



REPUBLIC OF BULGARIA
MINISTRY OF ENVIRONMENT AND WATER
EXECUTIVE ENVIRONMENT AGENCY

NATIONAL INVENTORY REPORT 2023

GREENHOUSE GAS EMISSIONS IN BULGARIA 1988-2021

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Reporting Entity

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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 (CO₂), methane (CH₄), nitrous oxide (N₂O) and halogenated hydrocarbons, i.e. greenhouse gases, have increased as a consequence of the 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 CO₂ have increased by 35%, CH₄ concentrations have more than doubled and N₂O 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 HadCM3³ 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 1988⁴ 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.

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

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>

⁵ http://www.gcric.org/CSP/pdf/bulgaria_snap.pdf

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 Regulation⁶ 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 2023 submission to the EU, the UNFCCC 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 (CO₂), methane (CH₄), nitrous oxide (N₂O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), nitrogen trifluoride (NF₃) and sulphur hexafluoride (SF₆).

Each of these gases has a different global warming potential. As an example, the gases HFCs, PFCs and SF₆ (so called F-gases) have much greater warming effect, in some cases over one hundred times, compared to methane (28), nitrous oxide (265) 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), representing GHG emissions as CO₂-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 Fifth Assessment Report of 2014.

Indirect CO₂ emissions resulting from atmospheric oxidation of CH₄ 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 CO₂ 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 (NMVOCs) and sulphur dioxide (SO₂) meaning sulphur oxides and other sulphur emissions calculated as SO₂. 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 tropospheric 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 2021. Full time series of the emissions and removals (with exception of F-gases) from 1988 to 2021 are included in the submission.

The structure of this NIR was re-elaborated 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 NIR⁸, 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

⁶ Regulation No 525/2013

⁷ Global Warming Potential referenced to the updated decay response for the Bern carbon cycle model and future CO₂ atmospheric concentrations held constant at current levels. http://unfccc.int/ghg_data/items/3825.php

⁸ http://unfccc.int/files/national_reports/annex_i_ghg_inventories/reporting_requirements/application/pdf/annotated_nir_outline.pdf

emission trend in Bulgaria from the year 1988 to the year 2021. 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 CO₂ and nitrous oxide emissions.

In Chapter 10 improvements and recalculations since the previous submission are summarised.

Annex 1 contains the mandatory key category reporting tables. A national reference calculation for CO₂ emissions from energy combustion can be found in Annex 4 (Comparison of CO₂ 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.

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.

The inventories are prepared according to the UNFCCC Guidelines⁹ and establishing the NIR structure in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.¹⁰

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 2021. 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 1988-2021 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 2021 Bulgaria's greenhouse gas emissions are total 53 917,27 Gg CO₂ eq. without reporting of sequestration from LULUCF sector. The emissions decreased by 52.55 % compared with the base year. Emissions in 2021 were 12.36% increased in comparison with the emissions of the previous year.

The net emissions including reporting of sequestration from LULUCF sector were 44 773,18 Gg CO₂ eq. The emissions decreased by 54.08 % 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 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 from 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 1988-2021, which resulted in the reduction of population by 23.90%.

⁹ <http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf>

¹⁰ http://unfccc.int/files/national_reports/annex_i_ghg_inventories/reporting_requirements/items/2759.php

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.

¹¹.

Under the UNFCCC, 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)¹²
- 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 – 2019.

The national greenhouse gas inventory for 2021 is submitted to the European Commission by Bulgarian Ministry of Environment and Water in fulfilment of Bulgaria's obligation regarding Regulation (EU) 2018/1999 of the European Parliament and of Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council as well as Commission Implementing Regulation (EU) 2020/1208 of 7 August 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014..

¹¹ Report of the review of the initial report of Bulgaria: <http://unfccc.int/resource/docs/2008/irr/bgr.pdf>

¹² <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>

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 (CO₂), methane (CH₄), nitrous oxide (N₂O) 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 CO₂ have increased by 35%, CH₄ concentrations have more than doubled and N₂O 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 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 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”.

The Paris Agreement, inter alia, sets out a long-term goal in line with the objective to keep the global temperature increase well below 2 °C above pre-industrial levels and to pursue efforts to keep it to 1,5 °C above pre-industrial levels. Forests, agricultural land and wetlands will play a central role in achieving this goal. In the Paris Agreement, the Parties also recognise the fundamental priority of safeguarding food security and ending hunger, in the context of sustainable development and efforts to eradicate poverty, and the particular vulnerabilities of food production systems to the adverse impacts of climate change, thereby fostering climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production. In order to achieve the objectives of the Paris Agreement, the Parties should increase their collective efforts. The Parties should prepare, communicate and maintain successive nationally determined contributions. The Paris Agreement replaces the approach taken under the 1997 Kyoto Protocol, which will not be continued beyond 2020.

The Paris Agreement also calls for a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, and invites Parties to take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases, including forests.

The inventory of the anthropogenic emissions by sources and removals by sinks is prepared in accordance with the methodologies accepted by the IPCC and agreed upon by the UNFCCC:

- 2006 IPCC guidelines for national greenhouse gas inventory (2006 IPCC GLs).

1.1.2 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES

The annual inventory and reporting of greenhouse gas emissions and removals provides an information base for the planning and monitoring of climate policy.

The National Inventory Report (NIR) of Bulgaria for the 2023 submission to the EU and the UNFCCC 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 (CO₂), methane (CH₄), nitrous oxide (N₂O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), nitrogen trifluoride (NF₃) and sulphur hexafluoride (SF₆).

Indirect CO₂ emissions resulting from atmospheric oxidation of CH₄ 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 CO₂ 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 (NMVOCs) and sulphur dioxide (SO₂) meaning sulphur oxides and other sulphur emissions calculated as SO₂. 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 tropospheric ozone.

The emission estimates and removals are presented by gas and by source category and refer to the year 2020. Full time series of the emissions and removals (with exception of F-gases) from 1988 to 2021 are included in the inventory submission.

The structure of this NIR was re-elaborated 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 2021. In Chapters 3 to 8 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 CO₂ and nitrous oxide emissions. In Chapter 10 improvements and recalculations since the previous submission are summarised.

Annex 1 contains the mandatory key category reporting tables. A national reference calculation for CO₂ emissions from energy combustion can be found in Annex 4 (Comparison of CO₂ 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.

As 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.

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

- Carbon dioxide - CO₂;
- Methane - CH₄;
- Nitrous oxide - N₂O;
- Hydrofluorocarbons – HFCs;
- Perfluorocarbons – PFCs;
- Sulphur hexafluoride - SF₆;

- Nitrogen trifluoride - NF₃.

Each of these gases has a different warming effect. As an example, the gases HFCs, PFCs, NF₃ and SF₆ (so called F-gases) have much greater warming effect, in some cases over one hundred times, compared to methane (28), nitrous oxide (265) and carbon dioxide (1).

A common assessment criteria for the effect of each GHG on the atmosphere warming should be introduced. This criteria is the so-called Global Warming Potential (GWP), representing GHG emissions as CO₂-eq. emissions. It allows totalling the effect of all GHGs, adjusted to a common base.

For defining of GWP, the Parties to the Convention accept values, over a time horizon of 100 years, as mentioned in the IPCC Fifth Assessment Report of 2014.

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 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 2021. 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 1988-2021 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 INSTITUTIONAL, LEGAL AND PROCEDURAL ARRANGEMENTS

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 2008-2023)	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 Environmental 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 national inventory. This is outlined in the national inventory preparation cycle .

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.

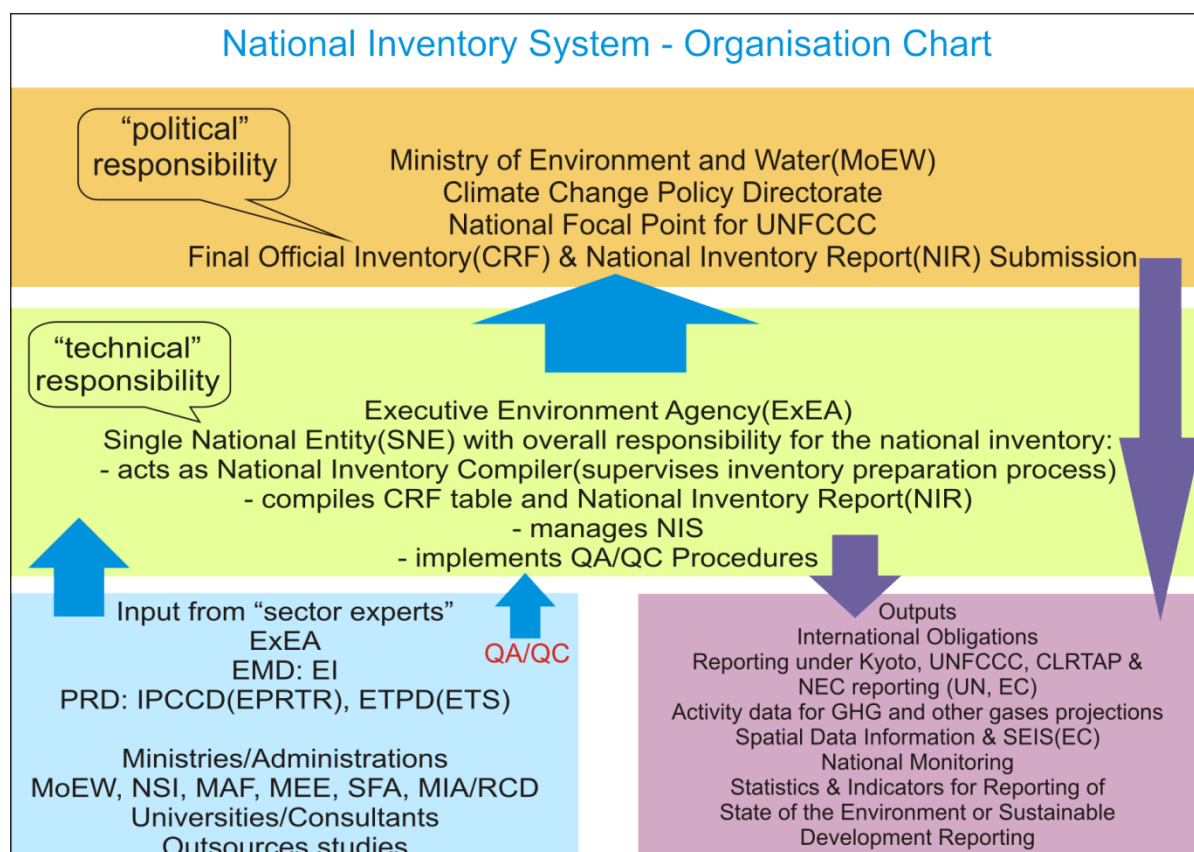


Figure 1 Organizational Chart of the Bulgarian National Inventory System

The Bulgarian Government by MoEW (Climate Change Policy Directorate) has the political responsibility for compliance with commitments under the UNFCCC and the Paris Agreement. In order to meet all challenges in this sphere, the Climate Change Policy has been transformed in a separate directorate. Now, it consists of 11 persons in total.

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

Climate change mitigation law

Climate change mitigation law adopted on first reading in the National Assembly on 23.10.2013, 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. Its 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 is 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 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 Monitoring Department (WD) and Permit Regime Directorate with the Integrated Pollution Prevention and Control Department (IPPCD) and Emission Trading Permit Department (ETPD).

