforestation) and etc. Therefore, Bulgaria uses a broad definition for Forest Management.

11.5.2.1.1 Conversion of natural forest to planted forest

There is no conversion of natural forest to planted forest in Bulgaria. Therefore, emissions are not accounted for from such activity.

11.5.2.2 Forest Management Reference Level

The forest management reference level (FMRL) for Bulgaria, inscribed in the appendix to the annex to Decision 2/CMP.7, is equal to –8.168 Mt CO2 eq. per year assuming instantaneous oxidation of HWP, and –7.950 Mt CO2 eq. applying first-order decay function for HWP. Bulgaria is one of the member States of the EU for which the JRC of the European Commission developed projections in collaboration with two EU modeling groups. The FMRL is the averages of the projected forest management (FM) data series for the period 2013-2020, taking account of policies implemented before mid-2009, with emissions/removals from harvested wood product (HWP) using the first order decay functions, and assuming instant oxidation. The contribution of HWP to the reference level of Bulgaria amounts to 0,218 Mt CO2 as described in the Submission of the FMRL by Bulgaria (2011). It was calculated using the C-HWP-Model, which estimates delayed emissions on the basis of the annual stock change of semi-finished wood products.

11.5.2.3 Technical correction of the FMRL

According to Decision 2/CMP.7, methodological consistency between the FMRL and reporting for forest management during the second commitment period has to be ensured, applying technical correction if necessary.
In respect to follow this recommendation Bulgaria in cooperation with JRC plan to apply technical correction at the end of the commitment period .

11.5.2.4 Information related to the natural disturbances provision under article 3.4

Since Bulgaria did not applied yet the provision, no additional information is needed and provided here.

11.5.2.5 Information of Harvested Wood Products under article 3.4

The HWP contribution to emissions and removals of CO2 is estimated and reported under FM activities. The HWP in solid waste disposal sites is not included, assumed to be instantaneously oxidized. The input to HWP excludes firewood (and woody residuals) as its carbon stock is accounted for using instantaneous oxidation. HWP originated from deforested land is excluded from the estimate assuming instantaneous oxidation.

The annual changes in carbon stocks and associated CO_2 emissions and removals from the HWP pool are estimated, following the production approach described in the Annex to Volume 4, Chapter 12, of the 2006 IPCC Guidelines (IPCC, 2006), in line with Decision 2/CMP.7 and the guidance provided by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement, IPCC 2014). The estimation follows the Tier 2 method - first order decay, which is based on Eq. 2.8.5 (KP Supplement, IPCC 2014). The default half-life constants were used:

- 35 years for sawnwood,
- 25 years for wood-based panels
- 2 years for paper and paperboard.

The activity data (production of sawnwood, wood based panels and paper and paperboard) are derived from FAO forest product statistics (Food and Agriculture Organization of the United Nations: forest product statistics, http://faostat3.fao.org/download/F/FO/E). Equation 2.8.1 (IPCC, 2014) has been applied to estimate the annual fraction of the feedstock coming from domestic harvest for the HWP categories sawnwood and wood-based panels and eq. 2.8.2 for category paper and paperboard.

The initial stock has been estimated using Equation 2.8.6 of KP Supplement with t0=1987. Default conversion factors has been applied as provided in Table 2.8.1 KP Supplement.

The FMRL of Bulgaria is based on a projection representing "business as usual scenario", so inherited emissions occurring during the second commitment period from HWP originating from forests prior to the start of the second commitment period are accounted for.

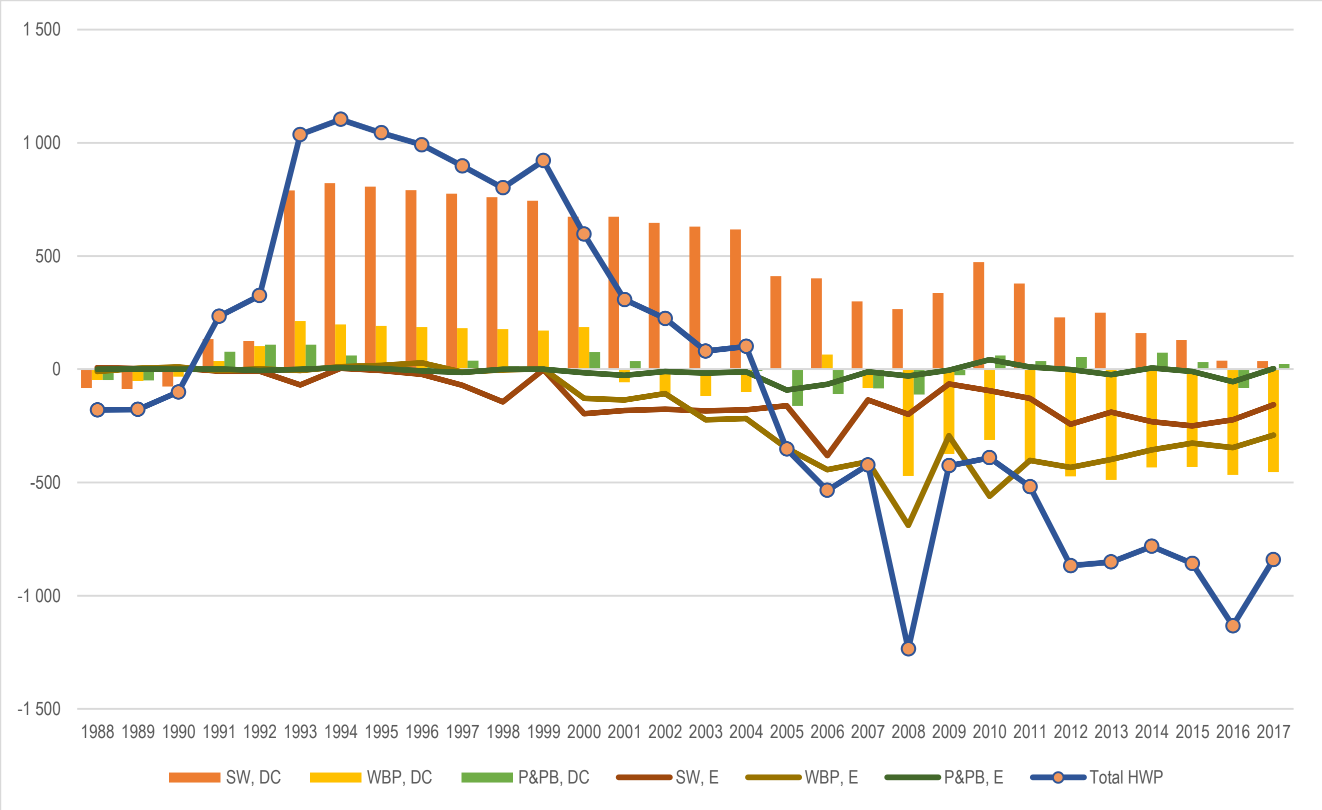

Figure 121 Emissions and removals from HWP, Gg CO2 eq

11.5.3 INFORMATION RELATING TO CROPLAND MANAGEMENT, GRAZING LAND MANAGEMENT, REVEGETATION AND WET DRAINAGE AND REWETTING, IF ELECTED, FOR THE BASE YEAR

NA for Bulgaria

11.6 OTHER INFORMATION

11.6.1 KEY CATEGORY ANALYSIS FOR ARTICLE 3.3 ACTIVITIES AND ANY ELECTED ACTIVITIES UNDER ARTICLE 3.4

11.7 INFORMATION REGARDING TO ARTICLE 6

NA for Bulgaria

12 INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1 BACKGROUND INFORMATION

Annex I parties are required to report from its national registry holding of and transaction of Kyoto Protocol units and inform about related issues as specified in Decision 15/CMP.1 Section E. Information about the transactions of the Kyoto-units is attached in to this document.

12.2 SUMMARY OF INFORMATION REPORTED IN THE SEF TABLES

Information from the national registry on acquisition, holding, transfer, cancellation, retirement and carry-over of AAUs, RMUs, ERUs, CERs, tCERs and lCERs for 2018 has been reported as separate file in xlsx and xml format each by separate upload.

12.3 DISCREPANCIES AND NOTIFICATION

Further information on Kyoto Protocol units referning to the respective paragraphs on decision 15/CMP 1 will be reported.

Paragraph 12: Discrepancies identified by the transaction log;

No discrepant transaction for the reporting period, pursuant of 15/CMP.1 annex I.E paragraph 12.

Paragraph13 & § 14: No CDM notifications occurred in 2018;

No CDM notifications were received by the National Registry during the reporting period, pursuant of 15/CMP.1 annex I.E paragraph 13 & 14.

Paragraph 15: No non–replacements occurred in 2018;

No non-replacements occurred during the reporting period, pursuant of 15/CMP.1 annex I.E paragraph 15.

Paragraph16: No invalid units exist as at 31 December 2018;

No invalid units exist for the reporting period, pursuant of 15/CMP.1 annex I.E paragraph 16

Paragraph 17: Actions necessary to correct any problem causing a discrepancy.

No actions were taken or changes made to address discrepancies for the period under review.

12.4 PUBLICLY ACCSSIBLE INFORMATION

Section E of the annex to decision 15/CMP.1 outlines provisions for the national registry to support, via a user-interface, non-confidential information being made available to the public. Bulgaria has made this information available on the Executive Environment Agency's website:

http://eea.government.bg/

The actual internet address of the Bulgarian registry in the Union registry is:

https://ets-registry.webgate.ec.europa.eu/euregistry/BG/index.xhtml

The following information has been made accessible to the public in line with the requirements. This information is non-confidential. Bulgaria considers all information to be confidential that is determined to be confidential according to article 110 of the Commission Regulation (EU) No 389/2013. Accounts' holding's publicly accessible information:

http://eea.government.bg/bg/r-r/r-te/registry/main3

The registry terms and conditions, operators guide, forms and guidance for opening the holding accounts are available at the website of Executive Environment Agency:

http://eea.government.bg/bg/r-r/r-te/registry/main7

http://eea.government.bg/bg/r-r/r-te/registry/main8

http://eea.government.bg/bg/r-r/r-te/registry/main9

http://eea.government.bg/bg/r-r/r-te/registry/main10

Joint implementation (JI) projects' publicly accessible information:

http://eea.government.bg/bg/r-r/r-te/registry/main3

The information of approved Joint Implementation projects and their documentation is added on the website of the competent authority (Ministry of the Environment and Waters) of JI projects and can be downloaded from the following link:

http://www5.moew.government.bg/?page_id=44747

Information according to paragraph 45 - 48 of the annex to decision 13/CMP.1:

(a) Account name: the holder of the account;

(b) Account type: the type of account (holding, cancellation or retirement);

(c) Commitment period: the commitment period with which a cancellation or retirement account is associated;

(d) Representative identifier: the representative of the account holder, using the Party identifier (the two-letter country code defined by ISO 3166) and a number unique to that representative within the Party's registry;

(e) Representative names nominated by the account holder and authorized to work with the account.

The Information includes the following Article 6 project information, for each project identifier if the Party has issued ERUs for a project:

(a) Project name: a unique name for the project;

(b) Project location: the Party and town or region in which the project is located;

(c) Years of ERU issuance: the years in which ERUs have been issued as a result of the Article 6 project;

(d) Reports: downloadable electronic versions of all publicly available documentation relating to the project, including proposals, monitoring, verification and issuance of ERUs, where relevant, subject to the confidentiality provisions in decision 9/CMP.1.

The information includes the following holding and transaction information relevant to the national registry, by serial number, for each calendar year:

(a) The total quantity of ERUs, CERs, AAUs and RMUs in each account at the beginning of the year (displayed in the year X+5, according to the Commission Regulation (EU) No 389/2013 the information is confidential until the year X+5);

(b) The total quantity of AAUs issued on the basis of the assigned amount pursuant to Article 3, paragraphs 7 and 8 (displayed in the year X+1);

(c) The total quantity of ERUs issued on the basis of Article 6 projects (displayed in the year X+1);

(d) The total quantity of ERUs, CERs, AAUs and RMUs acquired from other registries and the identity of the transferring accounts and registries (displayed in the year X+5, according to Commission Regulation (EU) No 389/2013 the information is confidential until the year X+5);

(e) The total quantity of RMUs issued on the basis of each activity under Article 3, paragraphs 3 and 4 (displayed in the year X+1)

(f) The total quantity of ERUs, CERs, AAUs and RMUs transferred to other registries and the identity of the acquiring accounts and registries (displayed in the year X+5, according to Commission regulation (EU) No 389/2013 the information is confidential until the year X+5)

(g) The total quantity of ERUs, CERs, AAUs and RMUs cancelled on the basis of activities under Article 3, paragraphs 3 and 4 (displayed in the year X+1)

(h) The total quantity of ERUs, CERs, AAUs and RMUs cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1 (displayed in the year X+1)

(i) The total quantity of other ERUs, CERs, AAUs and RMUs cancelled (displayed in the year X+1)

(j) The total quantity of ERUs, CERs, AAUs and RMUs retired (displayed in the year X+1)

(k) The total quantity of ERUs, CERs, and AAUs carried over from the previous commitment period (displayed in the year X+1)

(l) The Information does not include current holdings of ERUs, CERs, AAUs and RMUs in each account because this is confidential according to Commission Regulation (EU) No 389/2013.

12.5 CALCULATION OF THE COMMITEMENT PERIOD RESERVE CPR

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve (CPR) 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.

The national commitment period reserve is calculated in accordance with paragraph 6 of the Annex to decision 11/CMP.1 as 90% of the proposed assigned amount or 100% of eight times its most recently reviewed inventory, whichever is the lowest.

The first method calculation as 90% of the proposed assigned amount of Bulgaria gives the estimate:

CPR = 0,9 x 222 945 983 = 200 651 385 Mg CO_2 equivalent

The second method calculation as 100% of the most recently reviewed inventory (emission level 2016) of Bulgaria times eight gives the estimate:

CPR = 8 x 61 496 728 = 490 937 315 Mg CO_2 equivalent

Bulgaria has interpreted the ‘most recently reviewed inventory’ as the year 2016, which will be reviewed by Oktober 2018.

Therefore Bulgaria's estimated CPR is **200 651 385** Mg CO_2 equivalent.

12.6 KP-LULUCF ACCOUNTING

First commitment period In Table 260 data on accounting for the KP-LULUCF activities based on the reporting for the year 2017 are given. According to this information, Bulgaria would at the end of the commitment period be able to issue RMUs corresponding to the amount of 2.9 Tg CO_2 eq., which is Bulgaria’s cap value for forest management for the whole commitment period.

Table 260 Information table on accounting for activities under Articles 3.3 and 3.4 of the Kyoto Protocol.

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Base Year[2]	NET EMISSIONS/REMOVALS									Accounting parameters	Accounting quantity [4]
		2013	2014	2015	2016	2017	2018	2019	2020	Total[3]		
	(kt CO_2 eq)											
A. Article 3.3 activities												
A.1. Afforestation/reforestation		-1289.99	-1448.09	-1590.46	-1744.30	-1899.88				-7972.72		-7972.72
Excluded emissions from natural disturbances[5]		NO	NO	NO	NO	NO				NO		NO
Excluded subsequent removals from land subject to natural disturbances[6]		NO	NO	NO	NO	NO				NO		NO
A.2. Deforestation		140.22	66.39	176.69	150.54	160.84				694.68		694.68
B. Article 3.4 activities												
B.1. Forest management										-36079.69		3670.31
Net emissions/removals		-7285.78	-7211.77	-7184.56	-7348.32	-7049.27				-36079.69		
Excluded emissions from natural disturbances[5]		NA	NA	NA	NA	NA				NA		NA
Excluded subsequent removals from land subject to natural disturbances[6]		NO	NO	NO	NO	NO				NO		NO
Any debits from newly established forest (CEF-ne)[7],[8]		NA	NA	NA	NA	NA				NA		NA
Forest management reference level (FMRL)[9]											-7950.00	
Technical corrections to FMRL[10]											NA	
Forest management cap[11]											32691.37	3670.31
B.2. Cropland management (if elected)		NA	NA	NA	NA	NA				NA		NA
B.3. Grazing land management (if elected)		NA	NA	NA	NA	NA				NA		NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA				NA		NA
B.5. Wetland drainage and rewetting (if elected)		NA	NA	NA	NA	NA				NA		NA

Notes:

(2) Net emissions and removals from cropland management, grazing land management, revegetation and/or wetland drainage and rewetting, if elected, in the Party’s base year, as established by decision 9/CP.2.

(3) Cumulative net emissions and removals for all years of the commitment period reported in the current submission.

(4) The accounting quantity is the total quantity of units to be added to or subtracted from a Party's assigned amount for a particular activity in accordance with the provisions of Article 7.4 of the Kyoto Protocol.

(5) A Party that has indicated their intent to apply the natural disturbance provisions may choose to exclude emissions from natural disturbances either annually or at the end of the commitment period.

(6) Any subsequent removals on lands from which emissions from natural disturbances have been excluded is subtracted from the accounting quantity of the respective activity.

(7) A debit is generated in case the newly established forest does not reach at least the expected carbon stock at the end of the normal harvesting period. Total debits from carbon equivalent forests are subtracted from the accounting quantity forest management.

(8) In case of a projected forest management reference level, Parties should not fill in this row.

(9) Forest management reference level as inscribed in the appendix of the annex to decision 2/CMP.7, in kt CO2 eq per year.

(10) Technical corrections in accordance with paragraphs 14 and 15 of the annex to decision 2/CMP.7 and reported in table 4(KP-I)B.1.1 in kt CO2 eq per year.

(11) For the second commitment period, additions to the assigned amount of a Party resulting from forest management shall, in accordance with paragraph 13 of the annex to decision 2/CMP.7, not exceed 3.5 per cent of the national total emissions excluding LULUCF in the base year times eight.

13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

The order by the Executive Director of ExEA for Sector experts/QC experts will be revised in order to reflect relevant staffing changes of the inventory team.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Bulgaria have therefore occurred in 2017.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	A new registry administrator has been appointed since 30th January 2017: Ms. Polya Hristova e-mail: p.hristova@eea.government.bg Tel.:+359 2 9406416 Fax: +359 2 9559015 Executive Environment Agency Address: 136 Tzar Boris III Blvd., P.O. Box 251 1618 Sofia Bulgaria
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	The versions of the EUCR released after 8.0.8 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model, including the new tables, is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.8 of the national registry are listed in Annex B. 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 B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	The registry internet address changed during the reported period. The new URL is https://unionregistry.ec.europa.eu/euregistry/BG/index.xhtml

Reporting Item	Description
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 8.0.8 of the national registry are listed in Annex B. 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

According to the Article 3, paragraph 14 of the Kyoto Protocol, Annex I countries shall provide information on how is striving to implement commitments in such a way as to minimize potential adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention.

Impacts on third countries are mostly indirect and frequently cannot be directly attributed to a specific policy. Therefore we cannot consider that there is an adverse social, environmental and economic impact on developing countries due to our national climate change policy.

The application of the Joint Implementation mechanism in our country aims to renew the old tehnologies and improves energy efficiency, with no transboundary effects, as well as the implementation in Bulgaria of the European Union Emission Trading Scheme.

Nonetheless Bulgaria is of the view that taking the actions on mitigation, adaptation, development technology and transfer and capacity building in developing countries is very important for international climate change policy.

In this regard, in 2012 completed the project "Bulgarian contribution to the "short-term financing" 2011-2012: Sharing Bulgarian experience of monitoring, reporting and verification of greenhouse gas in the Republic of Macedonia for participation in the European Union Emission Trading Scheme of greenhouse gases". Through this project, Bulgaria has fulfilled its obligation, which made at the summit of the European Union in December 2009, to provide short-term financing of climate activities.

According to the Article 3, paragraph 14 of the Kyoto Protocol, Annex I countries shall provide information on how give priority, in implementing the commitments under Article 3, paragraph 14, to specific actions.

The majority of Bulgarian legislation measures in the climate change area, are connected mainly with transposing of the European legislation, as well as other activities on implementation of directives, connected with the politics on climate change.

The table below summarizes how the Party gives priority to selected actions, identified in paragraph 24 of the Annex to Decision 15/CMP.1.

Table 261 Selected actions, identified in Para 24 of the Annex to Decision 15/CMP.1.

Action	Implementation by the Party
The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities.	**Market imperfection** The Climate Change Mitigation Act and Clean Ambient Air Act and related secondary legislation, including a permit system for meeting minimum standards in accordance with EU regulation on Large Combustion Plants (LPS), participation in the EU ETS and technical inspection (e.g. for cars) etc; The Energy Act, in its part on combined heat and power generation introduces the requirements of the related EU directives and the use preferential feed-in tariffs and mandates the state regulations to the licensed activities in the power sector and purchase obligations for the Transmission and Distribution Companies to buy all electricity produced from high efficient cogeneration, and for district heating companies to buy all utilized waste thermal energy.

Action	Implementation by the Party
	The Energy from Renewable Sources Act introduces the requirements of the related EU directives and the use of instruments such as green certificates and preferential feed in tariffs, mandates the state regulations to the licensed activities in the power sector and purchase obligations for the Transmission and Distribution Companies to by all electricity produced from renewable sources. It regulates the acceptance and realization of national indicative targets for consumption of bio fuels and other renewable fuels in the transport sector as a part of the total consumption of transport fuels; The Energy Efficiency Act and related secondary legislation, including obligation to adopt municipal energy efficiency programs, requirements for energy efficiency labelling, the use of minimum standards resulting from the EU directive on energy efficient appliances, regulations for energy efficiency labelling of various types of products (appliances, cars), obligatory audits and amendments of the Energy Performance Standards for existing buildings; The Waste Management Act and the related secondary legislation including the obligation for collecting, management and usage (or combustion) of the omitted gases from the new waste deposits; **Fiscal policy** A number of stimulating measures for the subjects of taxation were introduced in the Act on amendment and supplement of the Corporate Income Tax Act and also in the Act on amendment and supplement of the Income Taxes on Natural Persons Act ; The on-going liberalization of energy market is in line with EU policies and directives; The main instrument addressing externalities is emission trading under the EU ETS.

PART 2: ANNEXES TO THE NATIONAL INVENTORY REPORT

ANNEX 1 KEY CATEGORY ANALYSIS (KCA)

The key category analysis is performed according to the 2006 IPCC Guidelines (IPCC 2006, chapter 4): An Approach 1 level and trend assessment is applied with the proposed threshold of 95%. An Approach 2 key category analysis has also been carried out for this submission of all level assessments weighted with their relative source uncertainty. All main source categories have been disaggregated into main sub-sources (e.g. 2A, 2B, 2C etc.) and gases (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

The key sources are defined according to the IPCC classification. It is advisably that the key sources in superior degree are correspondent to the structure of the fuels and the activities in the country.

By Approach 1 are defined key sources accounting two rules:

- Rule A – Level assessment of the GHG emissions in absolute value expressed in Gg;

- Rule B – Trend assessment of the emissions from the base year until the current year of the inventory.

By applying rule A is used information for the volume of the source emissions only for the current year of the inventory.

The application of rule B requires information for the GHG emissions for the base year in the country. That means that the trend assessment includes additional information and gives the possibility for thorough analysis of the key sources.