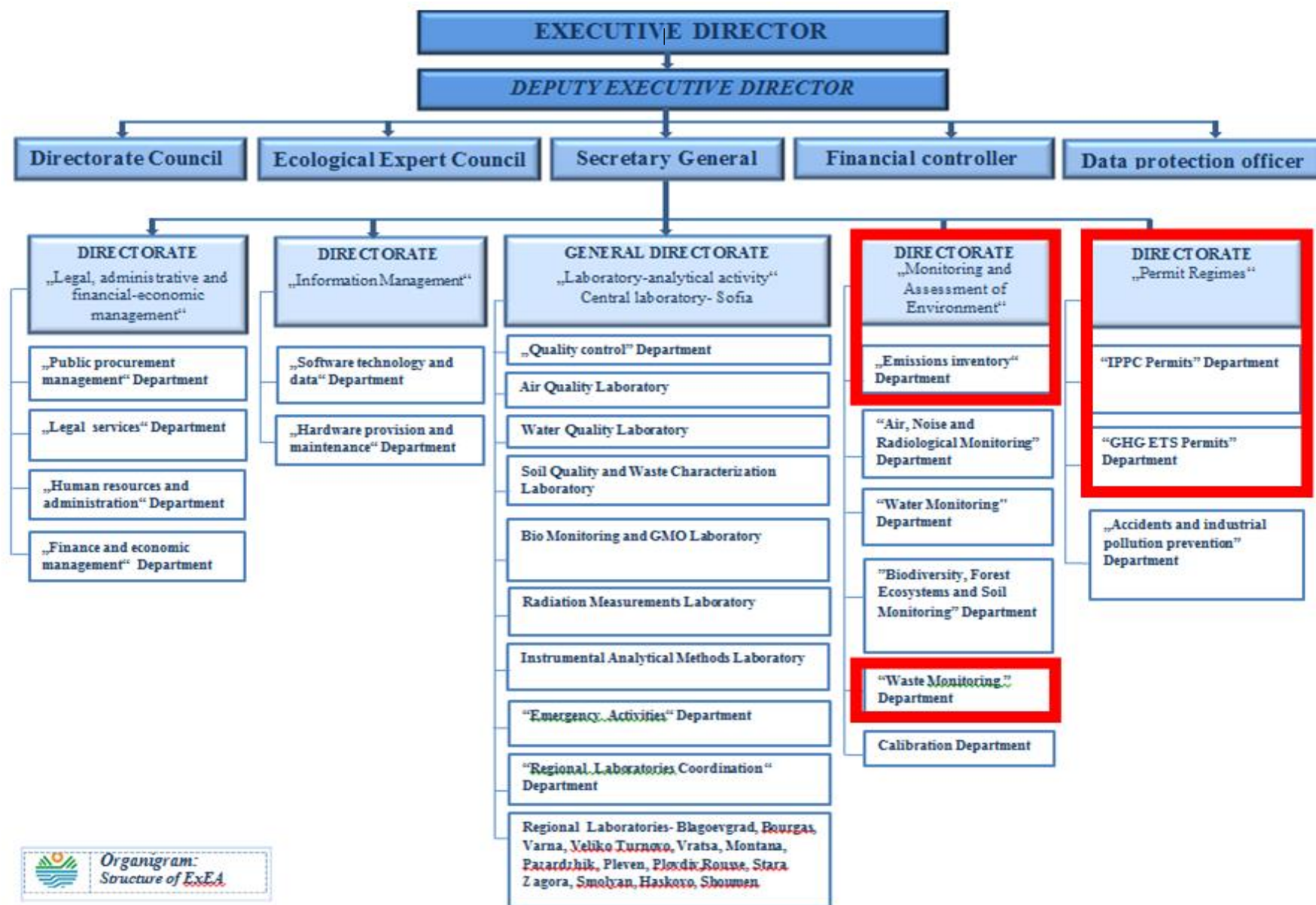


Figure 2 Organizational Chart of the Executive Environmental Agency (ExEA)

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 overall objective of the BGNIS is annually to produce a high quality inventory (National CRF, SEF tables and NIR) 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 TACCC criteria. (see also chapter 1.2.12)

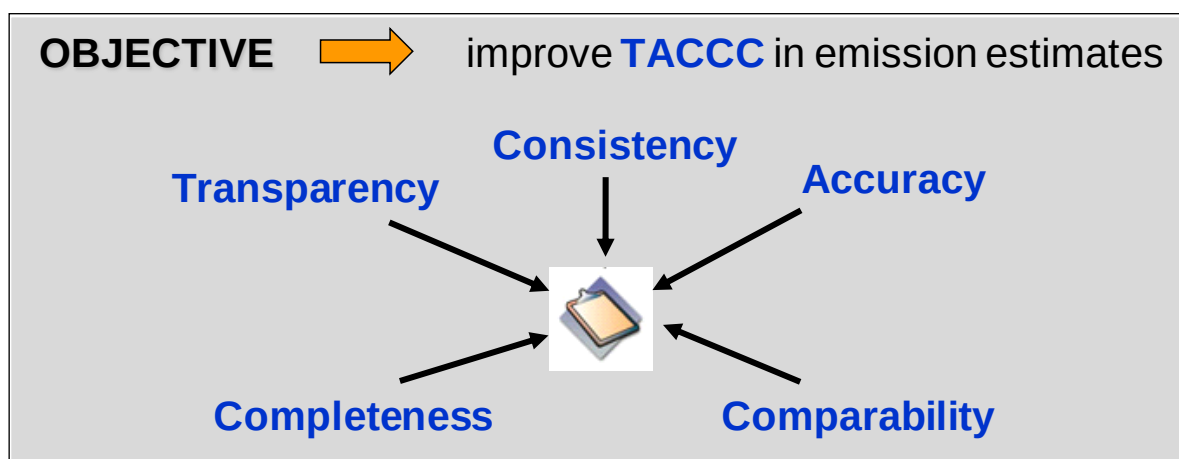


Figure 3 Objectives of the Bulgarian National Inventory System

1.1.4 OVERVIEW OF INVENTORY PLAN, 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 UNFCCC:

National Focal Point;

QA experts from Climate Change Policy Directorate;

Approval of inventory;

Submission of CRF / NIR // SEF.

The ExEA has been identified as the responsible organization for preparation of Bulgaria's National GHG Inventory under the UNFCCC 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 March 2021);

Statute on the organization and structure of ExEA (Decision of Council of ministers 162/03.08.2010 – final update 20.09.2019);

Order № 344/01.12.2020 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 261/05.09.2014 SG 76/2014 on the way and order of organization of the National Inventories of hazardous substances and greenhouse gases in the ambient air (last update 227/16.10.2017 SG 84/2017)

Add 1.

EPA (State Gazette No. 91/25.09.2002; corrected, SG No. 96/2002; last amendment March 2017), 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:

- (2) direct the National Environmental Monitoring System through the **Executive Environmental Agency**;

Article 13:

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

(2) The Executive Environmental Agency shall be a legal person.

(3) The Executive Environmental Agency shall be managed and represented by an Executive Director.

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

Chapter Eight: NATIONAL ENVIRONMENTAL MONITORING SYSTEM

Article 144: (1) 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 Environmental Agency (ExEA) according to **Regulation on the organization and structure of ExEA** (Decision of Council of ministers 162/03.08.2010 - final update 20.09.2019), 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 № 344/01.12.2020 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 261/05.09.2014 SG 76/2014 (last update 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 Environmental 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.

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"

LEGAL BASIS OF THE BULGARIAN NIS – SPECIFIC FUNCTIONS SINGLE NATIONAL ENTITY

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

Executive Environmental 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): Veneta Borikova
Organization: Ministry of Environment and Water

Address: 22 “Maria Luiza” blvd., 1202 Sofia, Bulgaria
 E-mail: vborikova@moew.government.bg
 Tel.: +359 2 940 61 83

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: Violeta Stoeva
 Organization: Executive Environmental Agency
 Address: 136, “Tsar Boris III” blvd., 1618 Sofia, Bulgaria
 e-mail: v.stoeva@eea.government.bg
 Tel.: +359 2 940 64 66
 Fax: +359 2 955 90 15

An overview of the general responsibilities in the inventory development and reporting process is given. 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).

1.2 INVENTORY PREPARATION, DATA COLLECTION, PROCESSING AND STORAGE

Collection of activity data by ExEA

The information is being collected on 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 261/05.09.2014 (SG 76/2014)).

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

Sectors	Data Source of Activity Data	Activity Data supplier	
	Country specific parameters used in the COPERT 5 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 (EPRTTR and ETS)	ExEA	Executive Environmental Agency
	National studies	MoEW/ ExEA	Ministry of Environment and Water/ Executive Environmental Agency
	National VOC register	ExEA	Executive Environmental Agency
3. Agriculture	National agriculture statistics	MAFF	Ministry of Agriculture, 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 Environmental Agency/ Waste Monitoring Department

Inventory preparation

The inventory preparation process covers:

- Identification key source categories¹³;
- Prepare estimates¹⁴ 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;

¹³ following the methods described in the 2006 IPCC GL (chapter 4, section 4.2);

¹⁴ in accordance with the methods described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

- Make a quantitative estimate of inventory uncertainty¹⁵ for each source category and for the inventory in total recalculations¹⁶ 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 procedures¹⁷ (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.

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.

National Inventory System - Responsibilities

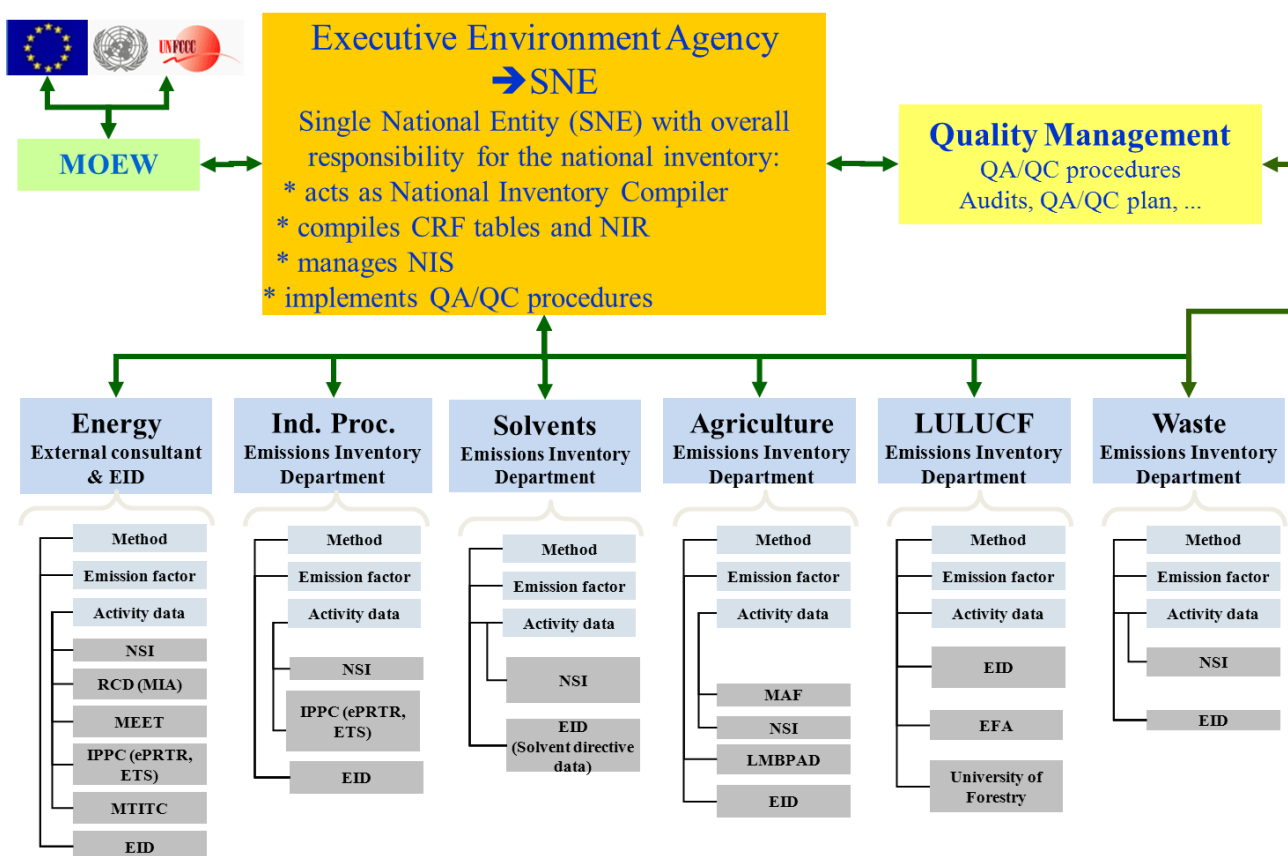


Figure 4 Bulgarian National Inventory System – Responsibilities

¹⁵ following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

¹⁶ prepared in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and relevant decisions of the COP and/or COP/MOP;

¹⁷ in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

The following table presents the responsibilities of all engaged institutions for preparation of GHGs emission inventory for 2023 submission.

Table 2 Preparation of GHGs emission inventory for 2022 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	ExEA, NSI MI, MTITC	Sector expert ExEA External consultants
	MI		
	MTITC		
Energy CRF1B	NSI	ExEA, NSI, ME	Sector expert ExEA External consultants
	ME		
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 External consultants
	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.