The identification of key categories consists of following steps:

- Identifying categories
- Level Assessment excluding LULUCF
- Level Assessment including LULUCF
- Trend Assessment excluding LULUCF
- Trend Assessment including LULUCF

Table 262 Key category Analysis T1: Trend assessment excluding LULUCF

Source	Gas	Fuel/Cat.	1988 (BY) Gg CO_2-eq.	2017 Gg CO_2-eq.	% excl. (2017)	Trend	Contribution to Trend	cumul. %
1A1	CO2	**Solid fuels**	25416.6	24316.0	39.62%	0.339690	21.97%	21.97%
1A2	CO2	**Solid fuels**	10047.7	434.5	0.71%	0.150260	9.72%	31.69%
1A3b	CO2	**Diesel Oil**	2617.2	5830.9	9.50%	0.138125	8.93%	40.63%
1A1	CO2	**Liquid fuels**	10099.2	1294.9	2.11%	0.124425	8.05%	48.68%
1A2	CO2	**Liquid fuels**	7319.8	1219.7	1.99%	0.081465	5.27%	53.95%
5D	CH4	**Wastewater treatment and discharge**	3045.9	753.9	2.75%	0.058777	3.80%	57.75%
2F	CO2eq	**Product uses as substitutes for ODS - HFCs and PFCs**	0.0	1817.9	2.96%	0.056360	3.65%	61.39%
2C1	CO2	**Iron and Steel Production**	3481.4	35.2	0.06%	0.055641	3.60%	64.99%
1A2	CO2	**Gaseous fuels**	0.0	1791.5	2.92%	0.055541	3.59%	68.58%
1A1	CO2	**Gaseous fuels**	6508.6	1943.7	3.17%	0.045798	2.96%	71.55%
1A3b	CO2	**LPG**	0.0	1317.8	2.15%	0.040856	2.64%	74.19%
1A4	CO2	**Solid fuel**	3548.1	663.5	1.08%	0.037245	2.41%	76.60%
1A4	CO2	**Liquid fuel**	2825.1	530.7	0.86%	0.029581	1.91%	78.51%
2B2	N2O	**Nitric Acid Production**	1932.0	93.5	0.15%	0.028585	1.85%	80.36%
5B	CH4	**Biological treatment of solid waste**	0.0	23.8	1.47%	0.028036	1.81%	82.18%
1B2	CO2	**Oil and Natural Gas**	5.0	804.2	1.31%	0.024851	1.61%	83.78%
2A4d	CO2	**DeSOx - instalations**	0.0	785.2	1.28%	0.024345	1.57%	85.36%
3Da	N2O	**Direct N2O emissions from managed soils**	4994.7	3394.7	5.53%	0.023854	1.54%	86.90%
1A3b	CO2	**Gasoline**	4217.0	1517.5	2.47%	0.021673	1.40%	88.30%
3A2	CH4	**Sheep**	1603.4	246.6	0.40%	0.018483	1.20%	89.50%
5A	CH4	**Solid waste disposal**	4922.4	2832.5	10.24%	0.016867	1.09%	90.59%
3A1	CH4	**Cattle**	3074.8	1160.9	1.89%	0.014116	0.91%	91.50%
1A4	CO2	**Gaseous fuel**	0.0	413.3	0.67%	0.012814	0.83%	92.33%
1A3e	CO2	**Gaseous fuel**	0.0	397.1	0.65%	0.012312	0.80%	93.13%
2B7	CO2	**Soda ash production**	397.6	561.8	0.92%	0.010938	0.71%	93.84%
1B1	CH4	**Solid fuel**	2179.2	844.5	1.38%	0.009329	0.60%	94.44%
2B1	CO2	**Ammonia Production**	2557.5	1086.5	1.77%	0.007991	0.52%	94.96%
3B3	CH4	**Swine**	519.9	69.4	0.11%	0.006322	0.41%	95.36%

Table 263 Key category Analysis T1: Trend assessment including LULUCF

Source	Gas	Fuel/Cat.	1988 (BY) Gg CO_2-eq.	2017 Gg CO_2-eq.	% incl. (2017)	Trend	Contribution to Trend	cumul. %
1A1	CO2	**Solid fuels**	25416.6	24316.0	33.05%	0.242280	18.45%	18.45%
1A2	CO2	**Solid fuels**	10047.7	434.5	0.59%	0.126083	9.60%	28.05%
1A1	CO2	**Liquid fuels**	10099.2	1294.9	1.76%	0.105986	8.07%	36.12%
1A3b	CO2	**Diesel Oil**	2617.2	5830.9	7.93%	0.105371	8.02%	44.14%
1A2	CO2	**Liquid fuels**	7319.8	1219.7	1.66%	0.070020	5.33%	49.47%
2C1	CO2	**Iron and Steel Production**	3481.4	35.2	0.05%	0.046476	3.54%	53.01%
2F	CO2eq	**Product uses as substitutes for ODS - HFCs and PFCs**	0.0	1817.9	2.47%	0.043944	3.35%	56.36%
1A2	CO2	**Gaseous fuels**	0.0	1791.5	2.44%	0.043306	3.30%	59.65%
1A1	CO2	**Gaseous fuels**	6508.6	1943.7	2.64%	0.041491	3.16%	62.81%
4C2	CO2	**Land converted to Grassland**	-2.2	-1687.3	2.29%	0.040757	3.10%	65.92%
1A4	CO2	**Solid fuel**	3548.1	663.5	0.90%	0.032192	2.45%	68.37%
1A3b	CO2	**LPG**	0.0	1317.8	1.79%	0.031855	2.43%	70.79%
4B1	CO2	**Cropland remainig Cropland**	-1109.8	540.6	0.73%	0.028154	2.14%	72.94%
1A4	CO2	**Liquid fuel**	2825.1	530.7	0.72%	0.025574	1.95%	74.88%
2B2	N2O	**Nitric Acid Production**	1932.0	93.5	0.13%	0.024004	1.83%	76.71%
5D	CH4	**Wastewater treatment and discharge**	3045.9	753.9	1.02%	0.023181	1.77%	78.48%
1A3b	CO2	**Gasoline**	4217.0	1517.5	2.06%	0.020644	1.57%	80.05%
1B2	CO2	**Oil and Natural Gas**	5.0	804.2	1.09%	0.019372	1.47%	81.52%
2A4d	CO2	**DeSOx - instalations**	0.0	785.2	1.07%	0.018982	1.45%	82.97%
4G	CO2	**Harvested wood products**	-180.0	-840.7	1.14%	0.017874	1.36%	84.33%
3A2	CH4	**Sheep**	1603.4	246.6	0.34%	0.015835	1.21%	85.54%
3Da	N2O	**Direct N2O emissions from managed soils**	4994.7	3394.7	4.61%	0.014162	1.08%	86.61%
4A2	CO2	**Land converted to Forest Land**	-567.9	-904.3	1.23%	0.014139	1.08%	87.69%
3A1	CH4	**Cattle**	3074.8	1160.9	1.58%	0.013737	1.05%	88.74%
4E2	CO2	**Land converted to Settlements**	524.3	846.8	1.15%	0.013342	1.02%	89.75%
1A4	CO2	**Gaseous fuel**	0.0	413.3	0.56%	0.009991	0.76%	90.51%
4F	CO2	**Land converted to other land**	11.9	-401.7	0.55%	0.009873	0.75%	91.26%
1A3e	CO2	**Gaseous fuel**	0.0	397.1	0.54%	0.009600	0.73%	92.00%
1B1	CH4	**Solid fuel**	2179.2	844.5	1.15%	0.009210	0.70%	92.70%
2B1	CO2	**Ammonia Production**	2557.5	1086.5	1.48%	0.008503	0.65%	93.34%
2B7	CO2	**Soda ash production**	397.6	561.8	0.76%	0.008175	0.62%	93.97%
4D2	CO2	**Land converted to Wetlands**	0.0	281.6	0.38%	0.006808	0.52%	94.48%
3B	N2O	**N2O em. from Manure Management**	1299.2	481.3	0.65%	0.006028	0.46%	94.94%
3B3	CH4	**Swine**	519.9	69.4	0.09%	0.005391	0.41%	95.35%

Table 264 Key category Analysis T1: Level Assessment excluding LULUCF 1988

Source	Gas	Fuel/Cat.	GHG emission [Gg CO_2 eq]	% excl.	cumul. %
1A1	CO2	Solid fuels	25 416.6	21.8%	21.8%
1A1	CO2	Liquid fuels	10 099.2	8.6%	30.4%
1A2	CO2	Solid fuels	10 047.7	8.6%	39.0%
1A2	CO2	Liquid fuels	7 319.8	6.3%	45.3%
1A1	CO2	Gaseous fuels	6 508.6	5.6%	50.9%
1A5	CO2	Stationary - Fossil fuels	5 093.8	4.4%	55.2%
3Da	N2O	Direct N2O emissions from managed soils	4 994.7	4.3%	59.5%
5A	CH4	Solid waste disposal	4 922.4	4.2%	63.7%
1A3b	CO2	Gasoline	4 217.0	3.6%	67.3%
1A4	CO2	Solid fuel	3 548.1	3.0%	70.4%
2C1	CO2	Iron and Steel Production	3 481.4	3.0%	73.4%
3A1	CH4	Cattle	3 074.8	2.6%	76.0%
5D	CH4	Wastewater treatment and discharge	3 045.9	2.6%	78.6%
1A4	CO2	Liquid fuel	2 825.1	2.4%	81.0%
1A3b	CO2	Diesel Oil	2 617.2	2.2%	83.3%
2B1	CO2	Ammonia Production	2 557.5	2.2%	85.5%
2A1	CO2	Cement Production	2 406.3	2.1%	87.5%
1B1	CH4	Solid fuel	2 179.2	1.9%	89.4%
2B2	N2O	Nitric Acid Production	1 932.0	1.7%	91.0%
3A2	CH4	Sheep	1 603.4	1.4%	92.4%
3Db	N2O	Indirect N2O Emissions from managed soils	1 474.9	1.3%	93.7%
3B	N2O	N2O em. from Manure Management	1 299.2	1.1%	94.8%
2A4a	CO2	Ceramics - Bricks and Tails	522.5	0.4%	95.2%

Table 265 Key category Analysis T1: Level Assessment including LULUCF 1988

Source	Gas	Fuel/Cat.	GHG emission [Gg CO_2 eq]	% incl.	cumul. %
1A1	CO2	Solid fuels	25 416.6	19.4%	19.4%
4A1	CO2	Forest Land remaining Forest Land	11 513.9	8.8%	28.2%
1A1	CO2	Liquid fuels	10 099.2	7.7%	36.0%
1A2	CO2	Solid fuels	10 047.7	7.7%	43.6%
1A2	CO2	Liquid fuels	7 319.8	5.6%	49.2%
1A1	CO2	Gaseous fuels	6 508.6	5.0%	54.2%
1A5	CO2	Stationary - Fossil fuels	5 093.8	3.9%	58.1%
3Da	N2O	Direct N2O emissions from managed soils	4 994.7	3.8%	61.9%
5A	CH4	Solid waste disposal	4 922.4	3.8%	65.7%
1A3b	CO2	Gasoline	4 217.0	3.2%	68.9%
1A4	CO2	Solid fuel	3 548.1	2.7%	71.6%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO_2 eq]	% incl.	cumul. %
2C1	CO2	**Iron and Steel Production**	3 481.4	2.7%	74.3%
3A1	CH4	**Cattle**	3 074.8	2.4%	76.6%
5D	CH4	**Wastewater treatment and discharge**	3 045.9	2.3%	79.0%
1A4	CO2	**Liquid fuel**	2 825.1	2.2%	81.1%
1A3b	CO2	**Diesel Oil**	2 617.2	2.0%	83.1%
2B1	CO2	**Ammonia Production**	2 557.5	2.0%	85.1%
2A1	CO2	**Cement Production**	2 406.3	1.8%	86.9%
1B1	CH4	**Solid fuel**	2 179.2	1.7%	88.6%
2B2	N2O	**Nitric Acid Production**	1 932.0	1.5%	90.1%
3A2	CH4	**Sheep**	1 603.4	1.2%	91.3%
3Db	N2O	**Indirect N2O Emissions from managed soils**	1 474.9	1.1%	92.4%
3B	N2O	**N2O em. from Manure Management**	1 299.2	1.0%	93.4%
4B1	CO2	**Cropland remainig Cropland**	1 109.8	0.8%	94.2%
4A2	CO2	**Land converted to Forest Land**	567.9	0.4%	94.7%
4E2	CO2	**Land converted to Settlements**	524.3	0.4%	95.1%

Table 266 Key category Analysis T1: Level Assessment excluding LULUCF 2017

Source	Gas	Fuel/Cat.	GHG emission [Gg CO_2 eq]	% excl.	cumul. %
1A1	CO2	**Solid fuels**	24 316.0	39.6%	39.6%
1A3b	CO2	**Diesel Oil**	5 830.9	9.5%	49.1%
3Da	N2O	**Direct N2O emissions from managed soils**	3 394.7	5.5%	54.7%
5A	CH4	**Solid waste disposal**	2 832.5	4.6%	59.3%
1A1	CO2	**Gaseous fuels**	1 943.7	3.2%	62.4%
2F	CO2eq	**Product uses as substitutes for ODS - HFCs and PFCs**	1 817.9	3.0%	65.4%
1A2	CO2	**Gaseous fuels**	1 791.5	2.9%	68.3%
1A3b	CO2	**Gasoline**	1 517.5	2.5%	70.8%
1A3b	CO2	**LPG**	1 317.8	2.1%	72.9%
1A1	CO2	**Liquid fuels**	1 294.9	2.1%	75.1%
2A1	CO2	**Cement Production**	1 237.6	2.0%	77.1%
1A2	CO2	**Liquid fuels**	1 219.7	2.0%	79.1%
3A1	CH4	**Cattle**	1 160.9	1.9%	80.9%
2B1	CO2	**Ammonia Production**	1 086.5	1.8%	82.7%
3Db	N2O	**Indirect N2O Emissions from managed soils**	889.4	1.4%	84.2%
1B1	CH4	**Solid fuel**	844.5	1.4%	85.5%
1B2	CO2	**Oil and Natural Gas**	804.2	1.3%	86.9%
2A4d	CO2	**DeSOx - instalations**	785.2	1.3%	88.1%
5D	CH4	**Wastewater treatment and discharge**	753.9	1.2%	89.4%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO_2 eq]	% excl.	cumul. %
1A4	CO2	Solid fuel	663.5	1.1%	90.4%
2B7	CO2	Soda ash production	561.8	0.9%	91.4%
1A4	CO2	Liquid fuel	530.7	0.9%	92.2%
3B	N2O	N2O em. from Manure Management	481.3	0.8%	93.0%
1A2	CO2	Solid fuels	434.5	0.7%	93.7%
1A4	CO2	Gaseous fuel	413.3	0.7%	94.4%
1A3e	CO2	Gaseous fuel	397.1	0.6%	95.0%

Table 267 Key category Analysis T1: Level Assessment including LULUCF 2017

Source	Gas	Fuel/Cat.	GHG emission [Gg CO_2 eq]	% incl.	cumul. %
1A1	CO2	Solid fuels	24 316.0	33.1%	33.1%
4A1	CO2	Forest Land remaining Forest Land	6 284.0	8.5%	41.6%
1A3b	CO2	Diesel Oil	5 830.9	7.9%	49.5%
3Da	N2O	Direct N2O emissions from managed soils	3 394.7	4.6%	54.1%
5A	CH4	Solid waste disposal	2 832.5	3.9%	58.0%
1A1	CO2	Gaseous fuels	1 943.7	2.6%	60.6%
2F	CO2eq	Product uses as substitutes for ODS - HFCs and PFCs	1 817.9	2.5%	63.1%
1A2	CO2	Gaseous fuels	1 791.5	2.4%	65.5%
4C2	CO2	Land converted to Grassland	1 687.3	2.3%	67.8%
1A3b	CO2	Gasoline	1 517.5	2.1%	69.9%
1A3b	CO2	LPG	1 317.8	1.8%	71.7%
1A1	CO2	Liquid fuels	1 294.9	1.8%	73.4%
2A1	CO2	Cement Production	1 237.6	1.7%	75.1%
1A2	CO2	Liquid fuels	1 219.7	1.7%	76.8%
3A1	CH4	Cattle	1 160.9	1.6%	78.4%
2B1	CO2	Ammonia Production	1 086.5	1.5%	79.8%
4A2	CO2	Land converted to Forest Land	904.3	1.2%	81.1%
3Db	N2O	Indirect N2O Emissions from managed soils	889.4	1.2%	82.3%
4E2	CO2	Land converted to Settlements	846.8	1.2%	83.4%
1B1	CH4	Solid fuel	844.5	1.1%	84.6%
4G	CO2	Harvested wood products	840.7	1.1%	85.7%
1B2	CO2	Oil and Natural Gas	804.2	1.1%	86.8%
2A4d	CO2	DeSOx - instalations	785.2	1.1%	87.9%
5D	CH4	Wastewater treatment and discharge	753.9	1.0%	88.9%
1A4	CO2	Solid fuel	663.5	0.9%	89.8%
2B7	CO2	Soda ash production	561.8	0.8%	90.6%
4B1	CO2	Cropland remainig Cropland	540.6	0.7%	91.3%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO_2 eq]	% incl.	cumul. %
1A4	CO2	**Liquid fuel**	530.7	0.7%	92.0%
3B	N2O	**N2O em. from Manure Management**	481.3	0.7%	92.7%
1A2	CO2	**Solid fuels**	434.5	0.6%	93.3%
1A4	CO2	**Gaseous fuel**	413.3	0.6%	93.8%
4F	CO2	**Land converted to other land**	401.7	0.5%	94.4%
1A3e	CO2	**Gaseous fuel**	397.1	0.5%	94.9%
1A4	CH4	**All fuel**	313.4	0.4%	95.3%

1.2 Approach 2 for Key Category Assessment

With the use of the uncertainty assessments for each key categories in the form of weight factor/coefficient is done, which is the Approach 2 method according to 2006 IPCC Guidelines. It is helpful in prioritising activities to improve inventory quality and to reduce overall uncertainty.

Under Approach 2, the source or sink category uncertainties are incorporated by weighting the Approach 1 level and trend assessment results with the source category’s relative uncertainty.

Therefore the following equation Approach 2 has been applied for the current year submission:

*Level Assessment, with Uncertainty = Approach 1 Level Assessment * Relative Category Uncertainty*

*Trend Assessment, with Uncertainty = Approach 1 Trend Assessment * Relative Category Uncertainty*

The results of the Approach 2 category analysis, without LULUCF categories, are provided in Table 268 and Table 270 for 2017, while inTable 269 and Table 271 the results, including LULUCF categories, are shown.

Table 268 Key category Analysis T2: Trend assessment excluding LULUCF

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment excluding LULUCF	Cumulative Percentage	T2
15	**5B**	**Biological treatment of solid waste**	CH4	0.018	401.123	7.274	0.258	0.258	1
18	**3Da**	**Direct N2O emissions from managed soils**	N2O	0.015	250.018	3.858	0.137	0.395	2
6	**5D**	**Wastewater treatment and discharge**	CH4	0.038	84.812	3.225	0.115	0.510	3
7	**2F**	**Product uses as substitutes for ODS - HFCs and PFCs**	CO2eq	0.036	50.990	1.859	0.066	0.576	4
16	**1B2**	**Oil and Natural Gas**	CO2	0.016	100.125	1.609	0.057	0.633	5
29	**3B**	**N2O em. from Manure Management**	N2O	0.004	300.007	1.213	0.043	0.676	6
26	**1B1**	**Solid fuel**	CH4	0.006	200.250	1.208	0.043	0.719	7
36	**3Db**	**Indirect N2O Emissions from managed soils**	N2O	0.002	500.009	1.145	0.041	0.760	8
21	**5A**	**Solid waste disposal**	CH4	0.011	85.440	0.932	0.033	0.793	9
4	**1A1**	**Liquid fuels**	CO2	0.080	7.616	0.613	0.022	0.814	10
3	**1A3b**	**Diesel Oil**	CO2	0.089	5.831	0.521	0.018	0.833	11
1	**1A1**	**Solid fuels**	CO2	0.220	2.236	0.491	0.017	0.850	12
5	**1A2**	**Liquid fuels**	CO2	0.053	7.616	0.401	0.014	0.865	13
31	**5C**	**Incineration and open burning of waste**	CH4	0.004	100.499	0.370	0.013	0.878	14
8	**2C1**	**Iron and Steel Production**	CO2	0.036	7.071	0.254	0.009	0.887	15
20	**3A2**	**Sheep**	CH4	0.012	20.100	0.240	0.009	0.895	16
2	**1A2**	**Solid fuels**	CO2	0.097	2.236	0.217	0.008	0.903	17
37	**5C**	**Incineration and open burning of waste**	N2O	0.002	100.499	0.190	0.007	0.910	18
14	**2B2**	**Nitric Acid Production**	N2O	0.018	10.198	0.189	0.007	0.917	19
22	**3A1**	**Cattle**	CH4	0.009	20.100	0.184	0.007	0.923	20
39	**1B2**	**Oil and Natural Gas**	CH4	0.002	100.125	0.177	0.006	0.929	21
13	**1A4**	**Liquid fuel**	CO2	0.019	8.602	0.165	0.006	0.935	22
11	**1A3b**	**LPG**	CO2	0.026	5.831	0.154	0.005	0.941	23
47	**1A1**	**All fuel**	N2O	0.001	200.022	0.150	0.005	0.946	24
33	**1A4**	**All fuel**	CH4	0.003	50.249	0.139	0.005	0.951	25
12	**1A4**	**Solid fuel**	CO2	0.024	5.385	0.130	0.005	0.956	26
51	**1A2**	**All fuel**	N2O	0.001	200.022	0.114	0.004	0.960	27
54	**1A4**	**All fuel**	N2O	0.001	200.062	0.100	0.004	0.963	28
28	**3B3**	**Swine**	CH4	0.004	20.100	0.082	0.003	0.966	29
19	**1A3b**	**Gasoline**	CO2	0.014	5.831	0.082	0.003	0.969	30
9	**1A2**	**Gaseous fuels**	CO2	0.036	2.236	0.080	0.003	0.972	31
34	**2C2**	**Ferroalloys Production**	CO2	0.003	25.495	0.069	0.002	0.974	32
10	**1A1**	**Gaseous fuels**	CO2	0.030	2.236	0.066	0.002	0.977	33
53	**3C**	**Rice Cultivation**	CH4	0.001	83.815	0.046	0.002	0.978	34
44	**3A4**	**Other livestock**	CH4	0.001	50.040	0.045	0.002	0.980	35
23	**1A4**	**Gaseous fuel**	CO2	0.008	5.385	0.045	0.002	0.981	36

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment excluding LULUCF	Cumulative Percentage	T2
24	1A3e	Gaseous fuel	CO2	0.008	5.099	0.041	0.001	0.983	37
42	1A3b	All fuel	N2O	0.001	40.112	0.039	0.001	0.984	38
27	2B1	Ammonia Production	CO2	0.005	7.280	0.038	0.001	0.986	39
17	2A4d	DeSOx - instalations	CO2	0.016	2.121	0.033	0.001	0.987	40
50	5D	Wastewater treatment and discharge	N2O	0.001	53.852	0.033	0.001	0.988	41
38	2C2	Zinc production	CO2	0.002	15.811	0.029	0.001	0.989	42
40	2C2	Lead production	CO2	0.002	15.811	0.024	0.001	0.990	43
30	2A4a	Ceramics - Bricks and Tails	CO2	0.004	5.831	0.023	0.001	0.991	44
41	3A3	Swine	CH4	0.001	20.100	0.023	0.001	0.991	45
49	2D	Non-energy products from fuels and solvent use	CO2	0.001	31.623	0.021	0.001	0.992	46
32	1A3b	Gaseous fuel	CO2	0.004	5.831	0.021	0.001	0.993	47
25	2B7	Soda ash production	CO2	0.007	2.828	0.020	0.001	0.994	48
73	1B2	Oil and Natural Gas	N2O	0.000	1000.012	0.016	0.001	0.994	49
58	2G1	Electrical equipment - SF6	CO2eq	0.000	50.990	0.016	0.001	0.995	50
57	5B	Biological treatment of solid waste	N2O	0.000	42.426	0.014	0.001	0.995	51
62	3F	Field burning of agricultural residues	CH4	0.000	55.902	0.013	0.000	0.996	52
35	1A2	Other fossil fuels	CO2	0.002	5.385	0.013	0.000	0.996	53
69	3F	Field burning of agricultural residues	N2O	0.000	201.556	0.013	0.000	0.997	54
59	1A3b	All fuel	CH4	0.000	40.112	0.012	0.000	0.997	55
63	3B4	Other livestock	CH4	0.000	50.040	0.010	0.000	0.997	56
48	2B5b	Calcium Carbide	CO2	0.001	11.180	0.008	0.000	0.998	57
65	1A3d	Gas/diesel oil	CO2	0.000	50.249	0.007	0.000	0.998	58
55	3B2	Sheep	CH4	0.000	20.100	0.007	0.000	0.998	59
56	3B1	Cattle	CH4	0.000	20.100	0.007	0.000	0.998	60
43	1A3a	Liquid fuel	CO2	0.001	7.071	0.007	0.000	0.999	61
46	1A3c	Liquid fuel	CO2	0.001	7.071	0.006	0.000	0.999	62
67	1A3c	Liquid fuel	N2O	0.000	60.208	0.006	0.000	0.999	63
64	2G	Other product manufacture and use	CO2	0.000	31.623	0.006	0.000	0.999	64
68	1A2	All fuel	CH4	0.000	50.090	0.004	0.000	0.999	65
61	2A3	Glass production	CO2	0.000	14.142	0.003	0.000	1.000	66
45	2A4b	Soda ash uses	CO2	0.001	2.236	0.002	0.000	1.000	67
71	1A1	All fuel	CH4	0.000	50.090	0.002	0.000	1.000	68
52	2A1	Cement Production	CO2	0.001	2.121	0.001	0.000	1.000	69
70	2H	Other	CO2	0.000	31.623	0.001	0.000	1.000	70
66	2G	Other product manufacture and use	N2O	0.000	10.050	0.001	0.000	1.000	71
74	3H	Urea application	CO2	0.000	50.040	0.001	0.000	1.000	72
60	2A2	Lime Production	CO2	0.000	2.828	0.001	0.000	1.000	73
76	5C	Incineration and open burning of waste	CO2	0.000	100.499	0.001	0.000	1.000	74

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment excluding LULUCF	Cumulative Percentage	T2
77	1A3e	Gaseous fuel	N2O	0.000	150.003	0.001	0.000	1.000	75
72	2C2	Ferroalloys Production	CH4	0.000	25.495	0.001	0.000	1.000	76
75	1A3a	Liquid fuel	N2O	0.000	40.311	0.000	0.000	1.000	77
78	1A3e	Gaseous fuel	CH4	0.000	50.010	0.000	0.000	1.000	78
79	1A3d	Gas/diesel oil	N2O	0.000	148.661	0.000	0.000	1.000	79
80	1A3c	Liquid fuel	CH4	0.000	60.208	0.000	0.000	1.000	80
81	1A3d	Gas/diesel oil	CH4	0.000	70.711	0.000	0.000	1.000	81
82	1A3a	Liquid fuel	CH4	0.000	40.311	0.000	0.000	1.000	82
83	1A3b	Other liquid fuels	CO2	0.000	5.831	0.000	0.000	1.000	83
84	1A5	Stationary - Fossil fuels	CO2	0.000	8.602	0.000	0.000	1.000	84
85	1A5	Stationary - Fossil fuels	CH4	0.000	50.249	0.000	0.000	1.000	85
86	1A5	Stationary - Fossil fuels	N2O	0.000	200.062	0.000	0.000	1.000	86
87	2B8	Petrochemical and carbon black production	CH4	0.000	11.180	0.000	0.000	1.000	87
88	2B8b	Ethylene	CO2	0.000	30.414	0.000	0.000	1.000	88
89	2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	0.000	20.616	0.000	0.000	1.000	89
90	2C1	Iron and Steel Production	CH4	0.000	26.926	0.000	0.000	1.000	90

Table 269 Key category Analysis T2: Trend assessment including LULUCF

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment including LULUCF	Cumulative Percentage	T2
10	4C2	Land converted to Grassland	CO2	0.031	444.813	13.804	0.327	0.327	1
13	4B1	Cropland remainig Cropland	CO2	0.021	184.043	3.945	0.093	0.420	2
22	3Da	Direct N2O emissions from managed soils	N2O	0.011	250.018	2.696	0.064	0.484	3
23	4A2	Land converted to Forest Land	CO2	0.011	191.262	2.059	0.049	0.533	4
7	2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0.033	50.990	1.706	0.040	0.574	5
35	4B2	Land converted to Cropland	CO2	0.004	415.466	1.676	0.040	0.613	6
37	4A1	Forest Land remaining Forest Land	CO2	0.004	436.010	1.532	0.036	0.650	7
16	5D	Wastewater treatment and discharge	CH4	0.018	84.812	1.497	0.035	0.685	8
18	1B2	Oil and Natural Gas	CO2	0.015	100.125	1.477	0.035	0.720	9
29	1B1	Solid fuel	CH4	0.007	200.250	1.404	0.033	0.753	10
33	3B	N2O em. from Manure Management	N2O	0.005	300.007	1.377	0.033	0.786	11
20	4G	Harvested wood products	CO2	0.014	73.682	1.003	0.024	0.810	12
43	4	Indirect N2O Emissions from managed soils	N2O	0.002	500.009	0.828	0.020	0.829	13
25	4E2	Land converted to Settlements	CO2	0.010	75.000	0.762	0.018	0.847	14
3	1A1	Liquid fuels	CO2	0.081	7.616	0.615	0.015	0.862	15
49	3Db	Indirect N2O Emissions from managed soils	N2O	0.001	500.009	0.552	0.013	0.875	16
4	1A3b	Diesel Oil	CO2	0.080	5.831	0.468	0.011	0.886	17

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment including LULUCF	Cumulative Percentage	T2
1	1A1	Solid fuels	CO2	0.184	2.236	0.412	0.010	0.896	18
5	1A2	Liquid fuels	CO2	0.053	7.616	0.406	0.010	0.905	19
27	4F	Land converted to other land	CO2	0.008	50.990	0.383	0.009	0.915	20
6	2C1	Iron and Steel Production	CO2	0.035	7.071	0.250	0.006	0.920	21
21	3A2	Sheep	CH4	0.012	20.100	0.242	0.006	0.926	22
2	1A2	Solid fuels	CO2	0.096	2.236	0.215	0.005	0.931	23
24	3A1	Cattle	CH4	0.010	20.100	0.210	0.005	0.936	24
15	2B2	Nitric Acid Production	N2O	0.018	10.198	0.186	0.004	0.941	25
61	5B	Biological treatment of solid waste	CH4	0.000	401.123	0.176	0.004	0.945	26
14	1A4	Liquid fuel	CO2	0.019	8.602	0.168	0.004	0.949	27
46	1B2	Oil and Natural Gas	CH4	0.001	100.125	0.146	0.003	0.952	28
12	1A3b	LPG	CO2	0.024	5.831	0.141	0.003	0.956	29
32	4D2	Land converted to Wetlands	CO2	0.005	26.502	0.137	0.003	0.959	30
11	1A4	Solid fuel	CO2	0.025	5.385	0.132	0.003	0.962	31
57	1A4	All fuel	N2O	0.001	200.062	0.120	0.003	0.965	32
58	1A1	All fuel	N2O	0.001	200.022	0.120	0.003	0.968	33
59	1A2	All fuel	N2O	0.001	200.022	0.119	0.003	0.970	34
40	1A4	All fuel	CH4	0.002	50.249	0.116	0.003	0.973	35
47	5A	Solid waste disposal	CH4	0.001	85.440	0.101	0.002	0.976	36
17	1A3b	Gasoline	CO2	0.016	5.831	0.092	0.002	0.978	37
34	3B3	Swine	CH4	0.004	20.100	0.083	0.002	0.980	38
8	1A2	Gaseous fuels	CO2	0.033	2.236	0.074	0.002	0.981	39
9	1A1	Gaseous fuels	CO2	0.032	2.236	0.071	0.002	0.983	40
39	2C2	Ferroalloys Production	CO2	0.003	25.495	0.067	0.002	0.985	41
51	3A4	Other livestock	CH4	0.001	50.040	0.049	0.001	0.986	42
30	2B1	Ammonia Production	CO2	0.006	7.280	0.047	0.001	0.987	43
26	1A4	Gaseous fuel	CO2	0.008	5.385	0.041	0.001	0.988	44
28	1A3e	Gaseous fuel	CO2	0.007	5.099	0.037	0.001	0.989	45
62	3C	Rice Cultivation	CH4	0.000	83.815	0.035	0.001	0.990	46
52	1A3b	All fuel	N2O	0.001	40.112	0.034	0.001	0.991	47
19	2A4d	DeSOx - instalations	CO2	0.014	2.121	0.031	0.001	0.991	48
44	2C2	Zinc production	CO2	0.002	15.811	0.026	0.001	0.992	49
53	2D	Non-energy products from fuels and solvent use	CO2	0.001	31.623	0.025	0.001	0.992	50
45	2C2	Lead production	CO2	0.002	15.811	0.024	0.001	0.993	51
36	2A4a	Ceramics - Bricks and Tails	CO2	0.004	5.831	0.023	0.001	0.994	52
48	3A3	Swine	CH4	0.001	20.100	0.023	0.001	0.994	53
69	4A1 (V)	Forest fires	CO2eq	0.000	65.973	0.019	0.000	0.995	54
38	1A3b	Gaseous fuel	CO2	0.003	5.831	0.019	0.000	0.995	55

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment including LULUCF	Cumulative Percentage	T2
31	**2B7**	**Soda ash production**	CO2	0.006	2.828	0.018	0.000	0.995	56
85	**1B2**	**Oil and Natural Gas**	N2O	0.000	1000.012	0.015	0.000	0.996	57
68	**2G1**	**Electrical equipment - SF6**	CO2eq	0.000	50.990	0.015	0.000	0.996	58
67	**5B**	**Biological treatment of solid waste**	N2O	0.000	42.426	0.013	0.000	0.996	59
66	**1A3b**	**All fuel**	CH4	0.000	40.112	0.013	0.000	0.997	60
41	**1A2**	**Other fossil fuels**	CO2	0.002	5.385	0.012	0.000	0.997	61
71	**3F**	**Field burning of agricultural residues**	CH4	0.000	55.902	0.011	0.000	0.997	62
79	**3F**	**Field burning of agricultural residues**	N2O	0.000	201.556	0.011	0.000	0.998	63
70	**3B4**	**Other livestock**	CH4	0.000	50.040	0.010	0.000	0.998	64
78	**5C**	**Incineration and open burning of waste**	CO2	0.000	100.499	0.008	0.000	0.998	65
56	**2B5b**	**Calcium Carbide**	CO2	0.001	11.180	0.008	0.000	0.998	66
63	**3B1**	**Cattle**	CH4	0.000	20.100	0.008	0.000	0.998	67
50	**1A3a**	**Liquid fuel**	CO2	0.001	7.071	0.007	0.000	0.999	68
64	**3B2**	**Sheep**	CH4	0.000	20.100	0.007	0.000	0.999	69
73	**1A3d**	**Gas/diesel oil**	CO2	0.000	50.249	0.007	0.000	0.999	70
75	**5D**	**Wastewater treatment and discharge**	N2O	0.000	53.852	0.006	0.000	0.999	71
54	**1A3c**	**Liquid fuel**	CO2	0.001	7.071	0.005	0.000	0.999	72
77	**1A3c**	**Liquid fuel**	N2O	0.000	60.208	0.005	0.000	0.999	73
76	**1A2**	**All fuel**	CH4	0.000	50.090	0.005	0.000	0.999	74
65	**2A3**	**Glass production**	CO2	0.000	14.142	0.005	0.000	0.999	75
72	**2G**	**Other product manufacture and use**	CO2	0.000	31.623	0.005	0.000	1.000	76
42	**2A1**	**Cement Production**	CO2	0.002	2.121	0.005	0.000	1.000	77
80	**1A1**	**All fuel**	CH4	0.000	50.090	0.002	0.000	1.000	78
55	**2A4b**	**Soda ash uses**	CO2	0.001	2.236	0.002	0.000	1.000	79
60	**2A2**	**Lime Production**	CO2	0.001	2.828	0.002	0.000	1.000	80
81	**3H**	**Urea application**	CO2	0.000	50.040	0.001	0.000	1.000	81
84	**4A2 (V)**	**Forest fires**	CO2eq	0.000	66.659	0.001	0.000	1.000	82
74	**2G**	**Other product manufacture and use**	N2O	0.000	10.050	0.001	0.000	1.000	83
82	**2H**	**Other**	CO2	0.000	31.623	0.001	0.000	1.000	84
87	**5C**	**Incineration and open burning of waste**	N2O	0.000	100.499	0.001	0.000	1.000	85
83	**2C2**	**Ferroalloys Production**	CH4	0.000	25.495	0.001	0.000	1.000	86
88	**1A3e**	**Gaseous fuel**	N2O	0.000	150.003	0.001	0.000	1.000	87
86	**1A3a**	**Liquid fuel**	N2O	0.000	40.311	0.000	0.000	1.000	88
89	**1A3e**	**Gaseous fuel**	CH4	0.000	50.010	0.000	0.000	1.000	89
90	**1A3d**	**Gas/diesel oil**	N2O	0.000	148.661	0.000	0.000	1.000	90
91	**1A3c**	**Liquid fuel**	CH4	0.000	60.208	0.000	0.000	1.000	91
92	**1A3d**	**Gas/diesel oil**	CH4	0.000	70.711	0.000	0.000	1.000	92
93	**1A3a**	**Liquid fuel**	CH4	0.000	40.311	0.000	0.000	1.000	93
94	**5C**	**Incineration and open burning of waste**	CH4	0.000	100.499	0.000	0.000	1.000	94

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment including LULUCF	Cumulative Percentage	T2
95	1A3b	Other liquid fuels	CO2	0.000	5.831	0.000	0.000	1.000	95
96	1A5	Stationary - Fossil fuels	CO2	0.000	8.602	0.000	0.000	1.000	96
97	1A5	Stationary - Fossil fuels	CH4	0.000	50.249	0.000	0.000	1.000	97
98	1A5	Stationary - Fossil fuels	N2O	0.000	200.062	0.000	0.000	1.000	98
99	2B8	Petrochemical and carbon black production	CH4	0.000	11.180	0.000	0.000	1.000	99
100	2B8b	Ethylene	CO2	0.000	30.414	0.000	0.000	1.000	100
101	2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	0.000	20.616	0.000	0.000	1.000	101
102	2C1	Iron and Steel Production	CH4	0.000	26.926	0.000	0.000	1.000	102

Table 270 Key category Analysis T2: Level Assessment excluding LULUCF 2017

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	L*U	Level assessment excluding LULUCF	Cumulative Percentage	T2
3	3Da	Direct N2O emissions from managed soils	N2O	0.055	250.018	13.830	0.351	0.351	1
15	3Db	Indirect N2O Emissions from managed soils	N2O	0.014	500.009	7.247	0.184	0.536	2
4	5A	Solid waste disposal	CH4	0.046	85.440	3.944	0.100	0.636	3
16	1B1	Solid fuel	CH4	0.014	200.250	2.756	0.070	0.706	4
23	3B	N2O em. from Manure Management	N2O	0.008	300.007	2.353	0.060	0.766	5
6	2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0.030	50.990	1.511	0.038	0.804	6
17	1B2	Oil and Natural Gas	CO2	0.013	100.125	1.312	0.033	0.837	7
19	5D	Wastewater treatment and discharge	CH4	0.012	84.812	1.042	0.026	0.864	8
1	1A1	Solid fuels	CO2	0.396	2.236	0.886	0.023	0.886	9
2	1A3b	Diesel Oil	CO2	0.095	5.831	0.554	0.014	0.900	10
13	3A1	Cattle	CH4	0.019	20.100	0.380	0.010	0.910	11
30	1B2	Oil and Natural Gas	CH4	0.004	100.125	0.357	0.009	0.919	12
36	1A1	All fuel	N2O	0.002	200.022	0.355	0.009	0.928	13
41	1A4	All fuel	N2O	0.001	200.062	0.278	0.007	0.935	14
27	1A4	All fuel	CH4	0.005	50.249	0.257	0.007	0.942	15
10	1A1	Liquid fuels	CO2	0.021	7.616	0.161	0.004	0.946	16
54	5B	Biological treatment of solid waste	CH4	0.000	401.123	0.156	0.004	0.950	17
12	1A2	Liquid fuels	CO2	0.020	7.616	0.151	0.004	0.954	18
8	1A3b	Gasoline	CO2	0.025	5.831	0.144	0.004	0.957	19
14	2B1	Ammonia Production	CO2	0.018	7.280	0.129	0.003	0.961	20
37	3C	Rice Cultivation	CH4	0.002	83.815	0.128	0.003	0.964	21
9	1A3b	LPG	CO2	0.021	5.831	0.125	0.003	0.967	22
32	5D	Wastewater treatment and discharge	N2O	0.002	53.852	0.123	0.003	0.970	23
52	1A2	All fuel	N2O	0.000	200.022	0.085	0.002	0.972	24
28	3A2	Sheep	CH4	0.004	20.100	0.081	0.002	0.974	25

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	L*U	Level assessment excluding LULUCF	Cumulative Percentage	T2
22	1A4	Liquid fuel	CO2	0.009	8.602	0.074	0.002	0.976	26
5	1A1	Gaseous fuels	CO2	0.032	2.236	0.071	0.002	0.978	27
42	3A4	Other livestock	CH4	0.001	50.040	0.067	0.002	0.980	28
7	1A2	Gaseous fuels	CO2	0.029	2.236	0.065	0.002	0.981	29
20	1A4	Solid fuel	CO2	0.011	5.385	0.058	0.001	0.983	30
43	1A3b	All fuel	N2O	0.001	40.112	0.053	0.001	0.984	31
39	2D	Non-energy products from fuels and solvent use	CO2	0.001	31.623	0.045	0.001	0.985	32
11	2A1	Cement Production	CO2	0.020	2.121	0.043	0.001	0.986	33
25	1A4	Gaseous fuel	CO2	0.007	5.385	0.036	0.001	0.987	34
33	2C2	Zinc production	CO2	0.002	15.811	0.036	0.001	0.988	35
26	1A3e	Gaseous fuel	CO2	0.006	5.099	0.033	0.001	0.989	36
49	3H	Urea application	CO2	0.001	50.040	0.027	0.001	0.990	37
18	2A4d	DeSOx - instalations	CO2	0.013	2.121	0.027	0.001	0.990	38
21	2B7	Soda ash production	CO2	0.009	2.828	0.026	0.001	0.991	39
65	3F	Field burning of agricultural residues	N2O	0.000	201.556	0.025	0.001	0.992	40
51	3F	Field burning of agricultural residues	CH4	0.000	55.902	0.025	0.001	0.992	41
59	5C	Incineration and open burning of waste	CO2	0.000	100.499	0.024	0.001	0.993	42
45	3B3	Swine	CH4	0.001	20.100	0.023	0.001	0.994	43
40	2A3	Glass production	CO2	0.001	14.142	0.020	0.001	0.994	44
31	1A3b	Gaseous fuel	CO2	0.003	5.831	0.017	0.000	0.995	45
24	1A2	Solid fuels	CO2	0.007	2.236	0.016	0.000	0.995	46
38	2B2	Nitric Acid Production	N2O	0.002	10.198	0.016	0.000	0.995	47
55	1A3b	All fuel	CH4	0.000	40.112	0.015	0.000	0.996	48
57	2G1	Electrical equipment - SF6	CO2eq	0.000	50.990	0.015	0.000	0.996	49
72	1B2	Oil and Natural Gas	N2O	0.000	1000.012	0.013	0.000	0.996	50
53	2G	Other product manufacture and use	CO2	0.000	31.623	0.012	0.000	0.997	51
58	5B	Biological treatment of solid waste	N2O	0.000	42.426	0.012	0.000	0.997	52
60	3B4	Other livestock	CH4	0.000	50.040	0.011	0.000	0.997	53
34	1A2	Other fossil fuels	CO2	0.002	5.385	0.011	0.000	0.998	54
29	2A2	Lime Production	CO2	0.004	2.828	0.010	0.000	0.998	55
50	3B1	Cattle	CH4	0.000	20.100	0.010	0.000	0.998	56
61	1A2	All fuel	CH4	0.000	50.090	0.010	0.000	0.998	57
56	3A3	Swine	CH4	0.000	20.100	0.007	0.000	0.999	58
44	2A4a	Ceramics - Bricks and Tails	CO2	0.001	5.831	0.007	0.000	0.999	59
46	1A3a	Liquid fuel	CO2	0.001	7.071	0.007	0.000	0.999	60
64	1A1	All fuel	CH4	0.000	50.090	0.007	0.000	0.999	61
66	1A3d	Gas/diesel oil	CO2	0.000	50.249	0.006	0.000	0.999	62
47	1A3c	Liquid fuel	CO2	0.001	7.071	0.005	0.000	0.999	63