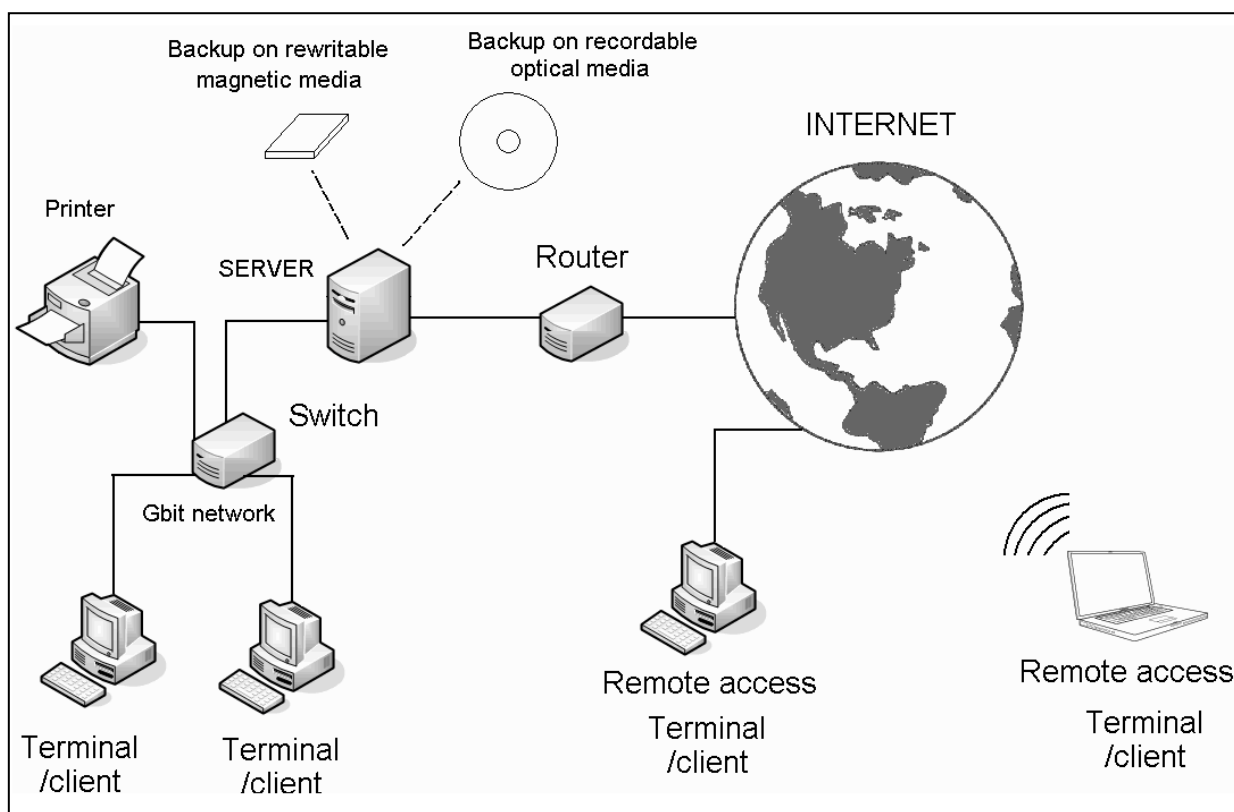


Figure 5 Documentation and data archiving in ExEA

1.2.1 QUALITY ASSURANCE, QUALITY CONTROL AND VERIFICATION

As it is written above the Executive Environmental 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 manager 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.

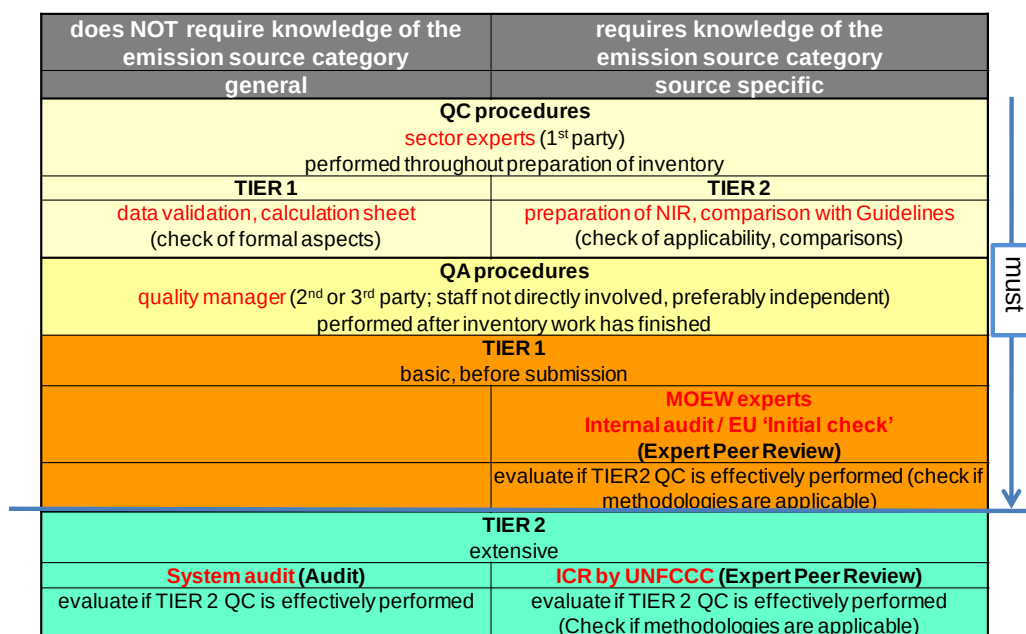


Figure 6 National quality assurance and quality control program

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 № 344/01.12.2020 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 2022 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 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	✓	✓

	2006 IPCC GL	ISO 9001
6. Personnel	✓	✓
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 2023 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 and external consultant
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 2022 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 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 2023 submission

Sector - CRF	Reporting Tables - CRF		National Report - NIR	
	Check	Correction	Check	Correction
Energy CRF1	MOEW ExEA	External consultant	MOEW ExEA	External consultant
IPPU CRF2	MOEW ExEA	Sector expert ExEA	MOEW ExEA	Sector expert ExEA
Agriculture CRF3	MOEW ExEA	Sector expert ExEA	MOEW ExEA	Sector expert ExEA
LULUCF CRF4	MOEW ExEA	External consultant	MOEW ExEA	External consultant
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.

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

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 audit¹⁸ 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)

¹⁸ 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.

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 2024

The next table presents the responsibilities of all engaged institutions for preparation of GHGs emission inventory for 2023 submission.

Table 7 Preparation of GHGs emission inventory for 2024 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 consultant
Energy/Transport CRF1A3	NSI	ExEA, NSI MI, MTITC	Sector expert ExEA External consultant
	MI		
	MTITC		
Energy CRF1B	NSI	ExEA, NSI, ME	Sector expert ExEA External consultant
	MEE		
Industry processes and product use CRF2	NSI	ExEA, NSI, Installations operators	Sector expert ExEA
	ExEA		
	MOEW		
	ExEA		

Sector CRF	Activity data	Methodology and selection of emission factors	Preparation of Sector inventories
Agriculture CRF3	MAF	ExEA, MAF	Sector expert ExEA
	NSPP		
LULUCF CRF4	EAF	ExEA, EAF	Sector expert ExEA External consultant
	MAFF		
Waste CRF5	NSI	ExEA, NSI	Sector expert ExEA
	ExEA		

The Work plan for preparation and submission of National GHGs inventory in 2024 is presented in the next table.

Table 8 Work plan for GHGs inventory preparation and submission 2024

Action	Responsible organization	Initial Deadline	Final Deadline	Comment
Sending of statistic questionnaire to all enterprises in the country	NSI with its regional inspectorates	31.03.23	15.06.23	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	31.03.23	15.06.23	
QA/QC Procedures - Implementation of the requirements of National QA/QC Plan.	NSI MAFF, ME, MEW, SFA, RCD	15.06.23	30.09.23	National QA/QC Plan
Provision of all collected activity data by questionnaires and other sources of information to ExEA	NSI MAFF, ME, MEW, EFA, MIA	30.09.23	30.10.23	
QA/QC Procedures - Implementation of the requirements of National QA/QC Plan	ExEA	30.10.23	15.11.23	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		30.11.23	
Preliminary estimation of emissions	ExEA, external consultants		15.12.23	
Provision of corrected activity data as a result of QA/QC procedures to ExEA	NSI MAFF, ME, MEW, EFA, MIA		20.12.23	
Recalculation of emissions, based on the corrected activity data of	ExEA and external consultant		31.12.23	

Action	Responsible organization	Initial Deadline	Final Deadline	Comment
inventory in the required format for reporting				
Preparation of Preliminary national inventory report (NIR) to the EC.	ExEA		10.01.24	
Submission of national GHG inventory under the RMM with the short NIR.	ExEA		15.01.24	Delivered to Eionet Central Data Repository
Submission of final national GHG inventory and NIR.	ExEA		15.03.24	Delivered to Eionet Central Data Repository
Submission of the final GHG inventory and NIR after the European Commission comments	MEW ExEA		15.04.24	Official submission to UNFCCC Delivered to Eionet Central Data Repository
Documentation and archiving of inventory. Preparation of inventory management report	ExEA		15.05.24	
Preparation of QA/QC plan for the next inventory.	ExEA		15.06.24	

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.

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 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 above and periodic internal evaluations of the inventory preparation process, re-evaluate the inventory planning process in order to meet the established quality objectives.

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 publication of confidentiality data on an aggregated level.

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

The most recent greenhouse gas inventory for the period 1988 to 2021 (NIR 2023) 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 – CO₂, CH₄ and N₂O (plus relevant ODS and SF₆).

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 – 2019.

The emission factors are mainly from:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC GL)
- EMEP/EEA air pollutant emission inventory guidebook – 2019.
- Country-specific

The following tables summarise the 'Applied method' and 'Emission factor' of the inventory 2021, submission 2023.

Table 9 Methods and the emission factors applied (CO₂, CH₄, N₂O)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO ₂		CH ₄		N ₂ O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	T1,T2	CR,CS,D	T1,T2	CR,CS,D	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						

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO ₂		CH ₄		N ₂ O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
B. Fugitive emissions from fuels	T1	D	T1,T2	CS,D	T1	D
1. Solid fuels	T1	D	T1,T2	CS,D		
2. Oil and natural gas	T1	D	T1	D	T1	D
C. CO ₂ transport and storage						
2. Industrial Processes	T1,T2	CR,CS,D,PS			T1,T3	CS,D,PS
A. Mineral industry	T1,T2	CS,D,PS				
B. Chemical industry	T2	CS,PS			T3	PS
C. Metal industry	T2	CS,PS				
D. Non-energy products from fuels and solvent use	T1,T2	CR,D				
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	T1,T2	D			T1	CS,D
H. Other						
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	D
E. Prescribed burning of savannas						
F. Field burning of agricultural residues			D	D	D	D
G. Liming						
H. Urea application	T1	D				
I. Other carbon-containing fertilizers						
J. Other						
4. LULUCF	T1,T2	CS,D	T1	D	T1	D
A. Forest land	T1,T2	CS,D	T1	D	T1	D
B. Cropland	T1,T2	CS,D			T1	D
C. Grassland	T1,T2	CS,D			T1	D
D. Wetlands	T1,T2	CS,D			T1	D
E. Settlements	T1,T2	CS,D			T1	D
F. Other land						
G. Harvested wood products	T2	D				
H. Other						
5. Waste	T1	D	T1,T2	CS,D	T1	D
A. Solid waste disposal			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						
7. Other (specified in Summary 1.A)						

Table 10 Methods and the emission factors applied: HFCs, PFCs, SF₆

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	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

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
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)	

1.4 BRIEF DESCRIPTION OF KEY CATEGORIES

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 CO₂, CH₄, N₂O, HFC, PFC, NF₃ and SF₆, 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.