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	L*U	Level assessment excluding LULUCF	Cumulative Percentage	T2
69	1A3c	Liquid fuel	N2O	0.000	60.208	0.005	0.000	0.999	64
48	2C1	Iron and Steel Production	CO2	0.001	7.071	0.004	0.000	1.000	65
35	2A4b	Soda ash uses	CO2	0.002	2.236	0.004	0.000	1.000	66
68	2H	Other	CO2	0.000	31.623	0.003	0.000	1.000	67
67	3B2	Sheep	CH4	0.000	20.100	0.002	0.000	1.000	68
63	2C2	Lead production	CO2	0.000	15.811	0.002	0.000	1.000	69
62	2G	Other product manufacture and use	N2O	0.000	10.050	0.002	0.000	1.000	70
71	5C	Incineration and open burning of waste	N2O	0.000	100.499	0.002	0.000	1.000	71
70	2B5b	Calcium Carbide	CO2	0.000	11.180	0.001	0.000	1.000	72
74	1A3e	Gaseous fuel	N2O	0.000	150.003	0.001	0.000	1.000	73
73	1A3a	Liquid fuel	N2O	0.000	40.311	0.000	0.000	1.000	74
75	1A3e	Gaseous fuel	CH4	0.000	50.010	0.000	0.000	1.000	75
76	1A3d	Gas/diesel oil	N2O	0.000	148.661	0.000	0.000	1.000	76
77	1A3c	Liquid fuel	CH4	0.000	60.208	0.000	0.000	1.000	77
79	1A3d	Gas/diesel oil	CH4	0.000	70.711	0.000	0.000	1.000	78
80	1A3a	Liquid fuel	CH4	0.000	40.311	0.000	0.000	1.000	79
78	2C2	Ferroalloys Production	CO2	0.000	25.495	0.000	0.000	1.000	80
81	5C	Incineration and open burning of waste	CH4	0.000	100.499	0.000	0.000	1.000	81
82	2C2	Ferroalloys Production	CH4	0.000	25.495	0.000	0.000	1.000	82
83	1A3b	Other liquid fuels	CO2	0.000	5.831	0.000	0.000	1.000	83
84	1A5	Stationary - Fossil fuels	CO2	0.000	8.602	0.000	0.000	1.000	84
85	1A5	Stationary - Fossil fuels	CH4	0.000	50.249	0.000	0.000	1.000	85
86	1A5	Stationary - Fossil fuels	N2O	0.000	200.062	0.000	0.000	1.000	86
87	2B8	Petrochemical and carbon black production	CH4	0.000	11.180	0.000	0.000	1.000	87
88	2B8b	Ethylene	CO2	0.000	30.414	0.000	0.000	1.000	88
89	2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	0.000	20.616	0.000	0.000	1.000	89
90	2C1	Iron and Steel Production	CH4	0.000	26.926	0.000	0.000	1.000	90

Table 271 Key category Analysis T2: Level Assessment including LULUCF 2017

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	L*U	Level assessment including LULUCF	Cumulative Percentage	T2
2	4A1	Forest Land remaining Forest Land	CO2	0.085	436.010	37.246	0.421	0.421	1
4	3Da	Direct N2O emissions from managed soils	N2O	0.046	250.018	11.538	0.130	0.552	2
9	4C2	Land converted to Grassland	CO2	0.023	444.813	10.203	0.115	0.667	3
18	3Db	Indirect N2O Emissions from managed soils	N2O	0.012	500.009	6.045	0.068	0.735	4
5	5A	Solid waste disposal	CH4	0.039	85.440	3.290	0.037	0.773	5
17	4A2	Land converted to Forest Land	CO2	0.012	191.262	2.351	0.027	0.799	6
20	1B1	Solid fuel	CH4	0.011	200.250	2.299	0.026	0.825	7

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	L*U	Level assessment including LULUCF	Cumulative Percentage	T2
29	3B	N2O em. from Manure Management	N2O	0.007	300.007	1.963	0.022	0.847	8
36	4B2	Land converted to Cropland	CO2	0.004	415.466	1.572	0.018	0.865	9
27	4B1	Cropland remainig Cropland	CO2	0.007	184.043	1.352	0.015	0.881	10
7	2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0.025	50.990	1.260	0.014	0.895	11
22	1B2	Oil and Natural Gas	CO2	0.011	100.125	1.095	0.012	0.907	12
24	5D	Wastewater treatment and discharge	CH4	0.010	84.812	0.869	0.010	0.917	13
19	4E2	Land converted to Settlements	CO2	0.012	75.000	0.863	0.010	0.927	14
21	4G	Harvested wood products	CO2	0.011	73.682	0.842	0.010	0.936	15
44	4	Indirect N2O Emissions from managed soils	N2O	0.002	500.009	0.767	0.009	0.945	16
1	1A1	Solid fuels	CO2	0.331	2.236	0.739	0.008	0.953	17
3	1A3b	Diesel Oil	CO2	0.079	5.831	0.462	0.005	0.959	18
15	3A1	Cattle	CH4	0.016	20.100	0.317	0.004	0.962	19
39	1B2	Oil and Natural Gas	CH4	0.003	100.125	0.298	0.003	0.965	20
46	1A1	All fuel	N2O	0.001	200.022	0.297	0.003	0.969	21
32	4F	Land converted to other land	CO2	0.005	50.990	0.278	0.003	0.972	22
51	1A4	All fuel	N2O	0.001	200.062	0.232	0.003	0.975	23
34	1A4	All fuel	CH4	0.004	50.249	0.214	0.002	0.977	24
12	1A1	Liquid fuels	CO2	0.018	7.616	0.134	0.002	0.979	25
64	5B	Biological treatment of solid waste	CH4	0.000	401.123	0.130	0.001	0.980	26
14	1A2	Liquid fuels	CO2	0.017	7.616	0.126	0.001	0.981	27
10	1A3b	Gasoline	CO2	0.021	5.831	0.120	0.001	0.983	28
16	2B1	Ammonia Production	CO2	0.015	7.280	0.108	0.001	0.984	29
47	3C	Rice Cultivation	CH4	0.001	83.815	0.107	0.001	0.985	30
11	1A3b	LPG	CO2	0.018	5.831	0.104	0.001	0.986	31
41	5D	Wastewater treatment and discharge	N2O	0.002	53.852	0.103	0.001	0.988	32
35	4D2	Land converted to Wetlands	CO2	0.004	26.502	0.101	0.001	0.989	33
62	1A2	All fuel	N2O	0.000	200.022	0.071	0.001	0.990	34
37	3A2	Sheep	CH4	0.003	20.100	0.067	0.001	0.990	35
28	1A4	Liquid fuel	CO2	0.007	8.602	0.062	0.001	0.991	36
6	1A1	Gaseous fuels	CO2	0.026	2.236	0.059	0.001	0.992	37
52	3A4	Other livestock	CH4	0.001	50.040	0.056	0.001	0.992	38
8	1A2	Gaseous fuels	CO2	0.024	2.236	0.054	0.001	0.993	39
25	1A4	Solid fuel	CO2	0.009	5.385	0.049	0.001	0.993	40
53	1A3b	All fuel	N2O	0.001	40.112	0.044	0.001	0.994	41
49	2D	Non-energy products from fuels and solvent use	CO2	0.001	31.623	0.037	0.000	0.994	42
13	2A1	Cement Production	CO2	0.017	2.121	0.036	0.000	0.995	43
31	1A4	Gaseous fuel	CO2	0.006	5.385	0.030	0.000	0.995	44

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	L*U	Level assessment including LULUCF	Cumulative Percentage	T2
42	**2C2**	**Zinc production**	CO2	0.002	15.811	0.030	0.000	0.995	45
33	**1A3e**	**Gaseous fuel**	CO2	0.005	5.099	0.028	0.000	0.996	46
59	**3H**	**Urea application**	CO2	0.000	50.040	0.023	0.000	0.996	47
23	**2A4d**	**DeSOx - instalations**	CO2	0.011	2.121	0.023	0.000	0.996	48
26	**2B7**	**Soda ash production**	CO2	0.008	2.828	0.022	0.000	0.997	49
76	**3F**	**Field burning of agricultural residues**	N2O	0.000	201.556	0.021	0.000	0.997	50
61	**3F**	**Field burning of agricultural residues**	CH4	0.000	55.902	0.021	0.000	0.997	51
70	**5C**	**Incineration and open burning of waste**	CO2	0.000	100.499	0.020	0.000	0.997	52
55	**3B3**	**Swine**	CH4	0.001	20.100	0.019	0.000	0.997	53
50	**2A3**	**Glass production**	CO2	0.001	14.142	0.016	0.000	0.998	54
69	**4A1 (V)**	**Forest fires**	CO2eq	0.000	65.973	0.015	0.000	0.998	55
40	**1A3b**	**Gaseous fuel**	CO2	0.002	5.831	0.014	0.000	0.998	56
30	**1A2**	**Solid fuels**	CO2	0.006	2.236	0.013	0.000	0.998	57
48	**2B2**	**Nitric Acid Production**	N2O	0.001	10.198	0.013	0.000	0.998	58
65	**1A3b**	**All fuel**	CH4	0.000	40.112	0.012	0.000	0.998	59
67	**2G1**	**Electrical equipment - SF6**	CO2eq	0.000	50.990	0.012	0.000	0.999	60
84	**1B2**	**Oil and Natural Gas**	N2O	0.000	1000.012	0.011	0.000	0.999	61
63	**2G**	**Other product manufacture and use**	CO2	0.000	31.623	0.010	0.000	0.999	62
68	**5B**	**Biological treatment of solid waste**	N2O	0.000	42.426	0.010	0.000	0.999	63
71	**3B4**	**Other livestock**	CH4	0.000	50.040	0.009	0.000	0.999	64
43	**1A2**	**Other fossil fuels**	CO2	0.002	5.385	0.009	0.000	0.999	65
38	**2A2**	**Lime Production**	CO2	0.003	2.828	0.009	0.000	0.999	66
60	**3B1**	**Cattle**	CH4	0.000	20.100	0.008	0.000	0.999	67
72	**1A2**	**All fuel**	CH4	0.000	50.090	0.008	0.000	0.999	68
66	**3A3**	**Swine**	CH4	0.000	20.100	0.006	0.000	0.999	69
54	**2A4a**	**Ceramics - Bricks and Tails**	CO2	0.001	5.831	0.006	0.000	1.000	70
56	**1A3a**	**Liquid fuel**	CO2	0.001	7.071	0.006	0.000	1.000	71
75	**1A1**	**All fuel**	CH4	0.000	50.090	0.006	0.000	1.000	72
77	**1A3d**	**Gas/diesel oil**	CO2	0.000	50.249	0.005	0.000	1.000	73
57	**1A3c**	**Liquid fuel**	CO2	0.001	7.071	0.004	0.000	1.000	74
80	**1A3c**	**Liquid fuel**	N2O	0.000	60.208	0.004	0.000	1.000	75
58	**2C1**	**Iron and Steel Production**	CO2	0.000	7.071	0.003	0.000	1.000	76
45	**2A4b**	**Soda ash uses**	CO2	0.001	2.236	0.003	0.000	1.000	77
79	**2H**	**Other**	CO2	0.000	31.623	0.002	0.000	1.000	78
78	**3B2**	**Sheep**	CH4	0.000	20.100	0.002	0.000	1.000	79
74	**2C2**	**Lead production**	CO2	0.000	15.811	0.002	0.000	1.000	80
73	**2G**	**Other product manufacture and use**	N2O	0.000	10.050	0.002	0.000	1.000	81
82	**5C**	**Incineration and open burning of waste**	N2O	0.000	100.499	0.002	0.000	1.000	82
83	**4A2 (V)**	**Forest fires**	CO2eq	0.000	66.659	0.001	0.000	1.000	83

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	L*U	Level assessment including LULUCF	Cumulative Percentage	T2
81	**2B5b**	**Calcium Carbide**	CO2	0.000	11.180	0.001	0.000	1.000	84
86	**1A3e**	**Gaseous fuel**	N2O	0.000	150.003	0.000	0.000	1.000	85
85	**1A3a**	**Liquid fuel**	N2O	0.000	40.311	0.000	0.000	1.000	86
87	**1A3e**	**Gaseous fuel**	CH4	0.000	50.010	0.000	0.000	1.000	87
88	**1A3d**	**Gas/diesel oil**	N2O	0.000	148.661	0.000	0.000	1.000	88
89	**1A3c**	**Liquid fuel**	CH4	0.000	60.208	0.000	0.000	1.000	89
91	**1A3d**	**Gas/diesel oil**	CH4	0.000	70.711	0.000	0.000	1.000	90
92	**1A3a**	**Liquid fuel**	CH4	0.000	40.311	0.000	0.000	1.000	91
90	**2C2**	**Ferroalloys Production**	CO2	0.000	25.495	0.000	0.000	1.000	92
93	**5C**	**Incineration and open burning of waste**	CH4	0.000	100.499	0.000	0.000	1.000	93
94	**2C2**	**Ferroalloys Production**	CH4	0.000	25.495	0.000	0.000	1.000	94
95	**1A3b**	**Other liquid fuels**	CO2	0.000	5.831	0.000	0.000	1.000	95
96	**1A5**	**Stationary - Fossil fuels**	CO2	0.000	8.602	0.000	0.000	1.000	96
97	**1A5**	**Stationary - Fossil fuels**	CH4	0.000	50.249	0.000	0.000	1.000	97
98	**1A5**	**Stationary - Fossil fuels**	N2O	0.000	200.062	0.000	0.000	1.000	98
99	**2B8**	**Petrochemical and carbon black production**	CH4	0.000	11.180	0.000	0.000	1.000	99
100	**2B8b**	**Ethylene**	CO2	0.000	30.414	0.000	0.000	1.000	100
101	**2B8c**	**Ethylene dichloride and vinyl chloride monomer**	CO2	0.000	20.616	0.000	0.000	1.000	101
102	**2C1**	**Iron and Steel Production**	CH4	0.000	26.926	0.000	0.000	1.000	102

ANNEX 2 ASSESSMENT OF THE UNCERTAINTY

Introduction

A consistent assessment of uncertainties of the Bulgarian greenhouse gas inventory requires a detailed understanding of the uncertainties of the respective input parameters. In the submission 2017 was prepared the detailed uncertainty evaluation, the Bulgarian inventory compilers have spent considerable effort to obtain uncertainties from individual contributors to the inventory. This leads to a situation where national information or at least national expert knowledge directly from the stage of inventory development may flow into the assessment of uncertainties.

The respective sectoral uncertainties are documented in detail in the sectoral chapters of this report.

Theoretical background

The assessment and propagation of uncertainties in emission inventories has been described in detail by IPCC (IPCC 2006). Principally, two different pathways may be taken to arrive at a total uncertainty, and to develop an inventory uncertainty. The “Approach 1” method is based on error propagation: assuming input information is available in form of normal distribution, and input uncertainties are statistically independent, the approach allows for reliable assessment of inventory uncertainty. More flexibility is possible in the “Approach 2” method. The Monte-Carlo approach allows any probability distribution of input parameters, and it also enables to define statistical dependencies between parameters. The most obvious dependency is a full dependency. This occurs when two values are based on the identical set of measurements. A variation or error in one value would then be fully reflected also in the other value. While “full dependency” theoretically can also be covered in error propagation, this is normally not done and only in a very limited way possible in the IPCC spreadsheets.

The general properties of error propagation allow to combine (add up) information in a way that the relative uncertainty (as percentage of the mean value) of the combination becomes lower than the relative uncertainty of any of the input parameters. This advantage of going into detail is often implicitly taken advantage of, when a problem is disassembled into sub-problems and the sub-results are being recombined. Nevertheless it is not always the most detailed level that yields results of lowest uncertainty. If measurements or assessments at the most detailed level are difficult, a more comprehensive level of information may provide the lower overall uncertainty.

As a consequence, optimizing the approach requires collecting input information at the most detailed level an inventory is prepared at. Attaching uncertainty data then may be done at a level where greatest confidence can be expected on the data. This may be the most detailed level, but more often uncertainty data will not be available, or a “balance” approach (energy balance, solvent balance) will allow more reliability at a more aggregated level.

Procedure

For the uncertainty assessment of the Bulgarian greenhouse gas inventory, the most detailed level of the inventory system was used as the base level. This “base level” of the inventory facilitates compilation of emission data for different purposes.

This approach of starting at the most detailed level the inventory offers facilitated an assessment of emission uncertainty at any level that the most reasonable uncertainty data are available. Very detailed information can be entered directly, for aggregate information the same uncertainty (as a statistically dependent entity) is applied for all input entries concerned.

Uncertainty information was taken from national studies, from international information (as e.g. in the IPCC reports) from variation presented in literature, and by contacting national experts. Structured interviews were held. The difference between an Approach 1 and an Approach 2 uncertainty approach can be explained by covariance of uncertainties between (key) source categories, which occurs when data are statistically dependent. The Approach 1 approach allows considering co-variance between years for one source category, but does not cover co-variances between source categories.

In all input and output parameters, uncertainty has been expressed as normal or lognormal probability density function. In line with the IPCC requirements, the uncertainty range is presented as the range with 95% probability of a given value being within its boundaries. Thus the boundaries were given as the 2.5 and 97.5-percentiles of the respective distribution. For a normal distribution, this is +/- 2 standard deviations from the mean.

Detailed Results of Approach 1 Uncertainty Analysis

The table on the next pages shows the detailed results of Approach 1 Uncertainty analysis. The structure of the table is identical to Table 3.2 of IPCC 2006 Guidelines. For explanations to the columns see pp. 3.30-3.31 in vol. 1 IPCC (2006).

Table 272 Approach 1 Uncertainty Calculation and Reporting, Gg CO_2-eq. (excluding LULUCF) for 2017.

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A1	Liquid fuels	CO2	10099.15	1294.85	3	7	7.6	0.161	-0.034	0.011	-0.240	0.047	0.245
1A1	Solid fuels	CO2	25416.61	24315.99	1	2	2.2	0.886	0.094	0.208	0.187	0.295	0.349
1A1	Gaseous fuels	CO2	6508.60	1943.75	1	2	2.2	0.071	-0.013	0.017	-0.025	0.024	0.035
1A1	All fuel	CH4	18.85	8.34	3	50	50.1	0.007	0.000	0.000	-0.001	0.000	0.001
1A1	All fuel	N2O	136.19	109.06	3	200	200.0	0.355	0.000	0.001	0.064	0.004	0.064
1A2	Liquid fuels	CO2	7319.76	1219.67	3	7	7.6	0.151	-0.022	0.010	-0.157	0.044	0.164
1A2	Solid fuels	CO2	10047.70	434.50	1	2	2.2	0.016	-0.041	0.004	-0.083	0.005	0.083
1A2	Gaseous fuels	CO2	0.00	1791.49	1	2	2.2	0.065	0.015	0.015	0.031	0.022	0.038
1A2	Other fossil fuels	CO2	0.00	119.78	5	2	5.4	0.011	0.001	0.001	0.002	0.007	0.008
1A2	All fuel	CH4	31.74	12.25	3	50	50.1	0.010	0.000	0.000	-0.002	0.000	0.002
1A2	All fuel	N2O	103.95	26.19	3	200	200.0	0.085	0.000	0.000	-0.049	0.001	0.049
1A3a	Liquid fuel	CO2	208.93	61.84	5	5	7.1	0.007	0.000	0.001	-0.002	0.004	0.004
1A3a	Liquid fuel	CH4	0.04	0.02	5	40	40.3	0.000	0.000	0.000	0.000	0.000	0.000
1A3a	Liquid fuel	N2O	1.75	0.54	5	40	40.3	0.000	0.000	0.000	0.000	0.000	0.000
1A3b	Gasoline	CO2	4217.04	1517.46	3	5	5.8	0.144	-0.006	0.013	-0.030	0.055	0.063
1A3b	Diesel Oil	CO2	2617.25	5830.88	3	5	5.8	0.554	0.038	0.050	0.191	0.212	0.285
1A3b	All fuel	CH4	71.67	22.81	3	40	40.1	0.015	0.000	0.000	-0.005	0.001	0.005
1A3b	All fuel	N2O	62.11	81.18	3	40	40.1	0.053	0.000	0.001	0.017	0.003	0.017
1A3b	LPG	CO2	0.00	1317.80	3	5	5.8	0.125	0.011	0.011	0.056	0.048	0.074
1A3b	Gaseous fuel	CO2	0.00	175.96	3	5	5.8	0.017	0.002	0.002	0.008	0.006	0.010
1A3b	Other liquid fuels	CO2	0.00	0.00	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	CO2	0.00	41.72	5	5	7.1	0.005	0.000	0.000	0.002	0.003	0.003
1A3c	Liquid fuel	CH4	0.00	0.06	5	60	60.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	N2O	0.00	4.80	5	60	60.2	0.005	0.000	0.000	0.002	0.000	0.002

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A3d	Gas/diesel oil	CO2	0.00	7.32	50	5	50.2	0.006	0.000	0.000	0.000	0.004	0.004
1A3d	Gas/diesel oil	CH4	0.00	0.02	50	50	70.7	0.000	0.000	0.000	0.000	0.000	0.000
1A3d	Gas/diesel oil	N2O	0.00	0.06	50	140	148.7	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	CO2	0.00	397.14	1	5	5.1	0.033	0.003	0.003	0.017	0.005	0.018
1A3e	Gaseous fuel	CH4	0.00	0.18	1	50	50.0	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	N2O	0.00	0.21	1	150	150.0	0.001	0.000	0.000	0.000	0.000	0.000
1A4	Liquid fuel	CO2	2825.06	530.74	5	7	8.6	0.074	-0.008	0.005	-0.057	0.032	0.066
1A4	Solid fuel	CO2	3548.08	663.55	2	5	5.4	0.058	-0.010	0.006	-0.051	0.016	0.054
1A4	Gaseous fuel	CO2	0.00	413.32	5	2	5.4	0.036	0.004	0.004	0.007	0.025	0.026
1A4	All fuel	CH4	334.66	313.45	5	50	50.2	0.257	0.001	0.003	0.059	0.019	0.062
1A4	All fuel	N2O	209.71	85.23	5	200	200.1	0.278	0.000	0.001	-0.043	0.005	0.043
1A5	Stationary - Fossil fuels	CO2	5093.82	0.00	5	7	8.6	0.000	-0.023	0.000	-0.160	0.000	0.160
1A5	Stationary - Fossil fuels	CH4	4.82	0.00	5	50	50.2	0.000	0.000	0.000	-0.001	0.000	0.001
1A5	Stationary - Fossil fuels	N2O	9.79	0.00	5	200	200.1	0.000	0.000	0.000	-0.009	0.000	0.009
1B1	Solid fuel	CH4	2179.20	844.50	10	200	200.2	2.756	-0.003	0.007	-0.515	0.102	0.525
1B2	Oil and Natural Gas	CO2	4.99	804.19	5	100	100.1	1.312	0.007	0.007	0.687	0.049	0.688
1B2	Oil and Natural Gas	CH4	248.20	218.81	5	100	100.1	0.357	0.001	0.002	0.076	0.013	0.077
1B2	Oil and Natural Gas	N2O	0.02	0.83	5	1000	1000.0	0.013	0.000	0.000	0.007	0.000	0.007
2A1	Cement Production	CO2	2406.34	1237.55	1.5	1.5	2.1	0.043	0.000	0.011	0.000	0.022	0.022
2A2	Lime Production	CO2	450.07	223.53	2	2	2.8	0.010	0.000	0.002	0.000	0.005	0.005
2A3	Glass production	CO2	186.24	85.78	10	10	14.1	0.020	0.000	0.001	-0.001	0.010	0.010
2A4a	Ceramics - Bricks and Tails	CO2	522.51	77.61	3	5	5.8	0.007	-0.002	0.001	-0.008	0.003	0.009
2A4b	Soda ash uses	CO2	126.58	110.01	2	1	2.2	0.004	0.000	0.001	0.000	0.003	0.003
2A4d	DeSOx - instalations	CO2	0.00	785.25	1.5	1.5	2.1	0.027	0.007	0.007	0.010	0.014	0.017
2B1	Ammonia Production	CO2	2557.48	1086.48	2	7	7.3	0.129	-0.002	0.009	-0.015	0.026	0.031

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duceed by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
2B2	Nitric Acid Production	N2O	1932.03	93.48	2	10	10.2	0.016	-0.008	0.001	-0.079	0.002	0.079
2B5b	Calcium Carbide	CO2	73.90	4.46	5	10	11.2	0.001	0.000	0.000	-0.003	0.000	0.003
2B7	Soda ash production	CO2	397.64	561.80	2	2	2.8	0.026	0.003	0.005	0.006	0.014	0.015
2B8	Petrochemical and carbon black production	CH4	17.43	0.00	5	10	11.2	0.000	0.000	0.000	-0.001	0.000	0.001
2B8b	Ethylene	CO2	442.12	0.00	5	30	30.4	0.000	-0.002	0.000	-0.060	0.000	0.060
2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	1.89	0.00	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
2C1	Iron and Steel Production	CO2	3481.44	35.17	5	5	7.1	0.004	-0.015	0.000	-0.077	0.002	0.077
2C1	Iron and Steel Production	CH4	32.42	0.00	10	25	26.9	0.000	0.000	0.000	-0.004	0.000	0.004
2C2	Ferroalloys Production	CO2	254.94	0.02	5	25	25.5	0.000	-0.001	0.000	-0.029	0.000	0.029
2C2	Ferroalloys Production	CH4	2.28	0.00	5	25	25.5	0.000	0.000	0.000	0.000	0.000	0.000
2C2	Lead production	CO2	162.82	8.61	5	15	15.8	0.002	-0.001	0.000	-0.010	0.001	0.010
2C2	Zinc production	CO2	90.47	139.28	5	15	15.8	0.036	0.001	0.001	0.012	0.008	0.014
2D	Non-energy products from fuels and solvent use	CO2	229.17	86.58	10	30	31.6	0.045	0.000	0.001	-0.009	0.010	0.014
2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0.00	1817.91	10	50	51.0	1.511	0.016	0.016	0.779	0.220	0.809
2G	Other product manufacture and use	N2O	32.60	12.04	10	1	10.0	0.002	0.000	0.000	0.000	0.001	0.001
2G	Other product manufacture and use	CO2	28.79	24.05	10	30	31.6	0.012	0.000	0.000	0.002	0.003	0.004
2G1	Electrical equipment - SF6	CO2eq	3.30	17.51	10	50	51.0	0.015	0.000	0.000	0.007	0.002	0.007
2H	Other	CO2	6.85	5.38	10	30	31.6	0.003	0.000	0.000	0.000	0.001	0.001
3A1	Cattle	CH4	3074.85	1160.86	0.64	20	20.0	0.379	-0.004	0.010	-0.078	0.009	0.078
3A2	Sheep	CH4	1603.36	246.57	1.63	20	20.1	0.081	-0.005	0.002	-0.102	0.005	0.102
3A3	Swine	CH4	151.58	22.68	0.51	50	50.0	0.018	0.000	0.000	-0.024	0.000	0.024
3A4	Other livestock	CH4	241.41	82.28	2	50	50.0	0.067	0.000	0.001	-0.019	0.002	0.019

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
3B	N2O em. from Manure Management	N2O	1299.25	481.27	2	300	300.0	2.353	-0.002	0.004	-0.518	0.012	0.518
3B1	Cattle	CH4	90.63	30.58	25	20	32.0	0.016	0.000	0.000	-0.003	0.009	0.010
3B2	Sheep	CH4	46.81	7.17	50	20	53.9	0.006	0.000	0.000	-0.003	0.004	0.005
3B3	Swine	CH4	519.93	69.38	25	20	32.0	0.036	-0.002	0.001	-0.035	0.021	0.041
3B4	Other livestock	CH4	43.98	13.34	50	30	58.3	0.013	0.000	0.000	-0.003	0.008	0.008
3C	Rice Cultivation	CH4	126.99	93.97	20	60	63.2	0.097	0.000	0.001	0.014	0.023	0.027
3Da	Direct N2O emissions from managed soils	N2O	4994.73	3394.70	3	200	200.0	11.065	0.007	0.029	1.317	0.123	1.323
3Db	Indirect N2O Emissions from managed soils	N2O	1474.87	889.40	3	500	500.0	7.247	0.001	0.008	0.489	0.032	0.490
3F	Field burning of agricultural residues	CH4	29.06	27.26	3	50	50.1	0.022	0.000	0.000	0.005	0.001	0.005
3F	Field burning of agricultural residues	N2O	8.34	7.56	3	20	20.2	0.002	0.000	0.000	0.001	0.000	0.001
3H	Urea application	CO2	62.17	33.42	2	50	50.0	0.027	0.000	0.000	0.000	0.001	0.001
5A	Solid waste disposal	CH4	4922.42	2832.50	30	80	85.4	3.944	0.002	0.024	0.168	1.029	1.043
5B	Biological treatment of solid waste	CH4	0.00	23.80	30	400	401.1	0.156	0.000	0.000	0.082	0.009	0.082
5B	Biological treatment of solid waste	N2O	0.00	17.02	30	30	42.4	0.012	0.000	0.000	0.004	0.006	0.008
5C	Incineration and open burning of waste	CO2	18.51	14.72	10	100	100.5	0.024	0.000	0.000	0.004	0.002	0.005
5C	Incineration and open burning of waste	CH4	0.00	0.00	10	100	100.5	0.000	0.000	0.000	0.000	0.000	0.000
5C	Incineration and open burning of waste	N2O	1.45	1.15	10	100	100.5	0.002	0.000	0.000	0.000	0.000	0.000
5D	Wastewater treatment and discharge	CH4	3045.85	753.87	67	52	84.8	1.042	-0.007	0.006	-0.377	0.612	0.719
5D	Wastewater treatment and discharge	N2O	239.07	140.72	20	50	53.9	0.123	0.000	0.001	0.006	0.034	0.035
Total			**116754.2**	**61367.2**				**14.51**					**2.38**
%			**100.0**	**100.0**									
National Total			**116754.2**	**61367.2**									

Table 273 Approach 1 Uncertainty Calculation and Reporting, Gg CO_2-eq. (excluding LULUCF) for 1988.

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duceed by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A1	Liquid fuels	CO2	10099.15	10099.15	3	7	7.6	0.659	0.000	0.086	0.000	0.367	0.367
1A1	Solid fuels	CO2	25416.61	25416.61	1	2	2.2	0.487	0.000	0.218	0.000	0.308	0.308
1A1	Gaseous fuels	CO2	6508.60	6508.60	1	2	2.2	0.125	0.000	0.056	0.000	0.079	0.079
1A1	All fuel	CH4	18.85	18.85	3	50	50.1	0.008	0.000	0.000	0.000	0.001	0.001
1A1	All fuel	N2O	136.19	136.19	3	200	200.0	0.233	0.000	0.001	0.000	0.005	0.005
1A2	Liquid fuels	CO2	7319.76	7319.76	3	7	7.6	0.477	0.000	0.063	0.000	0.266	0.266
1A2	Solid fuels	CO2	10047.70	10047.70	1	2	2.2	0.192	0.000	0.086	0.000	0.122	0.122
1A2	Gaseous fuels	CO2	0.00	0.00	1	2	2.2	0.000	0.000	0.000	0.000	0.000	0.000
1A2	Other fossil fuels	CO2	0.00	0.00	5	2	5.4	0.000	0.000	0.000	0.000	0.000	0.000
1A2	All fuel	CH4	31.74	31.74	3	50	50.1	0.014	0.000	0.000	0.000	0.001	0.001
1A2	All fuel	N2O	103.95	103.95	3	200	200.0	0.178	0.000	0.001	0.000	0.004	0.004
1A3a	Liquid fuel	CO2	208.93	208.93	5	5	7.1	0.013	0.000	0.002	0.000	0.013	0.013
1A3a	Liquid fuel	CH4	0.04	0.04	5	40	40.3	0.000	0.000	0.000	0.000	0.000	0.000
1A3a	Liquid fuel	N2O	1.75	1.75	5	40	40.3	0.001	0.000	0.000	0.000	0.000	0.000
1A3b	Gasoline	CO2	4217.04	4217.04	3	5	5.8	0.211	0.000	0.036	0.000	0.153	0.153
1A3b	Diesel Oil	CO2	2617.25	2617.25	3	5	5.8	0.131	0.000	0.022	0.000	0.095	0.095
1A3b	All fuel	CH4	71.67	71.67	3	40	40.1	0.025	0.000	0.001	0.000	0.003	0.003
1A3b	All fuel	N2O	62.11	62.11	3	40	40.1	0.021	0.000	0.001	0.000	0.002	0.002
1A3b	LPG	CO2	0.00	0.00	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3b	Gaseous fuel	CO2	0.00	0.00	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3b	Other liquid fuels	CO2	0.00	0.00	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	CO2	0.00	0.00	5	5	7.1	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	CH4	0.00	0.00	5	60	60.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	N2O	0.00	0.00	5	60	60.2	0.000	0.000	0.000	0.000	0.000	0.000

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A3d	Gas/diesel oil	CO2	0.00	0.00	50	5	50.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3d	Gas/diesel oil	CH4	0.00	0.00	50	50	70.7	0.000	0.000	0.000	0.000	0.000	0.000
1A3d	Gas/diesel oil	N2O	0.00	0.00	50	140	148.7	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	CO2	0.00	0.00	1	5	5.1	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	CH4	0.00	0.00	1	50	50.0	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	N2O	0.00	0.00	1	150	150.0	0.000	0.000	0.000	0.000	0.000	0.000
1A4	Liquid fuel	CO2	2825.06	2825.06	5	7	8.6	0.208	0.000	0.024	0.000	0.171	0.171
1A4	Solid fuel	CO2	3548.08	3548.08	2	5	5.4	0.164	0.000	0.030	0.000	0.086	0.086
1A4	Gaseous fuel	CO2	0.00	0.00	5	2	5.4	0.000	0.000	0.000	0.000	0.000	0.000
1A4	All fuel	CH4	334.66	334.66	5	50	50.2	0.144	0.000	0.003	0.000	0.020	0.020
1A4	All fuel	N2O	209.71	209.71	5	200	200.1	0.359	0.000	0.002	0.000	0.013	0.013
1A5	Stationary - Fossil fuels	CO2	5093.82	5093.82	5	7	8.6	0.375	0.000	0.044	0.000	0.309	0.309
1A5	Stationary - Fossil fuels	CH4	4.82	4.82	5	50	50.2	0.002	0.000	0.000	0.000	0.000	0.000
1A5	Stationary - Fossil fuels	N2O	9.79	9.79	5	200	200.1	0.017	0.000	0.000	0.000	0.001	0.001
1B1	Solid fuel	CH4	2179.20	2179.20	10	200	200.2	3.738	0.000	0.019	0.000	0.264	0.264
1B2	Oil and Natural Gas	CO2	4.99	4.99	5	100	100.1	0.004	0.000	0.000	0.000	0.000	0.000
1B2	Oil and Natural Gas	CH4	248.20	248.20	5	100	100.1	0.213	0.000	0.002	0.000	0.015	0.015
1B2	Oil and Natural Gas	N2O	0.02	0.02	5	1000	1000.0	0.000	0.000	0.000	0.000	0.000	0.000
2A1	Cement Production	CO2	2406.34	2406.34	1.5	1.5	2.1	0.044	0.000	0.021	0.000	0.044	0.044
2A2	Lime Production	CO2	450.07	450.07	2	2	2.8	0.011	0.000	0.004	0.000	0.011	0.011
2A3	Glass production	CO2	186.24	186.24	10	10	14.1	0.023	0.000	0.002	0.000	0.023	0.023
2A4a	Ceramics - Bricks and Tails	CO2	522.51	522.51	3	5	5.8	0.026	0.000	0.004	0.000	0.019	0.019
2A4b	Soda ash uses	CO2	126.58	126.58	2	1	2.2	0.002	0.000	0.001	0.000	0.003	0.003
2A4d	DeSOx - instalations	CO2	0.00	0.00	1.5	1.5	2.1	0.000	0.000	0.000	0.000	0.000	0.000
2B1	Ammonia Production	CO2	2557.48	2557.48	2	7	7.3	0.159	0.000	0.022	0.000	0.062	0.062

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duceed by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
2B2	Nitric Acid Production	N2O	1932.03	1932.03	2	10	10.2	0.169	0.000	0.017	0.000	0.047	0.047
2B5b	Calcium Carbide	CO2	73.90	73.90	5	10	11.2	0.007	0.000	0.001	0.000	0.004	0.004
2B7	Soda ash production	CO2	397.64	397.64	2	2	2.8	0.010	0.000	0.003	0.000	0.010	0.010
2B8	Petrochemical and carbon black production	CH4	17.43	17.43	5	10	11.2	0.002	0.000	0.000	0.000	0.001	0.001
2B8b	Ethylene	CO2	442.12	442.12	5	30	30.4	0.115	0.000	0.004	0.000	0.027	0.027
2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	1.89	1.89	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
2C1	Iron and Steel Production	CO2	3481.44	3481.44	5	5	7.1	0.211	0.000	0.030	0.000	0.211	0.211
2C1	Iron and Steel Production	CH4	32.42	32.42	10	25	26.9	0.007	0.000	0.000	0.000	0.004	0.004
2C2	Ferroalloys Production	CO2	254.94	254.94	5	25	25.5	0.056	0.000	0.002	0.000	0.015	0.015
2C2	Ferroalloys Production	CH4	2.28	2.28	5	25	25.5	0.000	0.000	0.000	0.000	0.000	0.000
2C2	Lead production	CO2	162.82	162.82	5	15	15.8	0.022	0.000	0.001	0.000	0.010	0.010
2C2	Zinc production	CO2	90.47	90.47	5	15	15.8	0.012	0.000	0.001	0.000	0.005	0.005
2D	Non-energy products from fuels and solvent use	CO2	229.17	229.17	10	30	31.6	0.062	0.000	0.002	0.000	0.028	0.028
2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0.00	0.00	10	50	51.0	0.000	0.000	0.000	0.000	0.000	0.000
2G	Other product manufacture and use	N2O	32.60	32.60	10	1	10.0	0.003	0.000	0.000	0.000	0.004	0.004
2G	Other product manufacture and use	CO2	28.79	28.79	10	30	31.6	0.008	0.000	0.000	0.000	0.003	0.003
2G1	Electrical equipment - SF6	CO2eq	3.30	3.30	10	50	51.0	0.001	0.000	0.000	0.000	0.000	0.000
2H	Other	CO2	6.85	6.85	10	30	31.6	0.002	0.000	0.000	0.000	0.001	0.001
3A1	Cattle	CH4	3074.85	3074.85	0.64	20	20.0	0.527	0.000	0.026	0.000	0.024	0.024
3A2	Sheep	CH4	1603.36	1603.36	1.63	20	20.1	0.276	0.000	0.014	0.000	0.032	0.032
3A3	Swine	CH4	151.58	151.58	0.51	50	50.0	0.065	0.000	0.001	0.000	0.001	0.001
3A4	Other livestock	CH4	241.41	241.41	2	50	50.0	0.103	0.000	0.002	0.000	0.006	0.006

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
3B	N2O em. from Manure Management	N2O	1299.25	1299.25	2	300	300.0	3.338	0.000	0.011	0.000	0.031	0.031
3B1	Cattle	CH4	90.63	90.63	25	20	32.0	0.025	0.000	0.001	0.000	0.027	0.027
3B2	Sheep	CH4	46.81	46.81	50	20	53.9	0.022	0.000	0.000	0.000	0.028	0.028
3B3	Swine	CH4	519.93	519.93	25	20	32.0	0.143	0.000	0.004	0.000	0.157	0.157
3B4	Other livestock	CH4	43.98	43.98	50	30	58.3	0.022	0.000	0.000	0.000	0.027	0.027
3C	Rice Cultivation	CH4	126.99	126.99	20	60	63.2	0.069	0.000	0.001	0.000	0.031	0.031
3Da	Direct N2O emissions from managed soils	N2O	4994.73	4994.73	3	200	200.0	8.557	0.000	0.043	0.000	0.181	0.181
3Db	Indirect N2O Emissions from managed soils	N2O	1474.87	1474.87	3	500	500.0	6.316	0.000	0.013	0.000	0.054	0.054
3F	Field burning of agricultural residues	CH4	29.06	29.06	3	50	50.1	0.012	0.000	0.000	0.000	0.001	0.001
3F	Field burning of agricultural residues	N2O	8.34	8.34	3	20	20.2	0.001	0.000	0.000	0.000	0.000	0.000
3H	Urea application	CO2	62.17	62.17	2	50	50.0	0.027	0.000	0.001	0.000	0.002	0.002
5A	Solid waste disposal	CH4	4922.42	4922.42	30	80	85.4	3.602	0.000	0.042	0.000	1.789	1.789
5B	Biological treatment of solid waste	CH4	0.00	0.00	30	400	401.1	0.000	0.000	0.000	0.000	0.000	0.000
5B	Biological treatment of solid waste	N2O	0.00	0.00	30	30	42.4	0.000	0.000	0.000	0.000	0.000	0.000
5C	Incineration and open burning of waste	CO2	18.51	18.51	10	100	100.5	0.016	0.000	0.000	0.000	0.002	0.002
5C	Incineration and open burning of waste	CH4	0.00	0.00	10	100	100.5	0.000	0.000	0.000	0.000	0.000	0.000
5C	Incineration and open burning of waste	N2O	1.45	1.45	10	100	100.5	0.001	0.000	0.000	0.000	0.000	0.000
5D	Wastewater treatment and discharge	CH4	3045.85	3045.85	67	52	84.8	2.213	0.000	0.026	0.000	2.472	2.472
5D	Wastewater treatment and discharge	N2O	239.07	239.07	20	50	53.9	0.110	0.000	0.002	0.000	0.058	0.058
Total			**116754.2**	**116754.2**				**12.58**					**3.16**
%			**100.0**	**100.0**									
National Total			**116754.2**	**116754.2**									

Table 274 Tier 1 Uncertainty Calculation and Reporting, Gg CO_2-eq.(Including LULUCF) for 2017.

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A1	Liquid fuels	CO2	10099.2	1294.9	3	7	7.6	0.185	-0.037	0.012	-0.261	0.053	0.266
1A1	Solid fuels	CO2	25416.6	24316.0	1	2	2.2	1.020	0.108	0.234	0.216	0.330	0.395
1A1	Gaseous fuels	CO2	6508.6	1943.7	1	2	2.2	0.082	-0.013	0.019	-0.027	0.026	0.038
1A1	All fuel	CH4	18.8	8.3	3	50	50.1	0.008	0.000	0.000	-0.001	0.000	0.001
1A1	All fuel	N2O	136.2	109.1	3	200	200.0	0.409	0.000	0.001	0.075	0.004	0.076
1A2	Liquid fuels	CO2	7319.8	1219.7	3	7	7.6	0.174	-0.024	0.012	-0.170	0.050	0.177
1A2	Solid fuels	CO2	10047.7	434.5	1	2	2.2	0.018	-0.045	0.004	-0.091	0.006	0.091
1A2	Gaseous fuels	CO2	0.0	1791.5	1	2	2.2	0.075	0.017	0.017	0.034	0.024	0.042
1A2	Other fossil fuels	CO2	0.0	119.8	5	2	5.4	0.012	0.001	0.001	0.002	0.008	0.008
1A2	All fuel	CH4	31.7	12.2	3	50	50.1	0.012	0.000	0.000	-0.002	0.000	0.002
1A2	All fuel	N2O	103.9	26.2	3	200	200.0	0.098	0.000	0.000	-0.052	0.001	0.052
1A3a	Liquid fuel	CO2	208.9	61.8	5	5	7.1	0.008	0.000	0.001	-0.002	0.004	0.005
1A3a	Liquid fuel	CH4	0.0	0.0	5	40	40.3	0.000	0.000	0.000	0.000	0.000	0.000
1A3a	Liquid fuel	N2O	1.8	0.5	5	40	40.3	0.000	0.000	0.000	0.000	0.000	0.000
1A3b	Gasoline	CO2	4217.0	1517.5	3	5	5.8	0.166	-0.006	0.015	-0.031	0.062	0.069
1A3b	Diesel Oil	CO2	2617.2	5830.9	3	5	5.8	0.638	0.043	0.056	0.216	0.238	0.321
1A3b	All fuel	CH4	71.7	22.8	3	40	40.1	0.017	0.000	0.000	-0.005	0.001	0.005
1A3b	All fuel	N2O	62.1	81.2	3	40	40.1	0.061	0.000	0.001	0.019	0.003	0.019
1A3b	LPG	CO2	0.0	1317.8	3	5	5.8	0.144	0.013	0.013	0.063	0.054	0.083
1A3b	Gaseous fuel	CO2	0.0	176.0	3	5	5.8	0.019	0.002	0.002	0.008	0.007	0.011
1A3b	Other liquid fuels	CO2	0.0	0.0	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	CO2	0.0	41.7	5	5	7.1	0.006	0.000	0.000	0.002	0.003	0.003
1A3c	Liquid fuel	CH4	0.0	0.1	5	60	60.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	N2O	0.0	4.8	5	60	60.2	0.005	0.000	0.000	0.003	0.000	0.003

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A3d	Gas/diesel oil	CO2	0.0	7.3	50	5	50.2	0.007	0.000	0.000	0.000	0.005	0.005
1A3d	Gas/diesel oil	CH4	0.0	0.0	50	50	70.7	0.000	0.000	0.000	0.000	0.000	0.000
1A3d	Gas/diesel oil	N2O	0.0	0.1	50	140	148.7	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	CO2	0.0	397.1	1	5	5.1	0.038	0.004	0.004	0.019	0.005	0.020
1A3e	Gaseous fuel	CH4	0.0	0.2	1	50	50.0	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	N2O	0.0	0.2	1	150	150.0	0.001	0.000	0.000	0.000	0.000	0.000
1A4	Liquid fuel	CO2	2825.1	530.7	5	7	8.6	0.086	-0.009	0.005	-0.062	0.036	0.071
1A4	Solid fuel	CO2	3548.1	663.5	2	5	5.4	0.067	-0.011	0.006	-0.055	0.018	0.058
1A4	Gaseous fuel	CO2	0.0	413.3	5	2	5.4	0.042	0.004	0.004	0.008	0.028	0.029
1A4	All fuel	CH4	334.7	313.4	5	50	50.2	0.295	0.001	0.003	0.068	0.021	0.071
1A4	All fuel	N2O	209.7	85.2	5	200	200.1	0.320	0.000	0.001	-0.043	0.006	0.043
1A5	Stationary - Fossil fuels	CO2	5093.8	0.0	5	7	8.6	0.000	-0.025	0.000	-0.175	0.000	0.175
1A5	Stationary - Fossil fuels	CH4	4.8	0.0	5	50	50.2	0.000	0.000	0.000	-0.001	0.000	0.001
1A5	Stationary - Fossil fuels	N2O	9.8	0.0	5	200	200.1	0.000	0.000	0.000	-0.010	0.000	0.010
1B1	Solid fuel	CH4	2179.2	844.5	10	200	200.2	3.171	-0.003	0.008	-0.523	0.115	0.536
1B2	Oil and Natural Gas	CO2	5.0	804.2	5	100	100.1	1.510	0.008	0.008	0.770	0.055	0.772
1B2	Oil and Natural Gas	CH4	248.2	218.8	5	100	100.1	0.411	0.001	0.002	0.088	0.015	0.089
1B2	Oil and Natural Gas	N2O	0.0	0.8	5	1000	1000.0	0.016	0.000	0.000	0.008	0.000	0.008
2A1	Cement Production	CO2	2406.3	1237.6	1.5	1.5	2.1	0.049	0.000	0.012	0.000	0.025	0.025
2A2	Lime Production	CO2	450.1	223.5	2	2	2.8	0.012	0.000	0.002	0.000	0.006	0.006
2A3	Glass production	CO2	186.2	85.8	10	10	14.1	0.023	0.000	0.001	-0.001	0.012	0.012
2A4a	Ceramics - Bricks and Tails	CO2	522.5	77.6	5	3	5.8	0.008	-0.002	0.001	-0.005	0.005	0.008
2A4b	Soda ash uses	CO2	126.6	110.0	2	1	2.2	0.005	0.000	0.001	0.000	0.003	0.003
2A4d	DeSOx - instalations	CO_2	0.0	785.2	1.5	1.5	2.1	0.031	0.008	0.008	0.011	0.016	0.020
2B1	Ammonia Production	CO2	2557.5	1086.5	2	7	7.3	0.148	-0.002	0.010	-0.015	0.030	0.033