Table 11 Methods and the emission factors applied: HFCs, PFCs, SF₆

Source	Fuel/Cat.	GHG	excl. LULUCF	incl. LULUCF
1	2	3	4	5
1A1	Liquid fuels	CO ₂	LA TA	LA TA
1A1	Solid fuels	CO ₂	LA TA	LA TA
1A1	Gaseous fuels	CO ₂	LA TA	LA TA
1A1	All fuel	CH ₄	LA TA	LA TA
1A1	All fuel	N ₂ O	LA TA	LA TA
1A2	Liquid fuels	CO ₂	LA TA	LA TA
1A2	Solid fuels	CO ₂	LA TA	LA TA

1A2	Gaseous fuels	CO2	LA TA	LA TA
1A2	Other fossil fuels	CO2	LA TA	LA TA
1A2	All fuel	CH4	LA TA	LA TA
1A2	All fuel	N2O	LA TA	LA TA
1A3a	Liquid fuel	CO2	LA TA	LA TA
1A3a	Liquid fuel	CH4	LA TA	LA TA
1A3a	Liquid fuel	N2O	LA TA	LA TA
1A3b	Gasoline	CO2	LA TA	LA TA
1A3b	Diesel Oil	CO2	LA	LA
1A3b	All fuel	CH4	LA TA	LA TA
1A3b	All fuel	N2O	LA TA	LA TA
1A3b	LPG	CO2	LA TA	LA TA
1A3b	Gaseous fuel	CO2	LA TA	LA TA
1A3b	Other liquid fuels	CO2	LA TA	LA TA
1A3b	Other fossil fuels	CO2	LA TA	LA TA
1A3c	Liquid fuel	CO2	LA TA	LA TA
1A3c	Liquid fuel	CH4	LA TA	LA TA
1A3c	Liquid fuel	N2O	LA TA	LA TA
1A3d	Gas/diesel oil	CO2	LA TA	LA TA
1A3d	Gas/diesel oil	CH4	LA TA	LA TA
1A3d	Gas/diesel oil	N2O	LA TA	LA TA
1A3e	Gaseous fuel	CO2	LA TA	LA TA
1A3e	Gaseous fuel	CH4	LA TA	LA TA
1A3e	Gaseous fuel	N2O	LA TA	LA TA
1A4	Liquid fuel	CO2	LA	LA
1A4	Solid fuel	CO2	LA	LA
1A4	Gaseous fuel	CO2	LA	LA TA
1A4	All fuel	CH4	LA	LA
1A4	All fuel	N2O	LA TA	LA TA
1A5	Stationary - Fossil fuels	CO2	LA TA	LA TA
1A5	Stationary - Fossil fuels	CH4	LA TA	LA TA
1A5	Stationary - Fossil fuels	N2O	LA TA	LA TA
1B1	Solid fuel	CO2	LA	LA TA
1B1	Solid fuel	CH4	LA	LA
1B2	Oil and Natural Gas	CO2	LA	LA
1B2	Oil and Natural Gas	CH4	LA	LA
1B2	Oil and Natural Gas	N2O	LA TA	LA TA
2A1	Cement Production	CO2	LA TA	LA TA
2A2	Lime Production	CO2	LA TA	LA TA
2A3	Glass production	CO2	LA TA	LA TA
2A4a	Ceramics - Bricks and Tiles	CO2	LA TA	LA TA
2A4b	Soda ash uses	CO2	LA TA	LA TA
2A4d	DeSOx - installations	CO2	LA	LA
2B1	Ammonia Production	CO2	LA	LA
2B2	Nitric Acid Production	N2O	LA	LA
2B5b	Calcium Carbide	CO2	LA TA	LA TA
2B7	Soda ash production	CO2	LA	LA TA
2B8	Petrochemical and carbon black production	CH4	LA TA	LA TA
2B8b	Ethylene	CO2	LA TA	LA TA
2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	LA TA	LA TA
2C1	Iron and Steel Production	CO2	LA	LA
2C1	Iron and Steel Production	CH4	LA TA	LA TA
2C2	Ferroalloys Production	CO2	LA TA	LA TA
2C2	Ferroalloys Production	CH4	LA TA	LA TA
2C2	Lead production	CO2	LA	LA

2C2	Zinc production	CO2	LA	LA
2D	Non-energy products from fuels and solvent use	CO2	LA	LA
2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	LA	LA
2G	Other product manufacture and use	N2O	LA TA	LA TA
2G	Other product manufacture and use	CO2	LA	LA TA
2G1	Electrical equipment - SF6	CO2eq	LA	LA
2H	Other	CO2	LA TA	TA
3A1	Cattle	CH4	LA	LA
3A2	Sheep	CH4	LA	LA
3A3	Swine	CH4	LA	LA
3A4	Other livestock	CH4	LA	LA
3B	N2O em. from Manure Management	N2O	LA	LA
3B1	Cattle	CH4	LA	LA TA
3B2	Sheep	CH4	LA	LA
3B3	Swine	CH4	LA	LA
3B4	Other livestock	CH4	LA	LA
3C	Rice Cultivation	CH4	LA	LA
3Da	Direct N2O emissions from managed soils	N2O	LA	LA
3Db	Indirect N2O Emissions from managed soils	N2O	LA	LA
3F	Field burning of agricultural residues	CH4	LA	LA
3F	Field burning of agricultural residues	N2O	LA	LA
3G	Liming	CO2	LA	LA
3H	Urea application	CO2		LA
4A1	Forest Land remaining Forest Land	CO2		LA
4A2	Land converted to Forest Land	CO2		LA
4A1 (V)	Forest fires	CO2eq		LA
4A2 (V)	Forest fires	CO2eq		LA
4B1	Cropland remainig Cropland	CO2		LA
4B2	Land converted to Cropland	CO2		LA
4C1	Grassland remaining grassland	CO2		LA
4C2	Land converted to Grassland	CO2		LA
4D2	Land converted to Wetlands	CO2		LA
4E2	Land converted to Settlements	CO2		LA
4F	Land converted to other land	CO2		LA
4G	Harvested wood products	CO2		LA
4	Indirect N2O Emissions from managed soils	N2O	LA	LA
5A	Solid waste disposal	CH4	LA	LA
5B	Biological treatment of solid waste	CH4		LA
5B	Biological treatment of solid waste	N2O	LA	LA
5C	Incineration and open burning of waste	CO2	LA	LA
5C	Incineration and open burning of waste	CH4	LA	LA
5C	Incineration and open burning of waste	N2O	LA	LA
5D	Wastewater treatment and discharge	CH4	LA	LA

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

1.5 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 12.

Combined uncertainty as a part of overall emissions for 2021 for every source has been calculated as following equation:

$$MCU_i = (EM_i / EM_{total}) \times CUI$$

where MCU_i – measured combined uncertainty,

EM_i - source emissions for 2021,

EM_{total} – total country emissions for 2021,

CN_i – combined uncertainty of the i-th source.

Uncertainty of the overall emissions trend for 2021 for every source has been calculated as HT_i – 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 2021 (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 2021 (row 7, column M in Table 6.1.) are given in Table 12. The relevant data for the previous inventory for 2020 are given for comparison (NIR 2022 and NIR 2023).

Table 12 Uncertainty in total GHG emissions, %

Uncertainty	Uncertainty NIR 2022	Uncertainty NIR 2023
Uncertainty in total GHG emissions	16.18%	13.65%
Overall uncertainty into the trend in total GHG emissions	2.66	2.25

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.

1.6 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: CO₂, N₂O, CH₄, F-gases (HFC, PFC, NF₃ and SF₆), NMVOC, NO_x, CO and SO₂. In accordance with the IPCC Guidelines, international aviation and marine bunker fuel emissions are not included in national totals. However, CO₂, CH₄ and N₂O 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. Where “NE” is used in an inventory to report emissions or removals of CO₂, N₂O, CH₄, HFCs, PFCs, SF₆ and NF₃, 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 provide in the NIR 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 CO₂ 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. 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.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

Description and interpretation of emission trends for aggregated greenhouse gas emissions

In 2021 Bulgaria's greenhouse gas emissions totalled 53 917 Gg CO₂ eq. without reporting of sequestration from LULUCF sector. The emissions decreased by 52.55% compared with the base year. Emissions in 2021 were 12.36% decreased in comparison with the emissions of the previous year.

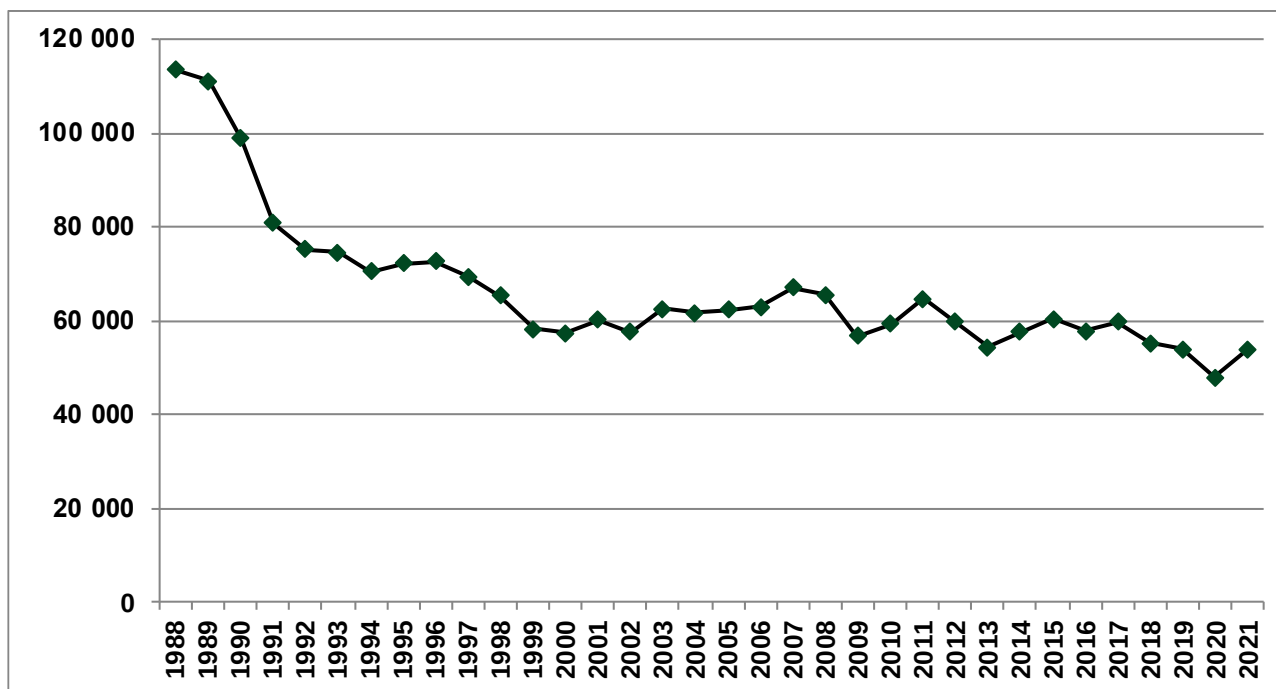


Figure 7 Total GHG emissions (without LULUCF) for 1988 – 2020, Gg CO₂ eq.

The net emissions including reporting of sequestration from LULUCF sector were 44 773 Gg CO₂ eq. The emissions decreased by 54.08 % compared with the base year.

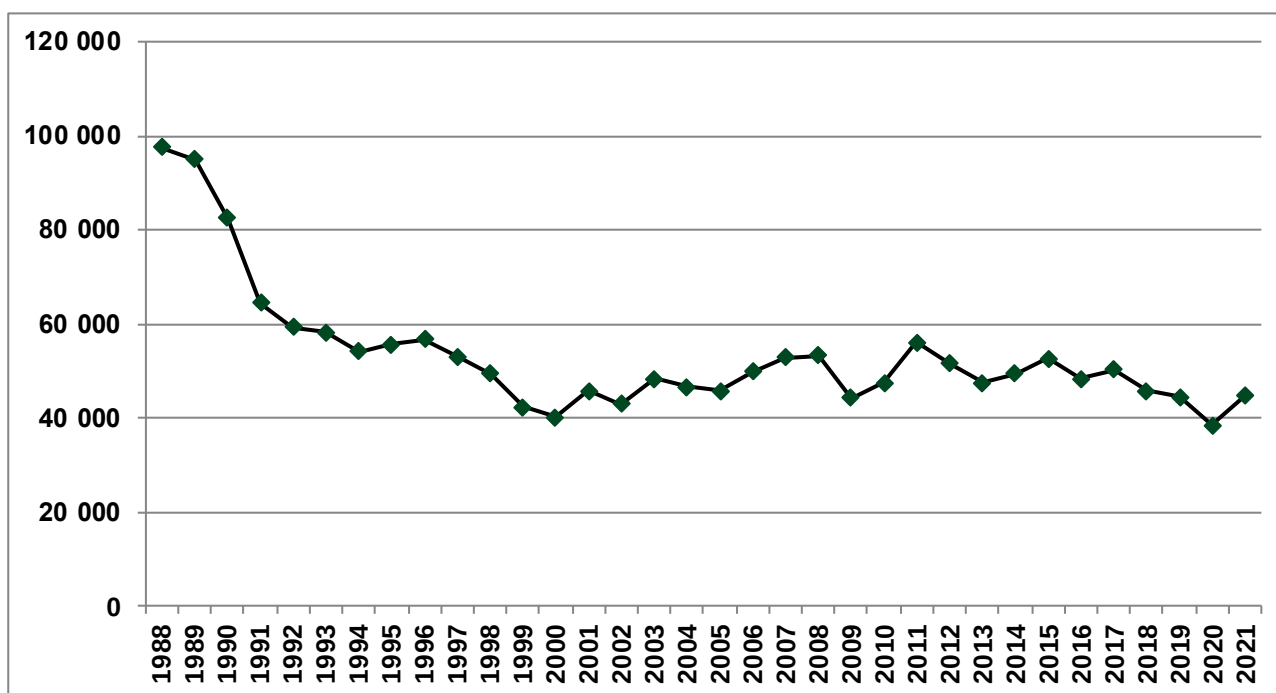


Figure 8 Total GHG emissions (with LULUCF) for 1988 – 2020, Gg CO₂ eq.