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
2B2	Nitric Acid Production	N2O	1932.0	93.5	2	10	10.2	0.018	-0.009	0.001	-0.086	0.003	0.086
2B5b	Calcium Carbide	CO2	73.9	4.5	5	10	11.2	0.001	0.000	0.000	-0.003	0.000	0.003
2B7	Soda ash production	CO2	397.6	561.8	2	2	2.8	0.030	0.003	0.005	0.007	0.015	0.017
2B8	Petrochemical and carbon black production	CH4	17.4	0.0	5	10	11.2	0.000	0.000	0.000	-0.001	0.000	0.001
2B8b	Ethylene	CO2	442.1	0.0	5	30	30.4	0.000	-0.002	0.000	-0.065	0.000	0.065
2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	1.9	0.0	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
2C1	Iron and Steel Production	CO2	3481.4	35.2	5	5	7.1	0.005	-0.017	0.000	-0.084	0.002	0.084
2C1	Iron and Steel Production	CH4	32.4	0.0	10	25	26.9	0.000	0.000	0.000	-0.004	0.000	0.004
2C2	Ferroalloys Production	CO2	254.9	0.0	5	25	25.5	0.000	-0.001	0.000	-0.031	0.000	0.031
2C2	Ferroalloys Production	CH4	2.3	0.0	5	25	25.5	0.000	0.000	0.000	0.000	0.000	0.000
2C2	Lead production	CO2	162.8	8.6	5	15	15.8	0.003	-0.001	0.000	-0.011	0.001	0.011
2C2	Zinc production	CO2	90.5	139.3	5	15	15.8	0.041	0.001	0.001	0.013	0.009	0.016
2D	Non-energy products from fuels and solvent use	CO2	229.2	86.6	10	30	31.6	0.051	0.000	0.001	-0.009	0.012	0.015
2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0.0	1817.9	10	50	51.0	1.738	0.017	0.017	0.873	0.247	0.908
2G	Other product manufacture and use	N2O	32.6	12.0	10	1	10.0	0.002	0.000	0.000	0.000	0.002	0.002
2G	Other product manufacture and use	CO2	28.8	24.0	10	30	31.6	0.014	0.000	0.000	0.003	0.003	0.004
2G1	Electrical equipment - SF6	CO2eq	3.3	17.5	10	50	51.0	0.017	0.000	0.000	0.008	0.002	0.008
2H	Other	CO2	6.9	5.4	10	30	31.6	0.003	0.000	0.000	0.001	0.001	0.001
3A1	Cattle	CH4	3074.8	1160.9	2	20	20.1	0.438	-0.004	0.011	-0.080	0.032	0.086
3A2	Sheep	CH4	1603.4	246.6	2	20	20.1	0.093	-0.006	0.002	-0.111	0.007	0.111
3A3	Swine	CH4	151.6	22.7	2	20	20.1	0.009	-0.001	0.000	-0.011	0.001	0.011
3A4	Other livestock	CH4	241.4	82.3	2	50	50.0	0.077	0.000	0.001	-0.020	0.002	0.020

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
3B	N2O em. from Manure Management	N2O	1299.2	481.3	2	300	300.0	2.708	-0.002	0.005	-0.532	0.013	0.532
3B1	Cattle	CH4	90.6	30.6	2	20	20.1	0.012	0.000	0.000	-0.003	0.001	0.003
3B2	Sheep	CH4	46.8	7.2	2	20	20.1	0.003	0.000	0.000	-0.003	0.000	0.003
3B3	Swine	CH4	519.9	69.4	2	20	20.1	0.026	-0.002	0.001	-0.038	0.002	0.038
3B4	Other livestock	CH4	44.0	13.3	2	50	50.0	0.013	0.000	0.000	-0.004	0.000	0.004
3C	Rice Cultivation	CH4	127.0	94.0	25	80	83.8	0.148	0.000	0.001	0.022	0.032	0.039
3Da	Direct N2O emissions from managed soils	N2O	4994.7	3394.7	3	250	250.0	15.916	0.008	0.033	2.005	0.138	2.010
3Db	Indirect N2O Emissions from managed soils	N2O	1474.9	889.4	3	500	500.0	8.339	0.001	0.009	0.642	0.036	0.643
3F	Field burning of agricultural residues	CH4	29.1	27.3	25	50	55.9	0.029	0.000	0.000	0.006	0.009	0.011
3F	Field burning of agricultural residues	N2O	8.3	7.6	25	200	201.6	0.029	0.000	0.000	0.006	0.003	0.007
3H	Urea application	CO2	62.2	33.4	2	50	50.0	0.031	0.000	0.000	0.001	0.001	0.001
4A1	Forest Land remaining Forest Land	CO2	-11513.9	-6284.0	3	436	436.0	-51.379	-0.004	-0.060	-1.610	-0.256	1.630
4A2	Land converted to Forest Land	CO2	-567.9	-904.3	10	191	191.3	-3.243	-0.006	-0.009	-1.126	-0.123	1.132
4A1(V)	Forest fires	CO2eq	1.71	16.59	3	66	66.0	0.021	0.000	0.000	0.010	0.001	0.010
4A2(V)	Forest fires	CO2eq	0.07	1.05	10	66	66.7	0.001	0.000	0.000	0.001	0.000	0.001
4B1	Cropland remainig Cropland	CO2	-1109.8	540.6	3	184	184.0	1.866	0.011	0.005	1.962	0.022	1.962
4B2	Land converted to Cropland	CO2	105.1	278.3	10	415	415.5	2.168	0.002	0.003	0.896	0.038	0.896
4C2	Land converted to Grassland	CO2	-2.2	-1687.3	10	445	444.8	-14.074	-0.016	-0.016	-7.205	-0.229	7.209
4D2	Land converted to Wetlands	CO2	0.0	281.6	10	25	26.5	0.140	0.003	0.003	0.066	0.038	0.077
4E2	Land converted to Settlements	CO2	524.3	846.8	10	74	75.0	1.191	0.006	0.008	0.413	0.115	0.429
4F	Land converted to other land	CO2	11.9	-401.7	10	50	51.0	-0.384	-0.004	-0.004	-0.196	-0.055	0.203
4G	Harvested wood products	CO2	-180.0	-840.7	10	73	73.7	-1.162	-0.007	-0.008	-0.525	-0.114	0.537
4	Indirect N2O Emissions from managed soils	N2O	40.5	112.8	3	500	500.0	1.058	0.001	0.001	0.442	0.005	0.442

IPCC Source category		GHG	Base year emissions (1988)	Year 2017 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2017	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
5A	Solid waste disposal	CH4	4922.4	2832.5	30	80	85.4	4.538	0.003	0.027	0.238	1.155	1.179
5B	Biological treatment of solid waste	CH4	0.0	23.8	30	400	401.1	0.179	0.000	0.000	0.091	0.010	0.092
5B	Biological treatment of solid waste	N2O	0.0	17.0	30	30	42.4	0.014	0.000	0.000	0.005	0.007	0.008
5C	Incineration and open burning of waste	CO2	18.5	14.7	10	100	100.5	0.028	0.000	0.000	0.005	0.002	0.005
5C	Incineration and open burning of waste	CH4	0.0	0.0	10	100	100.5	0.000	0.000	0.000	0.000	0.000	0.000
5C	Incineration and open burning of waste	N2O	1.4	1.2	10	100	100.5	0.002	0.000	0.000	0.000	0.000	0.000
5D	Wastewater treatment and discharge	CH4	3045.9	753.9	67	52	84.8	1.199	-0.008	0.007	-0.403	0.686	0.796
5D	Wastewater treatment and discharge	N2O	239.1	140.7	20	50	53.9	0.142	0.000	0.001	0.009	0.038	0.039
Total			**104064.1**	**53326.9**				**56.84**					**8.38**
%			**100.0**	**100.0**									
National Total			**104064.1**	**53326.9**									

* Considering LULUCF sector, values for the uncertainty related to activity data and emission factor have been assigned by expert judgment, taking into account the final combined uncertainty.

Table 275 Tier 1 Uncertainty Calculation and Reporting, Gg CO_2-eq.(Including LULUCF) for 1988.

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A1	Liquid fuels	CO2	10099.2	10099.2	3	7	7.6	0.739	0.000	0.097	0.000	0.412	0.412
1A1	Solid fuels	CO2	25416.6	25416.6	1	2	2.2	0.546	0.000	0.244	0.000	0.345	0.345
1A1	Gaseous fuels	CO2	6508.6	6508.6	1	2	2.2	0.140	0.000	0.063	0.000	0.088	0.088
1A1	All fuel	CH4	18.8	18.8	3	50	50.1	0.009	0.000	0.000	0.000	0.001	0.001
1A1	All fuel	N2O	136.2	136.2	3	200	200.0	0.262	0.000	0.001	0.000	0.006	0.006
1A2	Liquid fuels	CO2	7319.8	7319.8	3	7	7.6	0.536	0.000	0.070	0.000	0.298	0.298
1A2	Solid fuels	CO2	10047.7	10047.7	1	2	2.2	0.216	0.000	0.097	0.000	0.137	0.137
1A2	Gaseous fuels	CO2	0.0	0.0	1	2	2.2	0.000	0.000	0.000	0.000	0.000	0.000
1A2	Other fossil fuels	CO2	0.0	0.0	5	2	5.4	0.000	0.000	0.000	0.000	0.000	0.000
1A2	All fuel	CH4	31.7	31.7	3	50	50.1	0.015	0.000	0.000	0.000	0.001	0.001
1A2	All fuel	N2O	103.9	103.9	3	200	200.0	0.200	0.000	0.001	0.000	0.004	0.004
1A3a	Liquid fuel	CO2	208.9	208.9	5	5	7.1	0.014	0.000	0.002	0.000	0.014	0.014
1A3a	Liquid fuel	CH4	0.0	0.0	5	40	40.3	0.000	0.000	0.000	0.000	0.000	0.000
1A3a	Liquid fuel	N2O	1.8	1.8	5	40	40.3	0.001	0.000	0.000	0.000	0.000	0.000
1A3b	Gasoline	CO2	4217.0	4217.0	3	5	5.8	0.236	0.000	0.041	0.000	0.172	0.172
1A3b	Diesel Oil	CO2	2617.2	2617.2	3	5	5.8	0.147	0.000	0.025	0.000	0.107	0.107
1A3b	All fuel	CH4	71.7	71.7	3	40	40.1	0.028	0.000	0.001	0.000	0.003	0.003
1A3b	All fuel	N2O	62.1	62.1	3	40	40.1	0.024	0.000	0.001	0.000	0.003	0.003
1A3b	LPG	CO2	0.0	0.0	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3b	Gaseous fuel	CO2	0.0	0.0	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3b	Other liquid fuels	CO2	0.0	0.0	3	5	5.8	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	CO2	0.0	0.0	5	5	7.1	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	CH4	0.0	0.0	5	60	60.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	Liquid fuel	N2O	0.0	0.0	5	60	60.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3d	Gas/diesel oil	CO2	0.0	0.0	50	5	50.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3d	Gas/diesel oil	CH4	0.0	0.0	50	50	70.7	0.000	0.000	0.000	0.000	0.000	0.000

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
1A3d	Gas/diesel oil	N2O	0.0	0.0	50	140	148.7	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	CO2	0.0	0.0	1	5	5.1	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	CH4	0.0	0.0	1	50	50.0	0.000	0.000	0.000	0.000	0.000	0.000
1A3e	Gaseous fuel	N2O	0.0	0.0	1	150	150.0	0.000	0.000	0.000	0.000	0.000	0.000
1A4	Liquid fuel	CO2	2825.1	2825.1	5	7	8.6	0.234	0.000	0.027	0.000	0.192	0.192
1A4	Solid fuel	CO2	3548.1	3548.1	2	5	5.4	0.184	0.000	0.034	0.000	0.096	0.096
1A4	Gaseous fuel	CO2	0.0	0.0	5	2	5.4	0.000	0.000	0.000	0.000	0.000	0.000
1A4	All fuel	CH4	334.7	334.7	5	50	50.2	0.162	0.000	0.003	0.000	0.023	0.023
1A4	All fuel	N2O	209.7	209.7	5	200	200.1	0.403	0.000	0.002	0.000	0.014	0.014
1A5	Stationary - Fossil fuels	CO2	5093.8	5093.8	5	7	8.6	0.421	0.000	0.049	0.000	0.346	0.346
1A5	Stationary - Fossil fuels	CH4	4.8	4.8	5	50	50.2	0.002	0.000	0.000	0.000	0.000	0.000
1A5	Stationary - Fossil fuels	N2O	9.8	9.8	5	200	200.1	0.019	0.000	0.000	0.000	0.001	0.001
1B1	Solid fuel	CH4	2179.2	2179.2	10	200	200.2	4.193	0.000	0.021	0.000	0.296	0.296
1B2	Oil and Natural Gas	CO2	5.0	5.0	5	100	100.1	0.005	0.000	0.000	0.000	0.000	0.000
1B2	Oil and Natural Gas	CH4	248.2	248.2	5	100	100.1	0.239	0.000	0.002	0.000	0.017	0.017
1B2	Oil and Natural Gas	N2O	0.0	0.0	5	1000	1000.0	0.000	0.000	0.000	0.000	0.000	0.000
2A1	Cement Production	CO2	2406.3	2406.3	1.5	1.5	2.1	0.049	0.000	0.023	0.000	0.049	0.049
2A2	Lime Production	CO2	450.1	450.1	2	2	2.8	0.012	0.000	0.004	0.000	0.012	0.012
2A3	Glass production	CO2	186.2	186.2	10	10	14.1	0.025	0.000	0.002	0.000	0.025	0.025
2A4a	Ceramics - Bricks and Tails	CO2	522.5	522.5	5	3	5.8	0.029	0.000	0.005	0.000	0.036	0.036
2A4b	Soda ash uses	CO2	126.6	126.6	2	1	2.2	0.003	0.000	0.001	0.000	0.003	0.003
2A4d	DeSOx - instalations	CO2	0.0	0.0	1.5	1.5	2.1	0.000	0.000	0.000	0.000	0.000	0.000
2B1	Ammonia Production	CO2	2557.5	2557.5	2	7	7.3	0.179	0.000	0.025	0.000	0.070	0.070
2B2	Nitric Acid Production	N2O	1932.0	1932.0	2	10	10.2	0.189	0.000	0.019	0.000	0.053	0.053
2B5b	Calcium Carbide	CO2	73.9	73.9	5	10	11.2	0.008	0.000	0.001	0.000	0.005	0.005
2B7	Soda ash production	CO2	397.6	397.6	2	2	2.8	0.011	0.000	0.004	0.000	0.011	0.011
2B8	Petrochemical and carbon black production	CH4	17.4	17.4	5	10	11.2	0.002	0.000	0.000	0.000	0.001	0.001

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
2B8b	Ethylene	CO2	442.1	442.1	5	30	30.4	0.129	0.000	0.004	0.000	0.030	0.030
2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	1.9	1.9	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
2C1	Iron and Steel Production	CO2	3481.4	3481.4	5	5	7.1	0.237	0.000	0.033	0.000	0.237	0.237
2C1	Iron and Steel Production	CH4	32.4	32.4	10	25	26.9	0.008	0.000	0.000	0.000	0.004	0.004
2C2	Ferroalloys Production	CO2	254.9	254.9	5	25	25.5	0.062	0.000	0.002	0.000	0.017	0.017
2C2	Ferroalloys Production	CH4	2.3	2.3	5	25	25.5	0.001	0.000	0.000	0.000	0.000	0.000
2C2	Lead production	CO2	162.8	162.8	5	15	15.8	0.025	0.000	0.002	0.000	0.011	0.011
2C2	Zinc production	CO2	90.5	90.5	5	15	15.8	0.014	0.000	0.001	0.000	0.006	0.006
2D	Non-energy products from fuels and solvent use	CO2	229.2	229.2	10	30	31.6	0.070	0.000	0.002	0.000	0.031	0.031
2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0.0	0.0	10	50	51.0	0.000	0.000	0.000	0.000	0.000	0.000
2G	Other product manufacture and use	N2O	32.6	32.6	10	1	10.0	0.003	0.000	0.000	0.000	0.004	0.004
2G	Other product manufacture and use	CO2	28.8	28.8	10	30	31.6	0.009	0.000	0.000	0.000	0.004	0.004
2G1	Electrical equipment - SF6	CO2eq	3.3	3.3	10	50	51.0	0.002	0.000	0.000	0.000	0.000	0.000
2H	Other	CO2	6.9	6.9	10	30	31.6	0.002	0.000	0.000	0.000	0.001	0.001
3A1	Cattle	CH4	3074.8	3074.8	2	20	20.1	0.594	0.000	0.030	0.000	0.084	0.084
3A2	Sheep	CH4	1603.4	1603.4	2	20	20.1	0.310	0.000	0.015	0.000	0.044	0.044
3A3	Swine	CH4	151.6	151.6	2	20	20.1	0.029	0.000	0.001	0.000	0.004	0.004
3A4	Other livestock	CH4	241.4	241.4	2	50	50.0	0.116	0.000	0.002	0.000	0.007	0.007
3B	N2O em. from Manure Management	N2O	1299.2	1299.2	2	300	300.0	3.746	0.000	0.012	0.000	0.035	0.035
3B1	Cattle	CH4	90.6	90.6	2	20	20.1	0.018	0.000	0.001	0.000	0.002	0.002
3B2	Sheep	CH4	46.8	46.8	2	20	20.1	0.009	0.000	0.000	0.000	0.001	0.001
3B3	Swine	CH4	519.9	519.9	2	20	20.1	0.100	0.000	0.005	0.000	0.014	0.014
3B4	Other livestock	CH4	44.0	44.0	2	50	50.0	0.021	0.000	0.000	0.000	0.001	0.001
3C	Rice Cultivation	CH4	127.0	127.0	25	80	83.8	0.102	0.000	0.001	0.000	0.043	0.043
3Da	Direct N2O emissions from managed	N2O	4994.7	4994.7	3	250	250.0	12.000	0.000	0.048	0.000	0.204	0.204

IPCC Source category		GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
	soils												
3Db	Indirect N2O Emissions from managed soils	N2O	1474.9	1474.9	3	500	500.0	7.086	0.000	0.014	0.000	0.060	0.060
3F	Field burning of agricultural residues	CH4	29.1	29.1	25	50	55.9	0.016	0.000	0.000	0.000	0.010	0.010
3F	Field burning of agricultural residues	N2O	8.3	8.3	25	200	201.6	0.016	0.000	0.000	0.000	0.003	0.003
3H	Urea application	CO2	62.2	62.2	2	50	50.0	0.030	0.000	0.001	0.000	0.002	0.002
4A1	Forest Land remaining Forest Land	CO2	-11513.9	-11513.9	3	436	436.0	-48.241	0.000	-0.111	0.000	-0.469	0.469
4A2	Land converted to Forest Land	CO2	-567.9	-567.9	10	191	191.3	-1.044	0.000	-0.005	0.000	-0.077	0.077
4A1(V)	Forest fires	CO2eq	1.7	1.7	3	66	66.0	0.001	0.000	0.000	0.000	0.000	0.000
4A2(V)	Forest fires	CO2eq	0.1	0.1	10	66	66.7	0.000	0.000	0.000	0.000	0.000	0.000
4B1	Cropland remainig Cropland	CO2	-1109.8	-1109.8	3	184	184.0	-1.963	0.000	-0.011	0.000	-0.045	0.045
4B2	Land converted to Cropland	CO2	105.1	105.1	10	415	415.5	0.420	0.000	0.001	0.000	0.014	0.014
4C2	Land converted to Grassland	CO2	-2.2	-2.2	10	445	444.8	-0.010	0.000	0.000	0.000	0.000	0.000
4D2	Land converted to Wetlands	CO2	0.0	0.0	10	25	26.5	0.000	0.000	0.000	0.000	0.000	0.000
4E2	Land converted to Settlements	CO2	524.3	524.3	10	74	75.0	0.378	0.000	0.005	0.000	0.071	0.071
4F	Land converted to other land	CO2	11.9	11.9	10	50	51.0	0.006	0.000	0.000	0.000	0.002	0.002
4G	Harvested wood products	CO2	-180.0	-180.0	10	73	73.7	-0.127	0.000	-0.002	0.000	-0.024	0.024
4	Indirect N2O Emissions from managed soils	N2O	40.5	40.5	3	500	500.0	0.195	0.000	0.000	0.000	0.002	0.002
5A	Solid waste disposal	CH4	4922.4	4922.4	30	80	85.4	4.041	0.000	0.047	0.000	2.007	2.007
5B	Biological treatment of solid waste	CH4	0.0	0.0	30	400	401.1	0.000	0.000	0.000	0.000	0.000	0.000
5B	Biological treatment of solid waste	N2O	0.0	0.0	30	30	42.4	0.000	0.000	0.000	0.000	0.000	0.000
5C	Incineration and open burning of waste	CO2	18.5	18.5	10	100	100.5	0.018	0.000	0.000	0.000	0.003	0.003
5C	Incineration and open burning of waste	CH4	0.0	0.0	10	100	100.5	0.000	0.000	0.000	0.000	0.000	0.000
5C	Incineration and open burning of waste	N2O	1.4	1.4	10	100	100.5	0.001	0.000	0.000	0.000	0.000	0.000
5D	Wastewater treatment and discharge	CH4	3045.9	3045.9	67	52	84.8	2.482	0.000	0.029	0.000	2.773	2.773
5D	Wastewater treatment and discharge	N2O	239.1	239.1	20	50	53.9	0.124	0.000	0.002	0.000	0.065	0.065

IPCC Source category	GHG	Base year emissions (1988)	Year 1988 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 1988	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF uncertainty	Uncertainty in trend in national emissions intro-duced by AD uncertainty	Uncertainty introduced into the trend in total national emissions
A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO_2 eq.		%	%	%	%	%	%	%	%	%
Total		**104064.1**	**104064.1**				**50.83**					**3.58**
%		**100.0**	**100.0**									
National Total		**104064.1**	**104064.1**									

* Considering LULUCF sector, values for the uncertainty related to activity data and emission factor have been assigned by expert judgment, taking into account the final combined uncertainty.