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 from 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 decreasing population trend during the period 1988-2021, which resulted in the reduction of population by 23.90 %.

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 CO₂ emissions from the total greenhouse gas emissions varies around 78.42% excluding LULUCF and 73.01% including LULUCF. In absolute terms CO₂ emissions have decreased 54.08% since 1988. Around 75.0% of total CO₂ eq emissions originate from the Energy sector. The amount of energy-related CO₂ emissions has fluctuated much according to the economic trend, the energy supply structure (including electricity exports) and climate conditions.

Methane emissions (CH₄) have decreased by 56.81% 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 (N₂O) have also decreased by 51.36% which has been occasioned mostly by the reduced nitrogen fertilisation of agricultural fields, the biggest decline was in the beginning of time series.

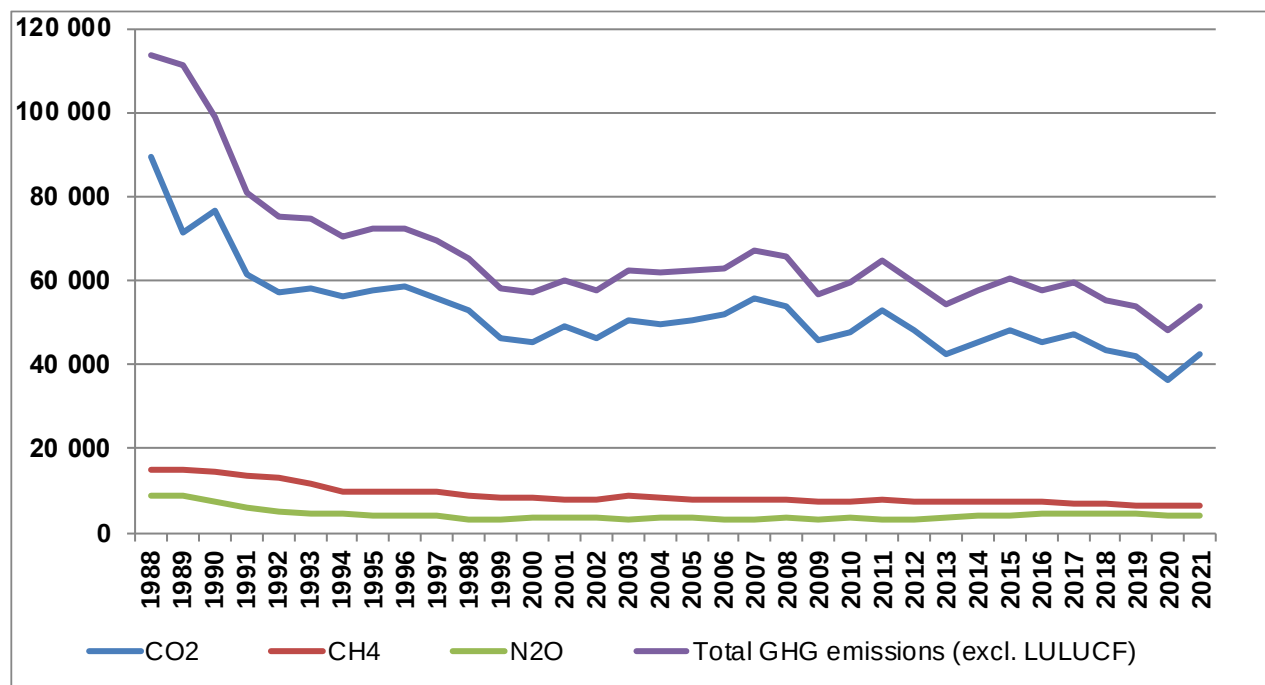


Figure 9 Total GHG emissions in Gg CO₂ eq. for 1988 – 2021

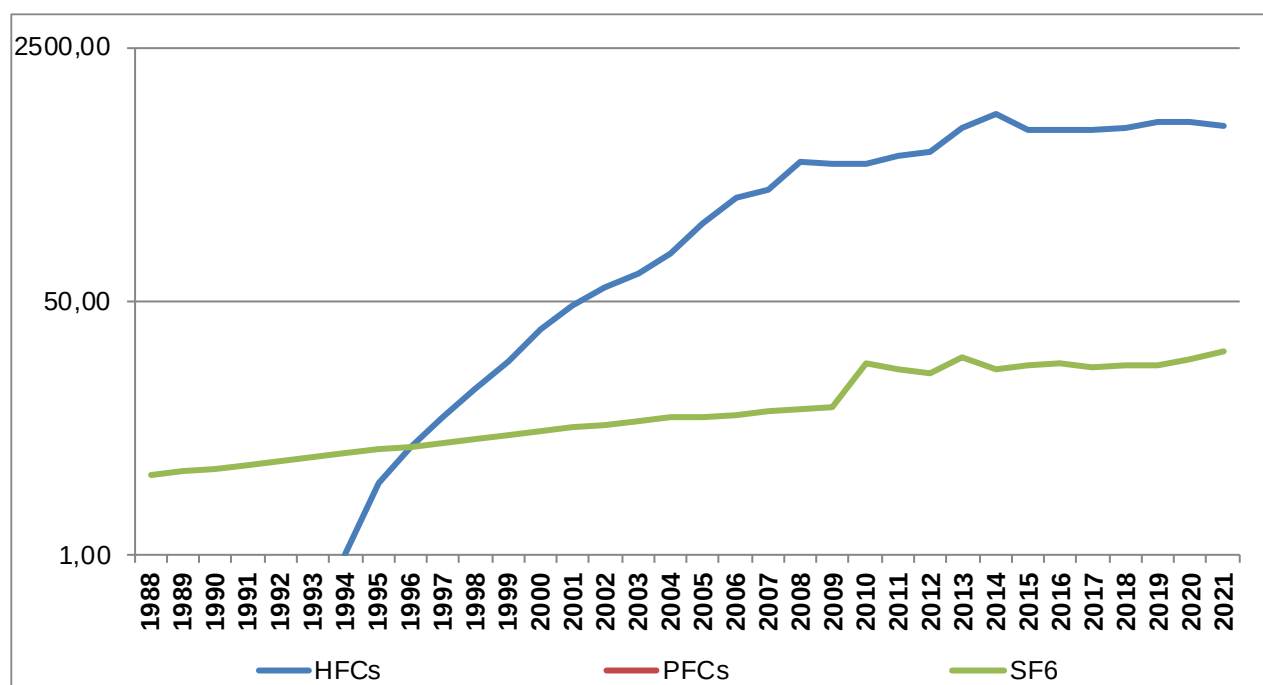


Figure 10 Actual emissions of HFCs, PFCs and SF₆ for 1988 – 2021, Gg CO₂ eq.

The emissions of F-gases have increased during 1995-2021. A key driver behind the trend has been the substitution of ozone depleting substances (ODS) by F-gases in many applications. The scale of the Chart is logarithmic, so that the trend can be clear.

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 2021 with the biggest share – 75.00%. Sector Agriculture ranked the third place with 11.30% , followed by IPPU ranked the second place with 8.40% and sector Waste with 5.3%.

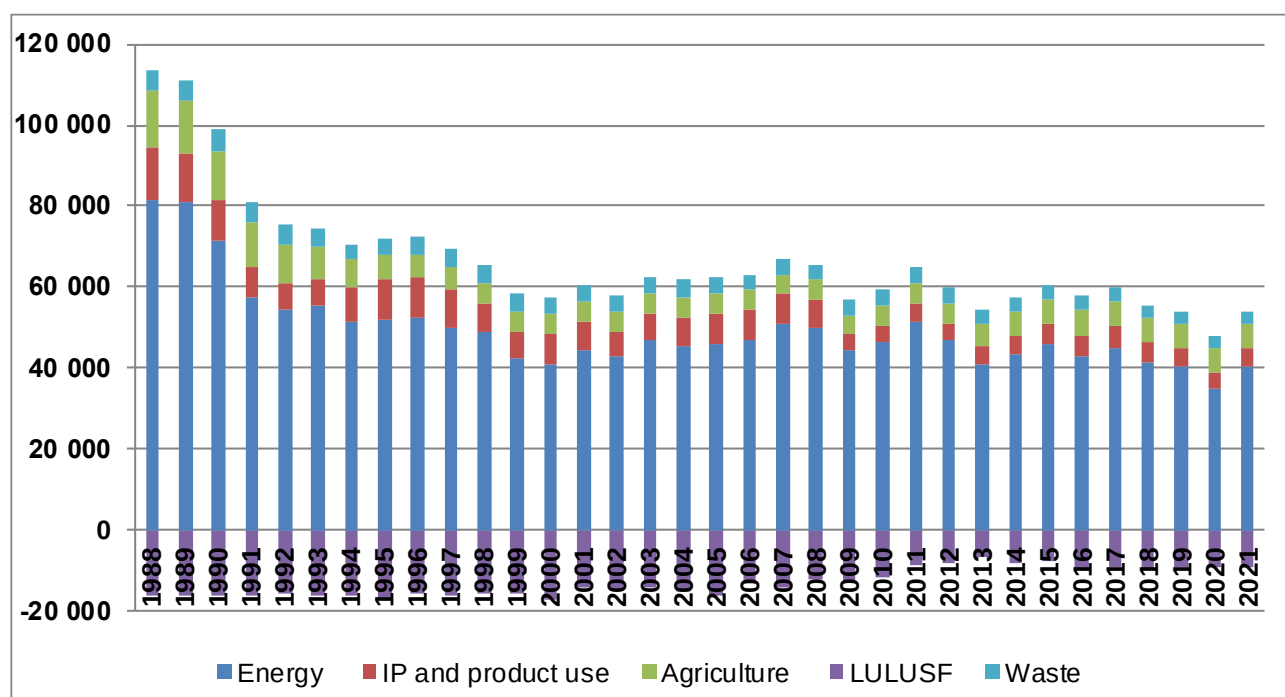


Figure 11 Total greenhouse gas emissions in CO₂-eq. per IPCC sector 1988-2021

Table 13 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	-50.41%
2. Industrial Processes and product use	-65.59%
3. Agriculture	-55.10%
4. Land Use, Land-Use Change and Forestry(5)	-43.25%
5. Waste	-46.39%
6. Other	0.00
Total (including LULUCF)	-54.08%

Energy

Emissions from the energy sector in 2021 decreased by 50.41% compared to the base year (40 444 Gg CO₂eq in 2021 compared to 81 562 Gg CO₂eq in 1988). Compared to previous year, the emissions in 2021 decreased with 16.6% mostly due to the decrease in electricity production from fossil fuels in the energy industries sector.

The main source of emissions in the energy sector is combustion of solid fuels, which is responsible for 41.00% of the emissions from fuel combustion in 2021, for other fossil fuels below 0.01% and liquid and gaseous fuels with 48.2%.

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 2021 was defined by a substantial fluctuation of emissions from fuel combustion in energy industries – increase by (47.6%) and energy use in manufacturing industry and construction (73.9%) and in other sectors (commercial, residential, agriculture and forestry) (69.7%), as well as a clear increase in GHG emissions from transport (40.4%).