ANNEX 3 DETAILED METHODOLOGICAL DESCRIPTION AND DATA FOR ESTIMATING CO2 EMISSIONS FROM FOSSIL FUEL COMBUSTION

The emission estimates were prepared according to the following allocation between Eurostat energy balance categories and CRF categories and by using the following corresponding NCVs in the calculation model:

Eurostat Category	CRF Category	NCV applied
Indigenous Production		Production (net)
Underground Production		
Surface Production		
From Other Sources		
From Other Sources - Oil		
From Other Sources - Natural Gas		
From Other Sources - Renewables		
Total Imports (Balance)		Imports (net)
Total Exports (Balance)		Exports (net)
International Marine Bunkers		
Stock Changes (National Territory)		
Inland Consumption (Calculated)		
Statistical Differences		
Transformation Sector		
Main Activity Producer Electricity Plants	1A1ai	Used in Main Activity Plants (net)
Main Activity Producer CHP Plants	1A1aii	Used in Main Activity Plants (net)
Main Activity Producer Heat Plants	1A1aiii	Used in Main Activity Plants (net)
Autoproducer Electricity Plants	1A2gviii	Used in industry (net)
Autoproducer CHP Plants	1A2gviii	Used in industry (net)
Autoproducer Heat Plants	1A2gviii	Used in industry (net)
Patent Fuel Plants (Transformation)		Used in industry (net)
Coke Ovens (Transformation)		Used in coke ovens (net)
BKB/PB plants (Transformation)		Used in industry (net)
Gas Works (Transformation)		
Blast Furnaces (Transformation)		Used in blast furnaces (net)
Coal Liquefaction Plants (Transformation)		
For Blended Natural Gas		
Not elsewhere specified (Transformation)		
Energy Sector		
Own Use in Electricity, CHP and Heat Plants	1A1ai	Used in Main Activity Plants (net)
Coal Mines	1A1ci	Production (net)
Patent Fuel Plants (Energy)	1A1ci	Production (net)
Coke Ovens (Energy)	1A1ci	Used in coke ovens (net)
BKB/PB plants (Energy)	1A1ci	Production (net)
Gas Works (Energy)		
Blast Furnaces (Energy)	1A2a	Used in blast furnaces (net)
Oil refineries	1A1b	Used in industry (net)
Coal Liquefaction Plants (Energy)		
Not elsewhere specified (Energy industry own use)	1A1ciii	For Other Uses (net)
Distribution Losses		
Total Final Consumption		
Total Non-Energy Use		
Non-Energy Use Industry/Transformation/Energy		
Of which: Non-Energy Use-Chemical/Petrochem		
Non-Energy Use in Transport		
Non-Energy Use in Other Sectors		
Final Energy Consumption		
Industry Sector		
Iron and Steel	1A2a	Used in industry (net)

Eurostat Category	CRF Category	NCV applied
Chemical and petrochemical	1A2c	Used in industry (net)
Non-Ferrous Metals	1A2b	Used in industry (net)
Non-Metallic Minerals	1A2f	Used in industry (net)
Transport Equipment	1A2gii	Used in industry (net)
Machinery	1A2gi	Used in industry (net)
Mining and Quarrying	1A2giii	Used in industry (net)
Food, Beverages and Tobacco	1A2e	Used in industry (net)
Paper, Pulp and Printing	1A2d	Used in industry (net)
Wood and Wood Products	1A2giv	Used in industry (net)
Construction	1A2gv	Used in industry (net)
Textiles and Leather	1A2gvi	Used in industry (net)
Not elsewhere specified (Industry)	1A2gviii	Used in industry (net)
Transport Sector		
Rail	1A3c	
Domestic Navigation	1A3d	
Not elsewhere specified (Transport)	1A3eii	
Other Sectors		
Commercial and Public Services	1A4ai	For Other Uses (net)
Residential	1A4bi	For Other Uses (net)
Agriculture/Forestry	1A4ci	For Other Uses (net)
Fishing	1A4ci	For Other Uses (net)
Not elsewhere specified (Other)	1A5a	For Other Uses (net)

For the sectoral approach were considered all fuels for which there was reported energy consumption.

Solid fuels: Anthracite Coking Coal Other Bituminous Coal Sub-bituminous Coal Lignite/Brown Coal Coke Oven Coke Coal Tar BKB/PB Coke Oven Gas Blast Furnace Gas	**Liquid fuels:** Crude Oil Refinery Gas LPG Motor Gasoline Aviation Gasoline Kerosene Type Jet Fuel Gas-Diesel Oil Residual Fuel Oil Petroleum Coke Other Products
Gaseous fuels: Natural Gas	

In order to avoid double counting in the Energy sector, the following categories were not considered:

- Lignite/Brown coal used in BKB Plants (Transformation). The quantities which were considered instead are BKBs in all sectors.
- Coking coal used in Coke Ovens (Transformation). The quantities which were considered instead are:
    - Coke oven coke used in Blast Furnaces (Transformation) and Iron and Steel industry sector
    - Coke oven gas used in Autoproducer CHP Plants, Blast Furnaces (Energy) and Iron and Steel industry sector.
- Blast Furnace Gas used in Autoproducer CHP Plants, Blast Furnaces (Energy) and Iron and Steel industry sector and also the quantities of Coke oven coke used in Blast Furnaces (Transformation). These fuels are accounted under the Industrial processes sector since the emissions are calculated based on mass balance approach.

In addition, following the recommendation of the Technical review of GHG inventories under the EU Effort Sharing Decision (ESD) in 2012, we revised the methodology concerning Iron & Steel sector in order to remove the double counting with the IP sector. The following quantities were disregarded from the Energy sector:

- Coke Oven Gas reported under blast furnaces;
- Blast Furnace Gas reported under blast furnaces, Autoproducers and Iron & Steel subcategories;
- Coke oven coke in blast furnaces.

ANNEX 4 CO2 REFERENCE APPROACH AND COMPARISON WITH SECTORAL APPROACH, AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE

For the reference approach both fuels were considered for which there was reported energy and non-energy consumption.

Solid fuels:	Liquid fuels:
Anthracite Coking Coal Other Bituminous Coal Sub-bituminous Coal Lignite/Brown Coal Coke Oven Coke Coal Tar BKB/PB	Crude Oil LPG Motor Gasoline Aviation Gasoline Kerosene Type Jet Fuel Other Kerosene Gas-Diesel Oil Residual Fuel Oil Petroleum Coke Other Products Naphtha White spirit Lubricants Bitumen Paraffin waxes Refinery Feedstocks
Gaseous fuels: Natural Gas	

In order to avoid double counting, the apparent consumption for different fuels was calculated according to the 2006 IPCC Guidelines, Vol. 2, Ch. 6.4.1.

The carbon used as feedstock, reductant, or as non-energy products has been excluded from the estimates.

For the purposes of the reference approach only were calculated weighted average net calorific value for solid fuels from production, imports and exports for each fuel and each year:

Table 276 Weighted average net calorific value for solid fuels

[MJ/t]	Anthracite	Coking Coal	Other Bituminous Coal	Sub-bituminous Coal	Lignite / Brown Coal	BKB	Coke Oven Coke
1988	24.259	24.702	25.076	-	7.034	20.097	28.200
1989	24.259	24.702	25.076	-	7.034	20.097	28.200
1990	25.413	25.88	25.686	-	6.682	18.367	25.061
1991	26.140	25.88	26.705	11.669	6.268	18.367	26.380
1992	24.617	27.215	24.077	11.669	6.813	18.359	26.380
1993	23.559	32.481	23.363	11.776	6.838	18.569	31.059
1994	24.953	31.863	24.847	11.583	6.733	18.680	30.019
1995	26.234	30.148	25.740	11.537	6.584	18.683	29.832
1996	24.227	32.804	24.541	11.643	6.680	18.722	29.714
1997	24.948	32.709	25.404	-	7.014	18.757	30.061
1998	25.352	32.658	25.583	-	7.014	17.917	30.141
1999	26.024	32.659	25.725	-	7.025	17.077	30.220
2000	23.266	33.412	23.260	-	6.762	15.739	30.117
2001	24.794	30.48	24.987	-	7.036	16.082	29.969
2002	25.352	27.457	25.660	-	7.089	16.459	30.031
2003	24.359	29.326	24.946	-	7.106	16.490	29.955
2004	24.804	28.610	24.227	-	7.161	15.976	27.423

[MJ/t]	Anthracite	Coking Coal	Other Bituminous Coal	Sub-bituminous Coal	Lignite / Brown Coal	BKB	Coke Oven Coke
2005	24.465	28.638	24.365	-	7.079	15.125	27.270
2006	24.916	25.122	25.131	-	7.010	11.712	29.700
2007	23.899	27.973	24.645	-	6.973	11.504	28.500
2008	22.728	28.610	25.527	-	6.987	12.568	28.500
2009	25.200	-	25.756	-	7.006	12.212	28.500
2010	24.812	-	26.253	-	7.004	12.768	28.500
2011	24.349	-	26.755	-	6.973	13.064	28.500
2012	26.155	-	25.563	-	6.992	12.475	28.500
2013	26.379	-	25.737	-	6.961	10.175	28.500
2014	28.711	-	26.681	-	6.820	12.191	28.500
2015	28.811	-	27.615	-	6.799	13.429	28.500
2016	30.231	-	26.737	-	6.810	11.636	28.500
2017	29.772		24.000		6.918	12.625	28.500

For the sectoral approach were used the NCVs per sector, as indicated in the National Energy Balance.

ANNEX 5 NATIONAL ENERGY BALANCE

The national energy balance will be provided to the ERT during the review due to the confidentiality of information.

ANNEX 6 ASSESSMENT OF COMPLETENESS AND (POTENTIAL) SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS AND REMOVALS EXCLUDED FOR THE ANNUAL INVENTORY SUBMISSION

Provided in Chapter 1.7

ANNEX 7 VEHICLE FLEET AND MILEAGE DATA FOR ROAD TRANSPORT

Subsector	Technology	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PC Gasoline Small	PRE ECE	1878	1712	1539	3030	2631	2365	2332	2137	1921	1800	1474	1695	1740	1715	2001
PC Gasoline Small	ECE 15/00-01	2262	2063	1854	3649	3169	2849	2809	2574	-	-	-	-	-	-	-
PC Gasoline Small	ECE 15/02	2291	2089	1877	3696	3209	2885	2845	2607	2343	2195	1798	2068	-	-	-
PC Gasoline Small	ECE 15/03	2700	2461	2213	4355	3781	3400	3352	3072	2761	2587	2118	2437	2502	2466	2876
PC Gasoline Small	ECE 15/04	3627	3307	2972	5851	5080	4567	4504	4127	3710	3475	2846	3273	3361	3312	3863
PC Gasoline Small	Euro 1	4366	3981	3578	7043	6115	5498	5421	4968	4466	4184	3426	3941	4046	3987	4650
PC Gasoline Small	Euro 2	5059	4612	4146	8161	7086	6371	6282	5756	5175	4848	3970	4566	4688	4620	5388
PC Gasoline Small	Euro 3	5837	5322	4784	9416	8176	7351	7248	6642	5971	5594	4580	5268	5409	5331	6217
PC Gasoline Small	Euro 4	-	-	5068	9975	8661	7787	7679	7036	6325	5926	4852	5581	5730	5647	6586
PC Gasoline Small	Euro 5	-	-	-	-	-	-	-	7873	7077	6631	5429	6245	6412	6319	7370
PC Gasoline Small	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	6412	6319	7370
PC Gasoline Medium	PRE ECE	2013	1835	1650	3247	2819	2535	2500	2290	2059	1929	1579	1817	1865	1838	2144
PC Gasoline Medium	ECE 15/00-01	2410	2197	1975	3888	3375	3035	2993	2742	-	-	-	-	-	-	-
PC Gasoline Medium	ECE 15/02	2528	2305	2072	4079	3541	3184	3140	2877	2586	2423	1984	2282	-	-	-
PC Gasoline Medium	ECE 15/03	2898	2642	2375	4675	4059	3650	3599	3298	2964	2777	2274	2616	2685	2647	3087
PC Gasoline Medium	ECE 15/04	3897	3553	3194	6287	5459	4908	4840	4435	3987	3735	3058	3518	3611	3559	4151
PC Gasoline Medium	Euro 1	4823	4397	3953	7780	6755	6074	5989	5488	4933	4622	3784	4353	4469	4405	5137
PC Gasoline Medium	Euro 2	5439	4959	4457	8774	7618	6849	6754	6189	5563	5212	4268	4909	5040	4967	5793
PC Gasoline Medium	Euro 3	6276	5722	5143	10124	8790	7903	7793	7141	6419	6014	4925	5665	5815	5732	6685
PC Gasoline Medium	Euro 4	-	-	5709	11236	9756	8772	8649	7926	7125	6675	5466	6287	6454	6361	7419
PC Gasoline Medium	Euro 5	-	-	-	-	-	-	-	8752	7868	7371	6036	6943	7128	7025	8193
PC Gasoline Medium	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	7128	7025	8193
PC Gasoline Large	PRE ECE	2117	1930	1735	3415	2965	2666	2629	2409	2165	2029	1661	1911	1962	1933	2255
PC Gasoline Large	ECE 15/00-01	2532	2309	2075	4085	3547	3189	3145	2882	-	-	-	-	-	-	-
PC Gasoline Large	ECE 15/02	2576	2349	2112	4156	3609	3245	3199	2932	2635	2469	2022	2326	-	-	-
PC Gasoline Large	ECE 15/03	3056	2786	2505	4930	4280	3849	3795	3477	3126	2929	2398	2758	2832	2791	3255
PC Gasoline Large	ECE 15/04	4054	3697	3323	6540	5679	5106	5035	4613	4147	3885	3181	3659	3757	3703	4319
PC Gasoline Large	Euro 1	4941	4505	4050	7971	6921	6223	6136	5623	5054	4735	3877	4460	4579	4513	5263
PC Gasoline Large	Euro 2	5805	5293	4757	9364	8131	7310	7208	6605	5938	5563	4555	5239	5379	5301	6183
PC Gasoline Large	Euro 3	6462	5893	5297	10425	9052	8139	8025	7354	6611	6193	5071	5833	5989	5902	6884
PC Gasoline Large	Euro 4	-	-	5954	11720	10176	9150	9022	8267	7432	6962	5701	6558	6732	6635	7739
PC Gasoline Large	Euro 5	-	-	-	-	-	-	-	9133	8210	7691	6298	7244	7437	7330	8549
PC Gasoline Large	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	7437	7330	8549
PC Diesel Small	Conventional	24354	31885	33866	23192	17011	15439	13392	12207	11866	12204	9845	10333	10770	10290	10905
PC Diesel Small	Euro 1	27436	35921	38152	26127	19164	17394	15087	13752	13368	13748	11091	11641	12134	11592	12285
PC Diesel Small	Euro 2	32315	42309	44938	30774	22572	20487	17770	16198	15746	16193	13063	13711	14292	13654	14470
PC Diesel Small	Euro 3	36668	48008	50991	34919	25612	23246	20163	18380	17867	18375	14823	15558	16216	15493	16419
PC Diesel Small	Euro 4	-	-	51440	35227	25838	23451	20341	18542	18024	18537	14953	15695	16359	15629	16564
PC Diesel Small	Euro 5	-	-	-	-	-	-	-	20856	20273	20850	16819	17654	18401	17580	18631
PC Diesel Small	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	18401	17580	18631
PC Diesel Medium	Conventional	24354	31885	33866	23192	17011	15439	13392	12207	11866	12204	9845	10333	10770	10290	10905
PC Diesel Medium	Euro 1	27436	35921	38152	26127	19164	17394	15087	13752	13368	13748	11091	11641	12134	11592	12285
PC Diesel Medium	Euro 2	32315	42309	44938	30774	22572	20487	17770	16198	15746	16193	13063	13711	14292	13654	14470
PC Diesel Medium	Euro 3	36668	48008	50991	34919	25612	23246	20163	18380	17867	18375	14823	15558	16216	15493	16419
PC Diesel Medium	Euro 4	-	-	51440	35227	25838	23451	20341	18542	18024	18537	14953	15695	16359	15629	16564

Subsector	Technology	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PC Diesel Medium	Euro 5	-	-	-	-	-	-	-	20856	20273	20850	16819	17654	18401	17580	18631
PC Diesel Medium	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	18401	17580	18631
PC Diesel Large	Conventional	26894	35211	37399	25611	18785	17050	14789	13481	13104	13477	10872	11411	11894	11363	12043
PC Diesel Large	Euro 1	30470	39892	42371	29016	21282	19317	16755	15273	14846	15268	12317	12928	13475	12874	13644
PC Diesel Large	Euro 2	34254	44847	47634	32620	23926	21716	18836	17170	16690	17165	13847	14534	15149	14473	15338
PC Diesel Large	Euro 3	40043	52427	55684	38133	27970	25386	22019	20072	19511	20066	16187	16990	17709	16919	17931
PC Diesel Large	Euro 4	-	-	57615	39455	28940	26267	22783	20768	20188	20762	16748	17579	18323	17506	18553
PC Diesel Large	Euro 5	-	-	-	-	-	-	-	23167	22520	23161	18683	19610	20440	19528	20696
PC Diesel Large	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	20440	19528	20696
PC Gasoline Hybrid Medium	Euro 4	-	-	-	-	-	-	9420	8632	7760	7270	5953	6847	7030	6928	8080
PC Gasoline Hybrid Medium	Euro 5	-	-	-	-	-	-	-	8788	7900	7401	6060	6971	7157	7054	8227
PC Gasoline Hybrid Medium	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	8342	8221	9588
PC LPG Medium	Conventional	64097	65852	74795	76681	62900	58358	60481	56838	51355	47001	44480	38327	36379	37435	39048
PC LPG Medium	Euro 1	72754	74747	84897	87038	71395	66240	68649	64515	58292	53349	50488	43504	41292	42491	44322
PC LPG Medium	Euro 2	77244	79360	90137	92410	75802	70328	72887	68497	61889	56642	53604	46189	43841	45113	47057
PC LPG Medium	Euro 3	80971	83188	94485	96868	79458	73721	76402	71801	64875	59374	56190	48417	45956	47289	49327
PC LPG Medium	Euro 4	-	-	92367	94696	77677	72067	74689	70191	63420	58042	54930	47331	44925	46229	48221
PC LPG Medium	Euro 5	-	-	-	-	-	-	-	73834	66711	61055	57781	49788	47257	48628	50724
PC LPG Medium	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	47257	48628	50724
PC CNG Medium	Euro 4	-	25655	42003	37345	40947	30932	36065	41464	38859	40341	42923	43979	39580	37691	38367
PC CNG Medium	Euro 5	-	-	-	-	-	-	-	43616	40876	42435	45150	46261	41634	39647	40358
PC CNG Medium	Euro 6	-	-	-	-	-	-	-	-	-	-	-	-	41634	39647	40358
LCV Gasoline <3,5 t	Conventional	5153	4698	4223	8313	7218	6489	6399	5864	5271	4938	4043	4651	4775	4706	5489
LCV Gasoline <3,5 t	Euro 1	5931	5408	4861	9568	8307	7469	7365	6749	6067	5684	4654	5353	5496	5417	6317
LCV Gasoline <3,5 t	Euro 2	6634	6049	5437	10702	9292	8355	8238	7549	6786	6358	5206	5988	6148	6059	7067
LCV Gasoline <3,5 t	Euro 3	7526	6862	6168	12141	10542	9478	9346	8564	7699	7212	5906	6793	6974	6874	8017
LCV Gasoline <3,5 t	Euro 4	-	-	6975	13728	11920	10717	10568	9684	8705	8155	6678	7681	7886	7772	9065
LCV Gasoline <3,5 t	Euro 5	-	-	-	-	-	11722	11558	10591	9521	8920	7304	8401	8625	8501	9914
LCV Gasoline <3,5 t	Euro 6	-	-	-	-	-	-	-	-	-	-	-	8401	8625	8501	9914
LCV Diesel <3,5 t	Conventional	25081	32837	34877	23884	17518	15900	13791	12572	12221	12568	10138	10641	11092	10597	11231
LCV Diesel <3,5 t	Euro 1	29096	38094	40461	27708	20323	18446	16000	14584	14177	14580	11762	12345	12868	12294	13029
LCV Diesel <3,5 t	Euro 2	32008	41906	44510	30481	22357	20292	17600	16044	15596	16039	12939	13580	14155	13524	14332
LCV Diesel <3,5 t	Euro 3	34922	45722	48563	33256	24393	22140	19203	17505	17016	17500	14117	14817	15444	14755	15638
LCV Diesel <3,5 t	Euro 4	-	-	55995	38346	28126	25528	22142	20184	19620	20178	16277	17085	17808	17013	18031
LCV Diesel <3,5 t	Euro 5	-	-	-	-	-	27375	23744	21644	21039	21638	17455	18321	19096	18244	19335
LCV Diesel <3,5 t	Euro 6	-	-	-	-	-	-	-	-	-	-	-	18321	19096	18244	19335
HDV Gasoline >3,5 t	Conventional	6779	6181	5556	10936	9496	8538	8419	7714	6935	6497	5320	6119	6282	6192	7221
HDV Diesel Rigid <=7,5 t	Conventional	36309	47538	50491	34577	25361	23019	19966	18200	17692	18195	14677	15405	16058	15341	16259
HDV Diesel Rigid <=7,5 t	Euro I	42572	55738	59201	40541	29736	26989	23410	21339	20743	21333	17209	18063	18828	17987	19063
HDV Diesel Rigid <=7,5 t	Euro II	50157	65668	69748	47764	35034	31798	27580	25141	24439	25134	20275	21281	22182	21192	22459
HDV Diesel Rigid <=7,5 t	Euro III	58693	76844	81618	55893	40996	37209	32274	29420	28598	29411	23726	24903	25957	24798	26282
HDV Diesel Rigid <=7,5 t	Euro IV	-	-	88258	60440	44331	40236	34900	31813	30925	31804	25656	26928	28069	26816	28420
HDV Diesel Rigid <=7,5 t	Euro V	-	-	-	-	-	40236	34900	31813	30925	31804	25656	26928	28069	26816	28420
HDV Diesel Rigid <=7,5 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	26928	28069	26816	28420
HDV Diesel Rigid 7,5 - 12 t	Conventional	37352	48903	51941	35570	26089	23680	20539	18722	18200	18717	15099	15848	16519	15782	16725