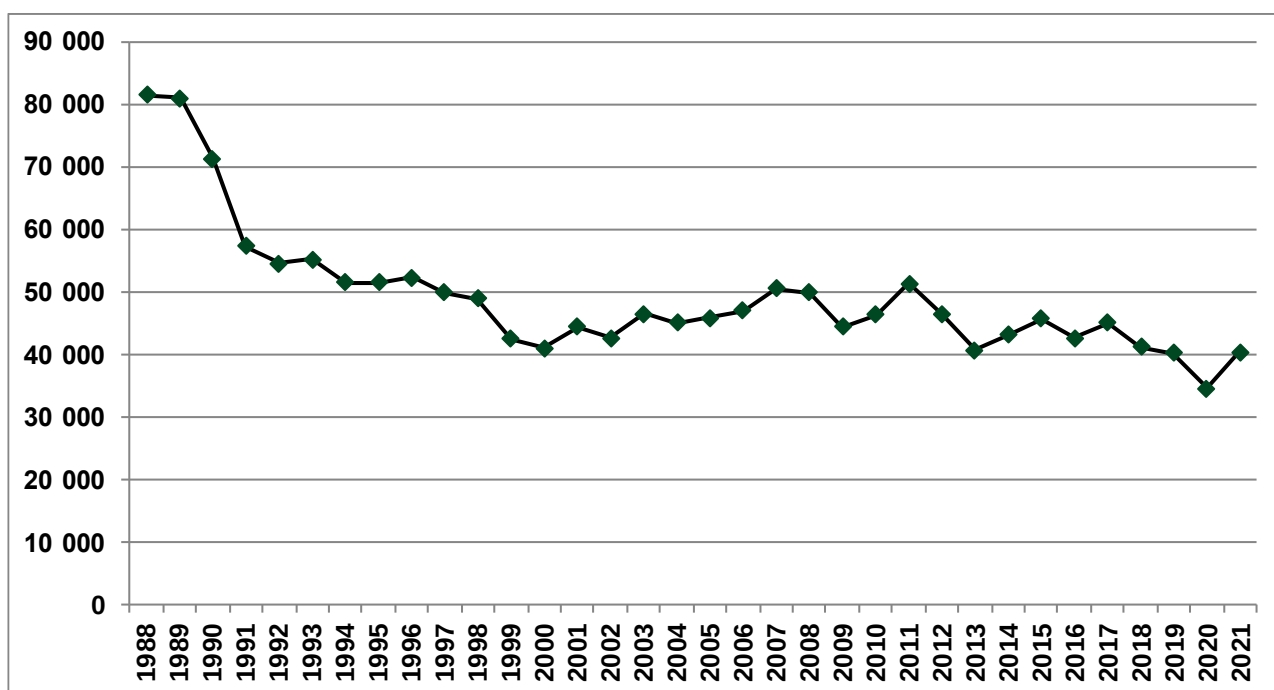


Figure 12 GHG emissions from Energy sector for 1988 – 2021, Gg CO₂ eq.

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

Industrial Processes and Product use

A non – steady trend with some fluctuations towards emission reduction in this sector is observed since 1988. The emissions in 2021 decreased with 65.59% compared to the base year.

In the year 2021 – 8.4% of national total greenhouse gas emissions (without LULUCF) originated from industrial processes and product use, compared to 11.6% in the base year 1988. In 2021, greenhouse gas emissions from Industrial Processes and Product use are 4 533.86 CO₂ equivalent compared to 13 176.76 Gg CO₂ in the base year.

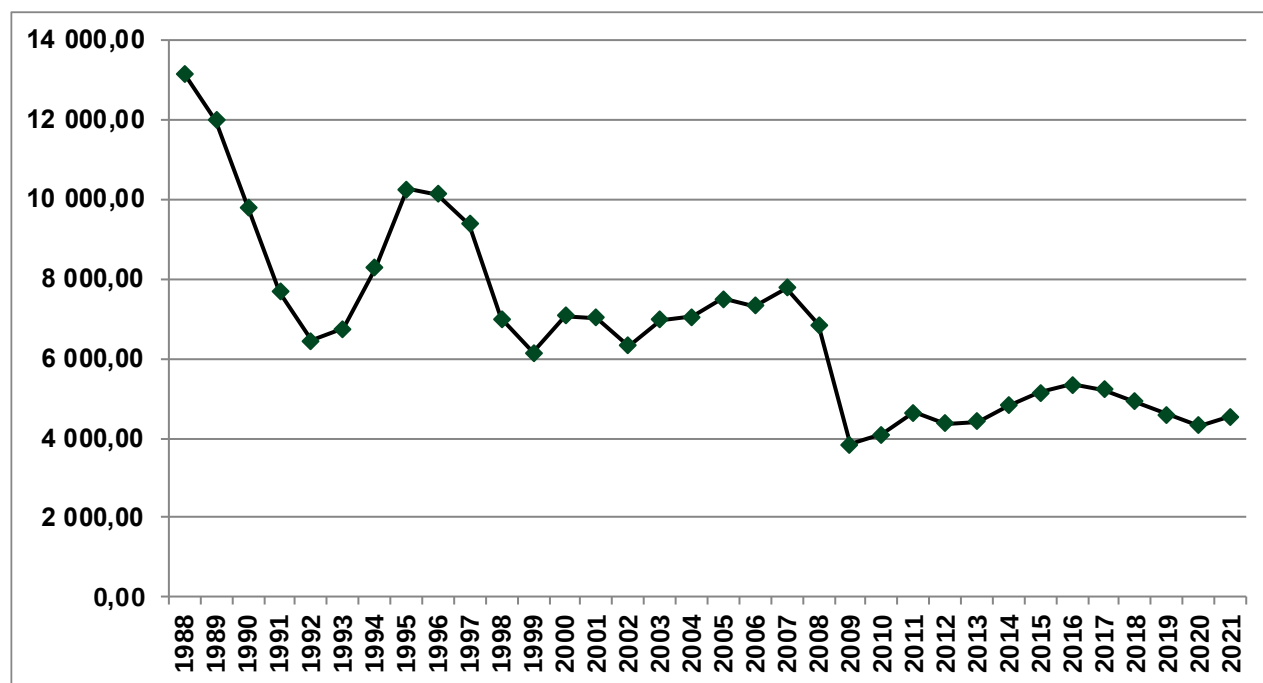


Figure 13 GHG emissions from Industrial processes sector for 1988 – 2021, Gg CO₂ eq.

In 2021 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 51.8%. The second category by share is Chemical Industry (ammonia and nitric acid production) with 27.35% share, followed by Product uses as ODS substitutes (Consumption of Halocarbons) with 16.31% and finally Metal Production (steel) with 2.93%.

Greenhouse gas emissions from the Industrial Processes and product use sector fluctuate during the period and reach a minimum in 2009. The reduction in 2021 for the whole sector is 65.60% while the biggest reduction (compared to the base year) can be seen in Metal Production category – 96.70%.

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.

Chapter 4 of this Report contains a more detailed analysis of GHG emissions in the sector.

Agriculture

The overall emission reduction in the sector has amounted to 55.10% since 1988. In the year 2021 the sector agriculture contributed 11.30% to the total of Bulgaria's greenhouse gas emissions (without LULUCF).

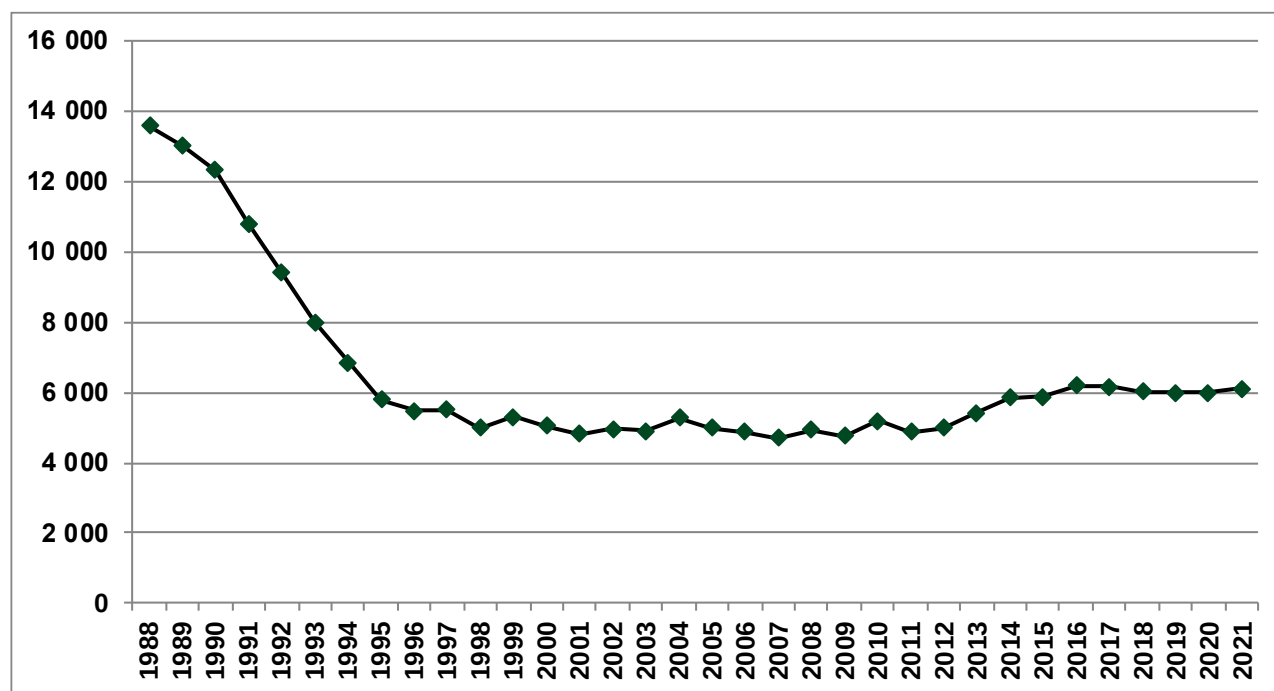


Figure 14 GHG emissions from Agriculture sector for 1988 – 2021, Gg CO₂ eq.

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 5 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 CO₂. All other categories are sources of CO₂ emissions. The trend of net CO₂ removals (CO₂ eq) from LULUCF decreases by 56.75% compared to the base year. The main reason for the overall decrease of the uptakes of CO₂ 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 CO₂eq) is still remarkable. The reason for this is that the emissions in the other sectors have dropped dramatically. For the current inventoried year the share is – 17.00%.

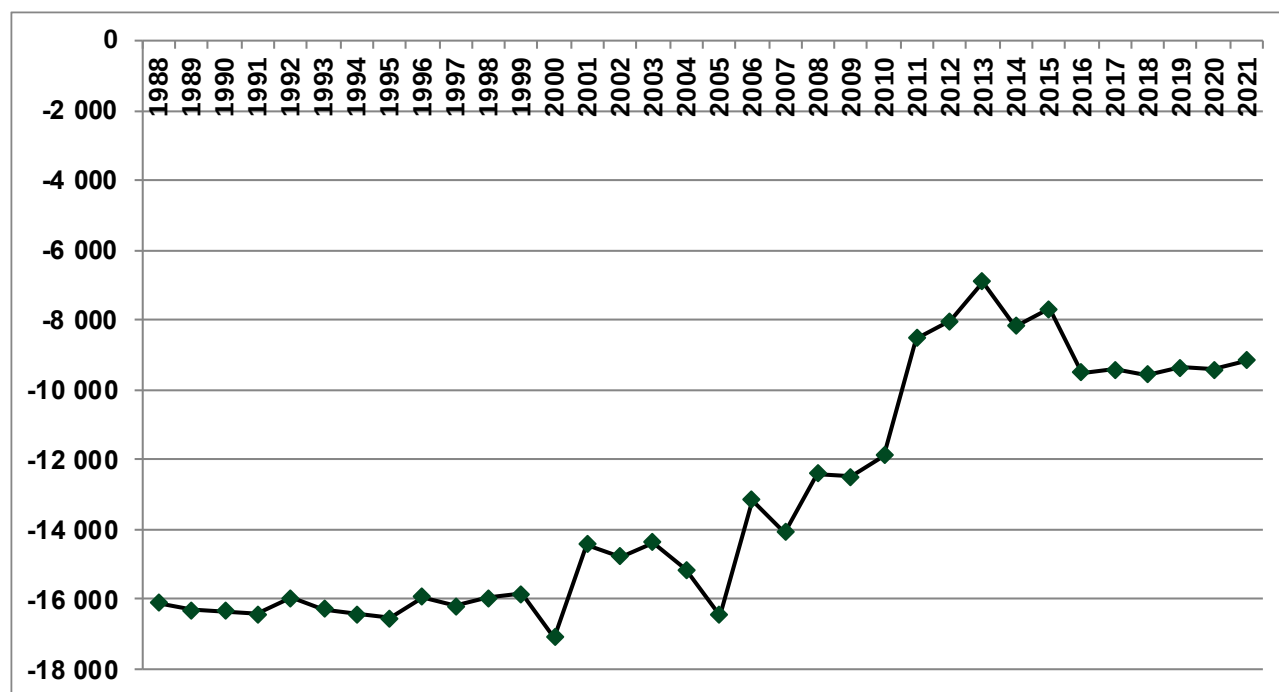


Figure 15 LULUCF emissions and removals for 1988 – 2021 CO₂ eq.

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 6 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 46.40 %. The decline was mainly driven by a steady population decrease over the past 25 – 30 years.

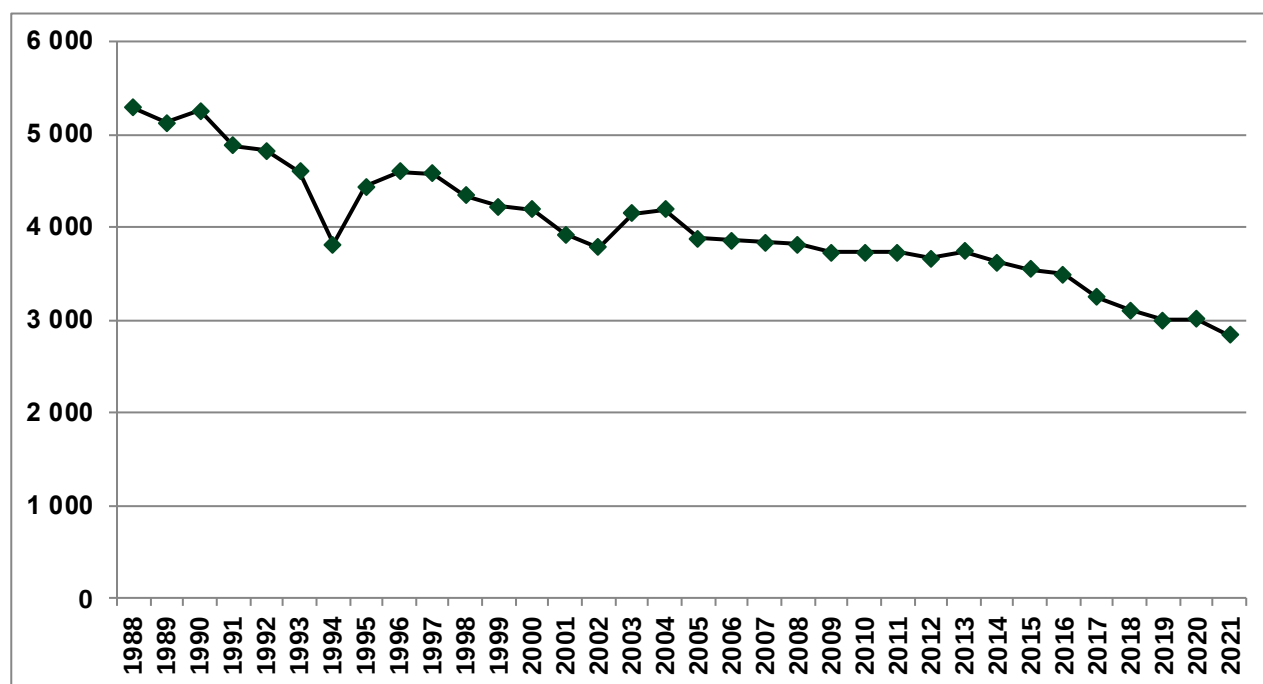


Figure 16 GHG emissions from Waste sector for 1988 – 2021, Gg CO₂ eq.

Chapter 7 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 57.80%
- CO with 87.30%
- SO_x with 43.44%
- NMVOC with 59.34%

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 2021 the sector is responsible for 75.0% of national total GHG emissions (40 444 Gg CO₂e from sector 1A of the total 53 985 Gg CO₂e excl. LULUCF).

3.2 EMISSION TREND

Emissions from the energy sector in 2021 decreased by 50.4% compared to the base year (40 444 Gg CO₂eq in 2021 compared to 81 562 Gg CO₂e in 1988). Compared to the year before, emissions in 2021 increased by 16.6% mostly due to the increase of electricity production from fossil fuels in the energy industries sector.

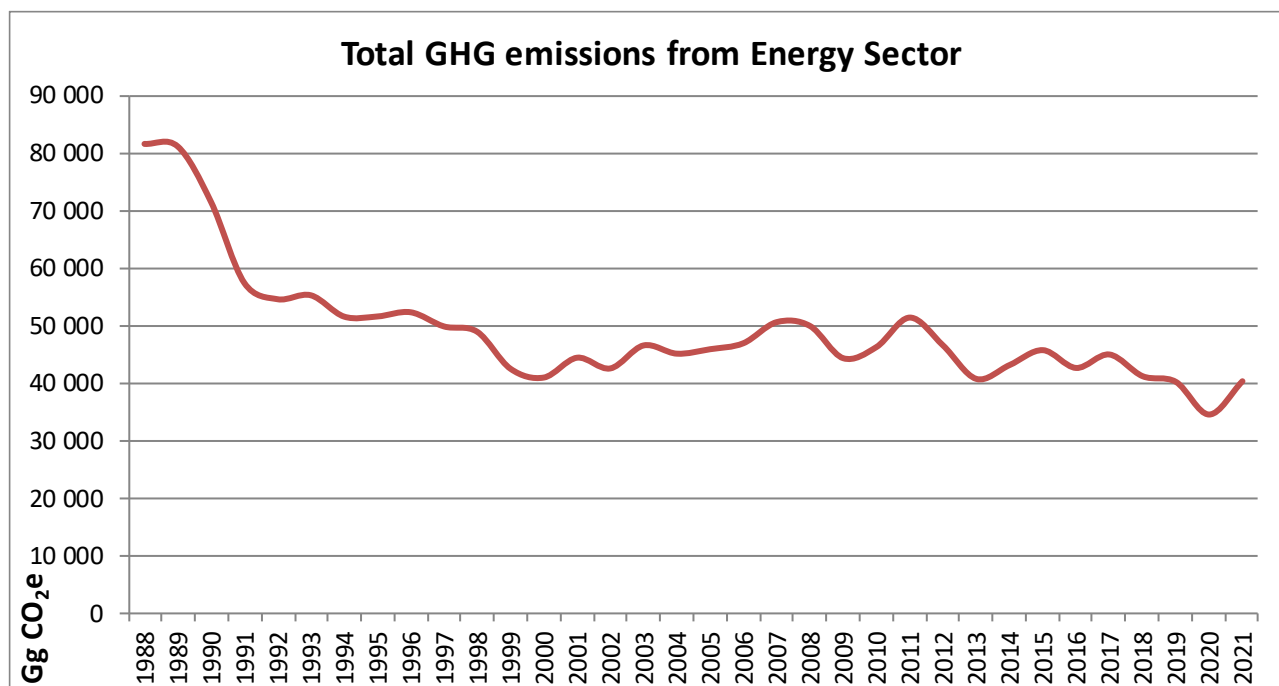


Figure 17 Total GHG emissions from Energy Sector

The main source of emissions in the energy sector is combustion of solid fuels, which is responsible for 52.1% of the emissions from fuel combustion in 2021, followed by liquid fuels with 32.1% and gaseous fuels with 14.0%.

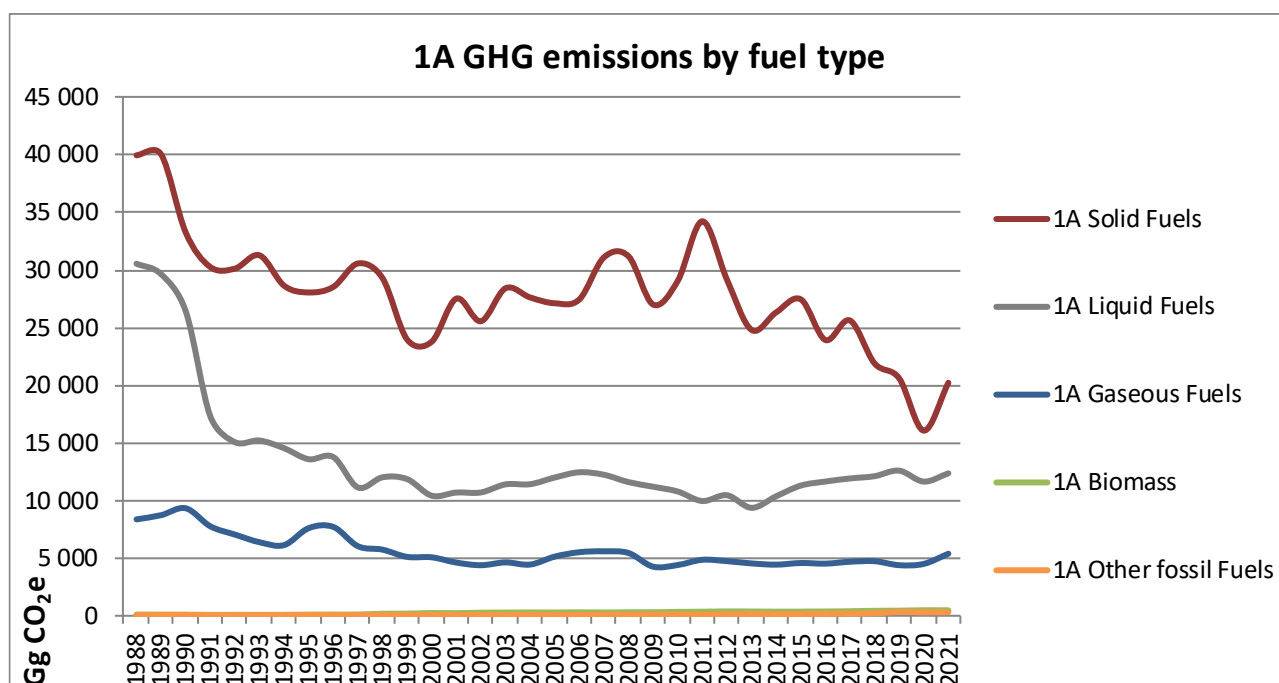


Figure 18 GHG emissions from fuel combustions by fuel type

On a subcategory level, the energy industries sector is the major source of emissions, responsible for 57.2% of the emissions from fuel combustion, followed by transport with 25.7% and manufacturing industries and construction with 11.8%.

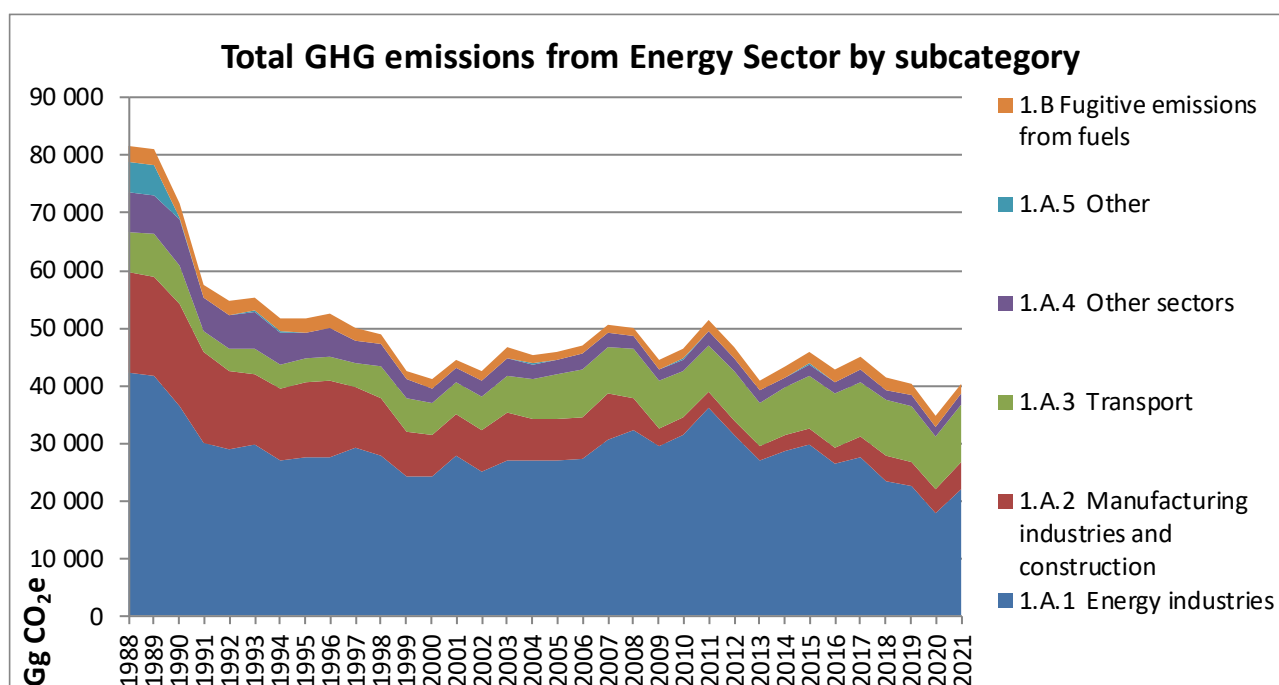


Figure 19 Total GHG emissions from Energy Sector by subcategory

Total emissions from the energy sector mainly consist of CO₂; with a total amount of 38 522 Gg for 2021, followed by CH₄ and N₂O, which only make up about 57.81 Gg and 1.15 Gg, respectively.