Subsector	Technology	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
HDV Diesel Rigid 7,5 - 12 t	Euro I	46906	61411	65227	44668	32763	29737	25793	23511	22855	23505	18961	19901	20744	19818	21003
HDV Diesel Rigid 7,5 - 12 t	Euro II	55089	72125	76607	52461	38479	34925	30292	27613	26842	27605	22269	23374	24363	23276	24668
HDV Diesel Rigid 7,5 - 12 t	Euro III	65149	85297	90597	62042	45506	41303	35825	32656	31744	32647	26336	27642	28812	27527	29173
HDV Diesel Rigid 7,5 - 12 t	Euro IV	-	-	98901	67728	49677	45089	39108	35650	34654	35639	28750	30176	31453	30050	31847
HDV Diesel Rigid 7,5 - 12 t	Euro V	-	-	-	-	-	45089	39108	35650	34654	35639	28750	30176	31453	30050	31847
HDV Diesel Rigid 7,5 - 12 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	30176	31453	30050	31847
HDV Diesel Rigid 12 - 14 t	Conventional	32573	42646	45296	31019	22752	20650	17911	16327	15871	16322	13167	13820	14405	13763	14586
HDV Diesel Rigid 12 - 14 t	Euro I	42545	55702	59163	40515	29717	26972	23395	21326	20730	21319	17198	18051	18815	17976	19051
HDV Diesel Rigid 12 - 14 t	Euro II	50861	66590	70727	48435	35525	32244	27967	25494	24782	25487	20560	21580	22493	21489	22775
HDV Diesel Rigid 12 - 14 t	Euro III	63456	83080	88241	60429	44323	40229	34893	31807	30919	31798	25651	26923	28063	26811	28414
HDV Diesel Rigid 12 - 14 t	Euro IV	-	-	91004	62320	45710	41488	35985	32803	31887	32793	26454	27766	28942	27650	29304
HDV Diesel Rigid 12 - 14 t	Euro V	-	-	-	-	-	41488	35985	32803	31887	32793	26454	27766	28942	27650	29304
HDV Diesel Rigid 12 - 14 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	27766	28942	27650	29304
HDV Diesel Rigid 14 - 20 t	Conventional	40995	53673	57008	39039	28634	25990	22542	20549	19975	20543	16572	17394	18130	17321	18357
HDV Diesel Rigid 14 - 20 t	Euro I	51405	67303	71484	48953	35906	32589	28267	25767	25047	25760	20780	21811	22734	21720	23018
HDV Diesel Rigid 14 - 20 t	Euro II	59240	77560	82379	56414	41378	37556	32575	29694	28865	29685	23947	25135	26199	25030	26527
HDV Diesel Rigid 14 - 20 t	Euro III	68683	89924	95511	65407	47974	43543	37768	34427	33466	34418	27764	29141	30375	29020	30755
HDV Diesel Rigid 14 - 20 t	Euro IV	-	-	97604	66840	49025	44497	38595	35182	34199	35172	28373	29780	31041	29656	31429
HDV Diesel Rigid 14 - 20 t	Euro V	-	-	-	-	-	44497	38595	35182	34199	35172	28373	29780	31041	29656	31429
HDV Diesel Rigid 14 - 20 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	29780	31041	29656	31429
HDV Diesel Rigid 20 - 26 t	Conventional	41056	53752	57092	39097	28677	26028	22576	20579	20004	20573	16596	17419	18157	17347	18384
HDV Diesel Rigid 20 - 26 t	Euro I	52090	68199	72437	49605	36384	33024	28643	26110	25381	26103	21057	22101	23037	22009	23325
HDV Diesel Rigid 20 - 26 t	Euro II	59732	78205	83064	56883	41722	37868	32846	29941	29105	29932	24146	25344	26417	25238	26747
HDV Diesel Rigid 20 - 26 t	Euro III	70942	92881	98652	67558	49552	44975	39010	35560	34566	35549	28677	30100	31374	29974	31767
HDV Diesel Rigid 20 - 26 t	Euro IV	-	-	89877	61549	45144	40975	35540	32397	31492	32387	26126	27422	28584	27308	28941
HDV Diesel Rigid 20 - 26 t	Euro V	-	-	-	-	-	40975	35540	32397	31492	32387	26126	27422	28584	27308	28941
HDV Diesel Rigid 20 - 26 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	27422	28584	27308	28941
HDV Diesel Rigid 26 - 28 t	Conventional	40892	53538	56865	38941	28562	25924	22486	20497	19925	20491	16530	17350	18085	17277	18311
HDV Diesel Rigid 26 - 28 t	Euro I	50332	65897	69992	47931	35156	31909	27677	25229	24524	25222	20346	21355	22259	21266	22538
HDV Diesel Rigid 26 - 28 t	Euro II	57862	75756	80462	55101	40415	36682	31817	29003	28193	28995	23390	24550	25589	24447	25909
HDV Diesel Rigid 26 - 28 t	Euro III	67991	89018	94549	64748	47491	43104	37387	34081	33129	34071	27484	28848	30069	28727	30445
HDV Diesel Rigid 26 - 28 t	Euro IV	-	-	97109	66501	48777	44272	38400	35004	34026	34993	28229	29629	30883	29505	31270
HDV Diesel Rigid 26 - 28 t	Euro V	-	-	-	-	-	44272	38400	35004	34026	34993	28229	29629	30883	29505	31270
HDV Diesel Rigid 26 - 28 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	29629	30883	29505	31270
HDV Diesel Rigid 28 - 32 t	Conventional	40985	53660	56994	39030	28628	25983	22537	20544	19970	20538	16568	17389	18126	17317	18352
HDV Diesel Rigid 28 - 32 t	Euro I	50990	66759	70907	48557	35616	32326	28038	25559	24845	25551	20612	21634	22550	21544	22832
HDV Diesel Rigid 28 - 32 t	Euro II	58669	76813	81586	55871	40980	37195	32261	29408	28587	29400	23716	24893	25947	24789	26271
HDV Diesel Rigid 28 - 32 t	Euro III	69664	91208	96875	66341	48659	44165	38307	34919	33944	34909	28161	29558	30809	29434	31195
HDV Diesel Rigid 28 - 32 t	Euro IV	-	-	91316	62534	45867	41631	36109	32915	31996	32906	26545	27861	29041	27745	29404
HDV Diesel Rigid 28 - 32 t	Euro V	-	-	-	-	-	41631	36109	32915	31996	32906	26545	27861	29041	27745	29404
HDV Diesel Rigid 28 - 32 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	27861	29041	27745	29404
HDV Diesel Rigid >32 t	Conventional	50497	66113	70221	48088	35271	32013	27767	25311	24605	25304	20413	21425	22332	21336	22612
HDV Diesel Rigid >32 t	Euro I	55719	72950	77482	53061	38919	35324	30639	27929	27149	27921	22523	23641	24642	23542	24950
HDV Diesel Rigid >32 t	Euro II	68370	89514	95076	65109	47755	43345	37596	34271	33313	34261	27638	29009	30237	28887	30615
HDV Diesel Rigid >32 t	Euro III	78747	103100	109506	74990	55003	49923	43302	39472	38369	39461	31832	33411	34826	33272	35262

Subsector	Technology	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
HDV Diesel Rigid >32 t	Euro IV	-	-	100314	68696	50386	45732	39667	36159	35149	36148	29160	30607	31903	30479	32302
HDV Diesel Rigid >32 t	Euro V	-	-	-	-	-	45732	39667	36159	35149	36148	29160	30607	31903	30479	32302
HDV Diesel Rigid >32 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	30607	31903	30479	32302
HDV Diesel Articulated 14 - 20 t	Conventional	53396	69909	74253	50849	37296	33852	29362	26765	26017	26757	21585	22655	23615	22561	23910
HDV Diesel Articulated 14 - 20 t	Euro I	64525	84480	89728	61447	45070	40907	35481	32343	31440	32334	26083	27377	28536	27263	28893
HDV Diesel Articulated 14 - 20 t	Euro II	77201	101076	107356	73519	53924	48943	42452	38697	37616	38686	31207	32756	34142	32619	34569
HDV Diesel Articulated 14 - 20 t	Euro III	96256	126024	133854	91664	67233	61023	52929	48248	46901	48234	38910	40840	42569	40669	43102
HDV Diesel Articulated 14 - 20 t	Euro IV	-	-	142085	97301	71368	64776	56184	51215	49785	51201	41303	43352	45187	43170	45752
HDV Diesel Articulated 14 - 20 t	Euro V	-	-	-	-	-	64776	56184	51215	49785	51201	41303	43352	45187	43170	45752
HDV Diesel Articulated 14 - 20 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	43352	45187	43170	45752
HDV Diesel Articulated 20 - 28 t	Conventional	59206	77515	82332	56381	41354	37535	32556	29677	28848	29668	23933	25120	26184	25015	26511
HDV Diesel Articulated 20 - 28 t	Euro I	70334	92086	97807	66979	49127	44590	38676	35255	34270	35245	28432	29842	31105	29717	31495
HDV Diesel Articulated 20 - 28 t	Euro II	84220	110265	117116	80202	58826	53393	46311	42215	41036	42203	34045	35733	37246	35584	37712
HDV Diesel Articulated 20 - 28 t	Euro III	102066	133630	141932	97197	71291	64706	56124	51160	49731	51146	41258	43305	45139	43124	45703
HDV Diesel Articulated 20 - 28 t	Euro IV	-	-	142085	97301	71368	64776	56184	51215	49785	51201	41303	43352	45187	43170	45752
HDV Diesel Articulated 20 - 28 t	Euro V	-	-	-	-	-	64776	56184	51215	49785	51201	41303	43352	45187	43170	45752
HDV Diesel Articulated 20 - 28 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	43352	45187	43170	45752
HDV Diesel Articulated 28 - 34 t	Conventional	63563	83220	88391	60531	44398	40297	34952	31861	30971	31852	25694	26969	28111	26856	28462
HDV Diesel Articulated 28 - 34 t	Euro I	74586	97652	103719	71028	52097	47285	41013	37386	36342	37375	30150	31646	32986	31514	33398
HDV Diesel Articulated 28 - 34 t	Euro II	89207	116794	124051	84951	62309	56554	49053	44715	43466	44702	36060	37849	39452	37691	39945
HDV Diesel Articulated 28 - 34 t	Euro III	107586	140857	149608	102453	75147	68206	59159	53927	52421	53912	43490	45647	47580	45456	48175
HDV Diesel Articulated 28 - 34 t	Euro IV	-	-	162886	111546	81816	74259	64410	58713	57073	58696	47349	49698	51802	49491	52450
HDV Diesel Articulated 28 - 34 t	Euro V	-	-	-	-	-	74259	64410	58713	57073	58696	47349	49698	51802	49491	52450
HDV Diesel Articulated 28 - 34 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	49698	51802	49491	52450
HDV Diesel Articulated 34 - 40 t	Conventional	60614	79360	84291	57723	42338	38428	33331	30383	29534	30374	24502	25718	26807	25610	27142
HDV Diesel Articulated 34 - 40 t	Euro I	77926	102024	108363	74208	54430	49402	42850	39060	37969	39049	31500	33063	34463	32925	34894
HDV Diesel Articulated 34 - 40 t	Euro II	92426	121009	128528	88017	64558	58595	50824	46329	45035	46315	37362	39215	40876	39051	41387
HDV Diesel Articulated 34 - 40 t	Euro III	111591	146100	155178	106267	77944	70745	61362	55935	54372	55919	45109	47346	49351	47149	49968
HDV Diesel Articulated 34 - 40 t	Euro IV	-	-	164499	112651	82626	74994	65048	59295	57639	59278	47818	50190	52315	49981	52970
HDV Diesel Articulated 34 - 40 t	Euro V	-	-	-	-	-	74994	65048	59295	57639	59278	47818	50190	52315	49981	52970
HDV Diesel Articulated 34 - 40 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	50190	52315	49981	52970
HDV Diesel Articulated 40 - 50 t	Conventional	69979	91620	97312	66640	48879	44364	38480	35077	34097	35067	28288	29691	30948	29567	31335
HDV Diesel Articulated 40 - 50 t	Euro I	85839	112385	119368	81744	59957	54419	47201	43027	41825	43014	34699	36420	37962	36268	38437
HDV Diesel Articulated 40 - 50 t	Euro II	105622	138285	146877	100583	73775	66961	58079	52943	51464	52928	42696	44814	46711	44627	47295
HDV Diesel Articulated 40 - 50 t	Euro III	126133	165141	175401	120116	88102	79965	69358	63224	61458	63206	50987	53517	55783	53293	56480
HDV Diesel Articulated 40 - 50 t	Euro IV	-	-	164499	112651	82626	74994	65048	59295	57639	59278	47818	50190	52315	49981	52970
HDV Diesel Articulated 40 - 50 t	Euro V	-	-	-	-	-	74994	65048	59295	57639	59278	47818	50190	52315	49981	52970
HDV Diesel Articulated 40 - 50 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	50190	52315	49981	52970
HDV Diesel Articulated 50 - 60 t	Conventional	64355	84257	89492	61285	44951	40799	35387	32258	31357	32248	26014	27305	28461	27191	28817
HDV Diesel Articulated 50 - 60 t	Euro I	76433	100070	106288	72787	53387	48456	42029	38312	37242	38301	30897	32430	33803	32294	34225
HDV Diesel Articulated 50 - 60 t	Euro II	92545	121165	128693	88130	64641	58671	50889	46388	45093	46375	37410	39266	40928	39102	41440
HDV Diesel Articulated 50 - 60 t	Euro III	112762	147634	156806	107382	78762	71487	62006	56522	54943	56505	45582	47843	49869	47643	50493
HDV Diesel Articulated 50 - 60 t	Euro IV	-	-	164499	112651	82626	74994	65048	59295	57639	59278	47818	50190	52315	49981	52970
HDV Diesel Articulated 50 - 60 t	Euro V	-	-	-	-	-	74994	65048	59295	57639	59278	47818	50190	52315	49981	52970
HDV Diesel Articulated 50 - 60 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	50190	52315	49981	52970

Subsector	Technology	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BUS Diesel Urban Midi <=15 t	Conventional	64914	84989	90269	61817	45341	41153	35695	32538	31629	32529	26240	27542	28708	27427	29067
BUS Diesel Urban Midi <=15 t	Euro I	79923	104640	111141	76111	55825	50669	43948	40061	38943	40050	32308	33910	35346	33769	35788
BUS Diesel Urban Midi <=15 t	Euro II	85306	111687	118627	81237	59585	54081	46908	42760	41565	42747	34484	36194	37727	36043	38199
BUS Diesel Urban Midi <=15 t	Euro III	90997	119138	126541	86656	63560	57689	50038	45612	44338	45599	36784	38609	40244	38448	40747
BUS Diesel Urban Midi <=15 t	Euro IV	-	-	119541	81863	60044	54498	47270	43089	41886	43077	34749	36473	38017	36321	38493
BUS Diesel Urban Midi <=15 t	Euro V	-	-	-	-	-	55185	47865	43632	42413	43619	35187	36933	38496	36778	38978
BUS Diesel Urban Midi <=15 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	36933	38496	36778	38978
BUS Diesel Urban Standard 15 - 18 t	Conventional	68735	89992	95583	65456	48010	43576	37796	34454	33491	34444	27785	29163	30398	29042	30778
BUS Diesel Urban Standard 15 - 18 t	Euro I	83538	109373	116168	79553	58350	52961	45936	41874	40704	41861	33769	35444	36945	35296	37407
BUS Diesel Urban Standard 15 - 18 t	Euro II	93114	121910	129485	88672	65039	59032	51202	46674	45370	46660	37640	39507	41180	39342	41695
BUS Diesel Urban Standard 15 - 18 t	Euro III	99296	130004	138081	94559	69357	62951	54601	49772	48382	49758	40139	42130	43914	41954	44463
BUS Diesel Urban Standard 15 - 18 t	Euro IV	-	-	133692	91554	67152	60950	52866	48190	46844	48176	38863	40791	42518	40620	43050
BUS Diesel Urban Standard 15 - 18 t	Euro V	-	-	-	-	-	82777	71798	65448	63620	65429	52781	55399	57745	55168	58467
BUS Diesel Urban Standard 15 - 18 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	55399	57745	55168	58467
BUS Diesel Urban Articulated >18 t	Conventional	65848	86211	91568	62706	45993	41745	36208	33006	32084	32997	26618	27938	29121	27821	29485
BUS Diesel Urban Articulated >18 t	Euro I	84006	109986	116819	79999	58677	53257	46194	42108	40932	42096	33958	35643	37152	35494	37617
BUS Diesel Urban Articulated >18 t	Euro II	94623	123885	131583	90109	66092	59988	52031	47430	46105	47416	38250	40147	41847	39979	42370
BUS Diesel Urban Articulated >18 t	Euro III	100426	131484	139653	95635	70146	63667	55223	50339	48933	50324	40596	42610	44414	42432	44969
BUS Diesel Urban Articulated >18 t	Euro IV	-	-	132590	90798	66598	60447	52430	47793	46458	47779	38543	40454	42167	40285	42695
BUS Diesel Urban Articulated >18 t	Euro V	-	-	-	-	-	82777	71798	65448	63620	65429	52781	55399	57745	55168	58467
BUS Diesel Urban Articulated >18 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	55399	57745	55168	58467
BUS Diesel Coach Standard <=18 t	Conventional	66233	86716	92104	63074	46263	41990	36420	33199	32272	33190	26774	28102	29292	27984	29658
BUS Diesel Coach Standard <=18 t	Euro I	77442	101392	107691	73748	54092	49096	42584	38818	37734	38807	31305	32858	34249	32720	34677
BUS Diesel Coach Standard <=18 t	Euro II	85377	111780	118726	81304	59635	54126	46947	42795	41600	42783	34512	36224	37758	36073	38230
BUS Diesel Coach Standard <=18 t	Euro III	92418	120998	128516	88009	64552	58590	50819	46324	45030	46311	37358	39212	40872	39048	41383
BUS Diesel Coach Standard <=18 t	Euro IV	-	-	134440	92066	67528	61291	53161	48460	47106	48446	39081	41019	42756	40848	43291
BUS Diesel Coach Standard <=18 t	Euro V	-	-	-	-	-	82777	71798	65448	63620	65429	52781	55399	57745	55168	58467
BUS Diesel Coach Standard <=18 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	55399	57745	55168	58467
BUS Diesel Coach Articulated >18 t	Conventional	65550	85821	91154	62423	45785	41556	36045	32857	31939	32847	26497	27812	28989	27696	29352
BUS Diesel Coach Articulated >18 t	Euro I	79025	103464	109892	75255	55198	50099	43454	39611	38505	39600	31945	33529	34949	33389	35386
BUS Diesel Coach Articulated >18 t	Euro II	90268	118184	125527	85962	63051	57227	49637	45247	43983	45234	36489	38299	39921	38139	40420
BUS Diesel Coach Articulated >18 t	Euro III	95678	125267	133050	91114	66830	60657	52612	47959	46619	47945	38676	40595	42314	40425	42843
BUS Diesel Coach Articulated >18 t	Euro IV	-	-	132917	91023	66763	60596	52559	47911	46573	47897	38638	40554	42271	40385	42800
BUS Diesel Coach Articulated >18 t	Euro V	-	-	-	-	-	82777	71798	65448	63620	65429	52781	55399	57745	55168	58467
BUS Diesel Coach Articulated >18 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	55399	57745	55168	58467
BUS CNG Urban	Euro I	-	44026	72079	64086	70267	53080	61888	71154	66684	69227	73657	75469	67920	64679	65839
BUS CNG Urban	Euro II	-	49072	80341	71432	78322	59165	68982	79311	74328	77163	82100	84120	75706	72093	73386
BUS CNG Urban	Euro III	-	52330	85675	76174	83522	63092	73562	84576	79262	82286	87551	89705	80732	76880	78258
BUS CNG Urban	EEV	-	-	112658	100166	109827	82964	96731	111214	104226	108202	115125	117957	106159	101093	102906
BUS CNG Urban	Euro VI	-	-	-	-	-	-	-	-	-	-	-	117957	106159	101093	102906
MOP Gasoline 2-stroke <50 cm³	Conventional	1092	996	895	1762	1530	1376	1357	1243	1118	1047	857	986	1012	998	1164
MOP Gasoline 2-stroke <50 cm³	Euro 1	1152	1050	944	1858	1613	1450	1430	1310	1178	1104	904	1039	1067	1052	1227
MOP Gasoline 2-stroke <50 cm³	Euro 2	854	779	700	1378	1197	1076	1061	972	874	819	670	771	792	780	910
MOP Gasoline 2-stroke <50 cm³	Euro 3	-	-	-	1153	1001	900	888	813	731	685	561	645	662	653	761
MOT Gasoline 2-stroke >50 cm³	Conventional	1625	1481	1332	2621	2276	2046	2018	1849	1662	1557	1275	1467	1506	1484	1731

Subsector	Technology	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
MOT Gasoline 2-stroke >50 cm³	Euro 1	1695	1545	1389	2734	2373	2134	2104	1928	1733	1624	1330	1530	1570	1548	1805
MOT Gasoline 2-stroke >50 cm³	Euro 2	1920	1750	1573	3097	2689	2417	2384	2184	1963	1840	1506	1733	1779	1753	2045
MOT Gasoline 2-stroke >50 cm³	Euro 3	-	-	-	3174	2756	2478	2443	2239	2013	1885	1544	1776	1823	1797	2096
MOT Gasoline 4-stroke <250 cm³	Conventional	2105	1919	1725	3395	2948	2651	2614	2395	2153	2017	1652	1900	1950	1922	2242
MOT Gasoline 4-stroke <250 cm³	Euro 1	2341	2134	1918	3776	3279	2948	2907	2664	2394	2243	1837	2113	2169	2138	2493
MOT Gasoline 4-stroke <250 cm³	Euro 2	2073	1890	1699	3344	2904	2611	2574	2359	2121	1987	1627	1871	1921	1893	2208
MOT Gasoline 4-stroke <250 cm³	Euro 3	-	-	-	3572	3101	2789	2750	2520	2265	2122	1738	1999	2052	2022	2359
MOT Gasoline 4-stroke 250 - 750 cm³	Conventional	2166	1975	1775	3494	3033	2727	2689	2464	2215	2075	1699	1955	2007	1978	2307
MOT Gasoline 4-stroke 250 - 750 cm³	Euro 1	2436	2222	1997	3930	3413	3068	3026	2772	2492	2335	1912	2199	2258	2225	2595
MOT Gasoline 4-stroke 250 - 750 cm³	Euro 2	2183	1991	1789	3522	3058	2750	2711	2484	2233	2092	1713	1971	2023	1994	2326
MOT Gasoline 4-stroke 250 - 750 cm³	Euro 3	-	-	-	3572	3101	2789	2750	2520	2265	2122	1738	1999	2052	2022	2359
MOT Gasoline 4-stroke >750 cm³	Conventional	2198	2005	1802	3547	3079	2769	2730	2502	2249	2107	1725	1984	2037	2008	2342
MOT Gasoline 4-stroke >750 cm³	Euro 1	2506	2285	2054	4042	3509	3155	3111	2851	2563	2401	1966	2262	2322	2288	2669
MOT Gasoline 4-stroke >750 cm³	Euro 2	2240	2043	1836	3614	3138	2821	2782	2549	2292	2147	1758	2022	2076	2046	2386
MOT Gasoline 4-stroke >750 cm³	Euro 3	-	-	-	3572	3101	2789	2750	2520	2265	2122	1738	1999	2052	2022	2359