Table 14 Emissions of GHG and their trends for the years 1988 – 2021

Year	CO ₂ [Gg]	CH ₄ [Gg]	N ₂ O [Gg]	Total GHG [Gg CO ₂ e]
1988	78 087.55	107.49	1.76	81 562.45
1990	68 272.82	99.73	1.69	71 512.07
1995	48 868.99	89.74	1.07	51 664.40

Year	CO ₂ [Gg]	CH ₄ [Gg]	N ₂ O [Gg]	Total GHG [Gg CO ₂ e]
2000	39 050.08	63.40	0.97	41 081.59
2005	44 012.00	60.57	1.07	45 990.93
2010	44 353.73	62.55	1.00	46 370.94
2011	49 143.23	72.91	1.09	51 474.23
2012	44 500.10	67.09	1.04	46 654.14
2013	38 932.15	59.67	0.95	40 854.56
2014	41 317.48	59.44	0.99	43 244.03
2015	43 743.70	64.53	1.05	45 829.61
2016	40 768.81	61.09	1.00	42 745.06
2017	42 963.08	65.71	1.04	45 078.84
2018	39 355.10	59.82	1.08	41 316.77
2019	38 467.16	56.34	1.10	40 337.10
2020	32 929.19	52.81	1.02	34 678.69
2021	38 521.74	57.81	1.15	40 444.13

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 CO₂ 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

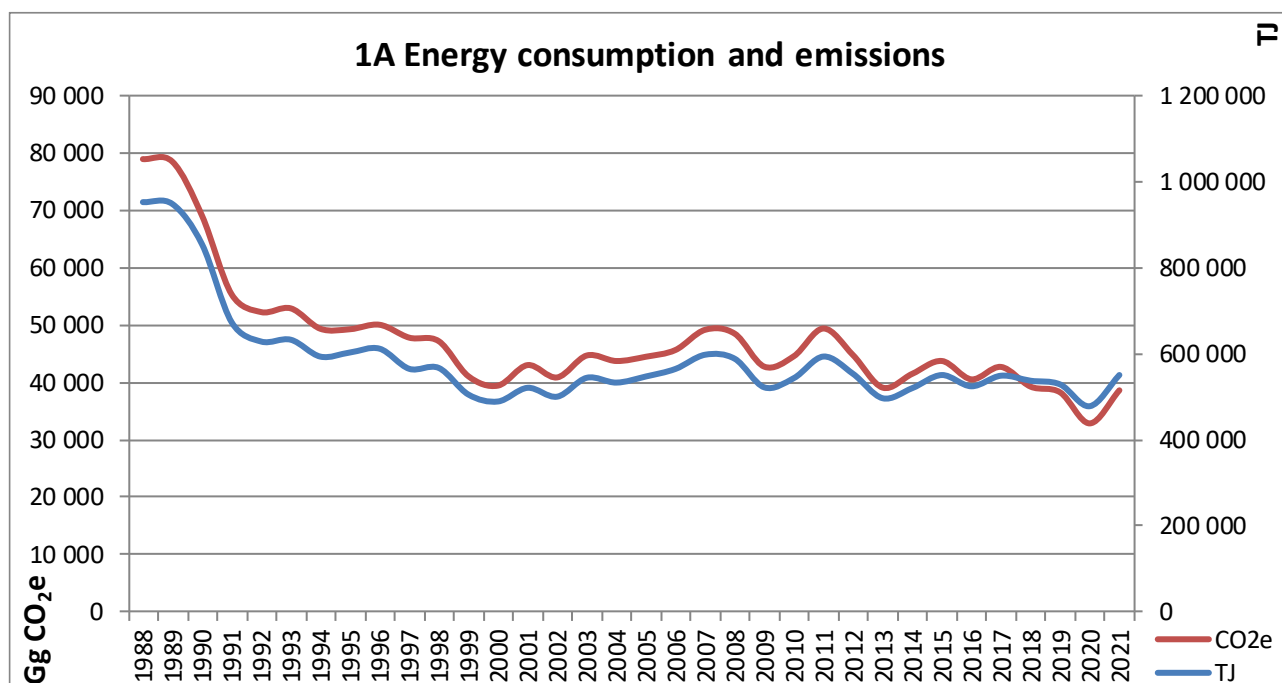


Figure 20 Comparison of the sectoral approach with the reference approach

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

Table 15 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	945.55	6.93%	82 746.10	77 924.43	6.19%
1990	894.21	848.22	5.42%	73 857.04	68 148.24	8.38%
1995	679.03	596.11	13.91%	56 803.49	48 702.08	16.63%
2000	502.90	467.82	7.50%	43 387.51	38 925.64	11.46%
2005	558.01	519.76	7.36%	48 156.13	43 887.87	9.73%
2010	518.26	506.58	2.31%	45 824.64	43 979.37	4.20%
2011	567.70	554.31	2.41%	50 782.46	48 748.75	4.17%
2012	523.19	508.43	2.90%	46 098.80	44 117.08	4.49%
2013	465.78	449.58	3.61%	40 509.57	38 520.14	5.16%
2014	493.76	475.25	3.90%	43 246.37	40 933.51	5.65%
2015	518.32	501.64	3.32%	45 345.23	43 143.32	5.10%
2016	483.98	471.62	2.62%	41 857.03	39 955.90	4.76%
2017	513.24	495.70	3.54%	44 577.08	42 085.61	5.92%
2018	485.76	468.02	3.79%	40 901.17	38 643.65	5.84%
2019	470.61	452.89	3.91%	40 146.34	37 640.15	6.66%
2020	419.93	401.60	4.56%	34 566.99	32 244.81	7.20%
2021	488.65	466.44	4.76%	40 828.08	37 959.21	7.56%

Table 16 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	402.95	14.01%	32 468.00	30 120.74	7.79%
1990	362.76	353.01	2.76%	26 775.59	26 010.57	2.94%
1995	222.87	182.90	21.86%	16 429.52	13 382.51	22.77%
2000	145.58	142.45	2.20%	10 640.67	10 270.64	3.60%
2005	177.02	160.81	10.08%	13 024.11	11 843.93	9.96%

Year	Energy consumption, PJ		Difference	CO ₂ Emissions, Gg		Difference
	Reference approach	Sectoral approach		Reference approach	Sectoral approach	
2010	152.70	144.56	5.63%	11 267.48	10 677.20	5.53%
2011	143.87	135.22	6.39%	10 492.38	9 857.41	6.44%
2012	150.97	141.29	6.86%	11 069.93	10 358.45	6.87%
2013	138.15	126.62	9.11%	10 102.96	9 281.08	8.86%
2014	150.64	139.04	8.34%	11 026.72	10 270.41	7.36%
2015	163.99	153.30	6.97%	11 936.17	11 186.54	6.70%
2016	168.23	158.10	6.41%	12 404.87	11 539.40	7.50%
2017	174.94	161.38	8.40%	13 057.57	11 807.61	10.59%
2018	173.79	163.45	6.32%	12 864.71	11 997.88	7.22%
2019	178.75	170.60	4.78%	13 370.19	12 473.54	7.19%
2020	163.35	158.17	3.27%	12 164.94	11 534.89	5.46%
2021	170.50	167.13	2.02%	12 657.62	12 241.22	3.40%

Table 17 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%	41 941.99	39 467.58	6.27%
1990	361.45	327.08	10.51%	37 697.17	32 856.19	14.73%
1995	313.87	275.77	13.82%	32 518.96	27 731.81	17.26%
2000	263.17	232.90	13.00%	27 549.11	23 549.84	16.98%
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	284.18	239.48	18.67%	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	249.79	247.29	1.01%	26 581.28	25 414.03	4.59%
2018	222.16	216.38	2.67%	23 017.11	21 709.66	6.02%
2019	206.60	198.44	4.11%	21 906.74	20 425.25	7.25%
2020	167.64	158.59	5.70%	17 357.49	15 900.60	9.16%
2021	214.08	198.55	7.82%	22 276.53	20 026.82	11.23%

Table 18 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	142.29	137.45	3.52%	7 855.01	7 587.76	3.52%
2000	94.15	92.48	1.81%	5 197.73	5 105.16	1.81%
2005	96.25	93.50	2.94%	5 313.25	5 162.62	2.92%
2010	81.74	80.44	1.63%	4 515.66	4 445.63	1.58%
2011	89.94	88.44	1.70%	4 970.53	4 889.51	1.66%
2012	87.57	86.46	1.28%	4 833.59	4 774.46	1.24%
2013	84.52	82.66	2.24%	4 679.32	4 578.78	2.20%
2014	81.80	80.69	1.37%	4 534.42	4 475.36	1.32%
2015	84.28	82.92	1.64%	4 688.23	4 614.34	1.60%
2016	83.73	81.97	2.15%	4 658.41	4 561.65	2.12%
2017	86.88	85.08	2.12%	4 820.15	4 721.93	2.08%
2018	87.81	85.85	2.27%	4 876.63	4 769.87	2.24%
2019	82.48	79.69	3.50%	4 582.96	4 429.67	3.46%
2020	86.46	81.74	5.77%	4 799.27	4 539.12	5.73%
2021	101.58	97.43	4.26%	5 635.33	5 406.82	4.23%

3.3.1.3 Explanation of differences

A comparison between the Reference Approach (RA) and the Sectoral Approach (RA) indicates a difference of 4.5% in terms of energy consumption and 5.4% in terms of CO₂ emissions for 2021.

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 4.2% for the period 1990-2021 and 4.7% for 2021 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 CO₂ emissions from the biofuel 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 2021 the difference due to statistical differences and distribution losses for gaseous fuels is equal to 4 142 TJ, which is 3.6% of the total consumption of gaseous fuels. In terms of emissions, this is equivalent to 229.8 Gg CO₂. For liquid fuels, in 2021 the refinery losses are 4.7% of the refinery intake, which is equal to 8 345 TJ or 611.7 Gg CO₂.

If all those quantified differences are accounted, the remaining difference between the reference and the sectoral approaches for 2021 is equal to 2.1% in terms of energy consumption and 5.3% 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 19 GHG Emissions from International bunker fuels

Year	Total [Gg CO ₂ e]	Aviation [Gg CO ₂ e]	Navigation [Gg CO ₂ e]
1988	2 069.80	1 111.46	958.33
1990	903.09	718.71	184.38
1995	1 773.58	911.67	861.91
2000	444.20	241.64	202.57
2005	916.66	568.50	348.17
2010	813.30	504.96	308.34
2011	750.54	511.15	239.39

Year	Total [Gg CO ₂ e]	Aviation [Gg CO ₂ e]	Navigation [Gg CO ₂ e]
2012	694.37	492.56	201.81
2013	765.73	480.17	285.55
2014	768.61	511.15	257.46
2015	806.05	532.84	273.22
2016	886.07	641.26	244.81
2017	970.44	717.78	252.65
2018	1 031.71	772.36	259.35
2019	954.84	718.42	236.42
2020	678.95	414.93	264.02
2021	761.38	494.28	267.09

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 8.2% of the total apparent energy consumption during the period 1988-2021 and 6.9% for 2021. The apparent consumption is calculated according to Equation 6.2 in Vol. 2, Ch. 6 of the 2006 IPCC Guidelines.

Table 20 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	1090.56	8.6%
1990	92.88	987.09	9.4%
1995	82.82	763.05	10.9%
2000	60.60	563.50	10.8%
2005	48.49	606.48	8.0%
2010	26.90	545.16	4.9%
2011	34.29	601.99	5.7%
2012	30.48	553.67	5.5%

Year	Non-energy use, PJ	Apparent energy consumption incl. non-energy use, PJ	%
2013	29.76	494.84	6.0%
2014	33.21	526.60	6.3%
2015	42.29	559.56	7.6%
2016	41.47	525.26	7.9%
2017	40.93	554.62	7.4%
2018	37.38	523.08	7.1%
2019	36.21	508.52	7.1%
2020	35.16	456.40	7.7%
2021	36.17	526.18	6.9%

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

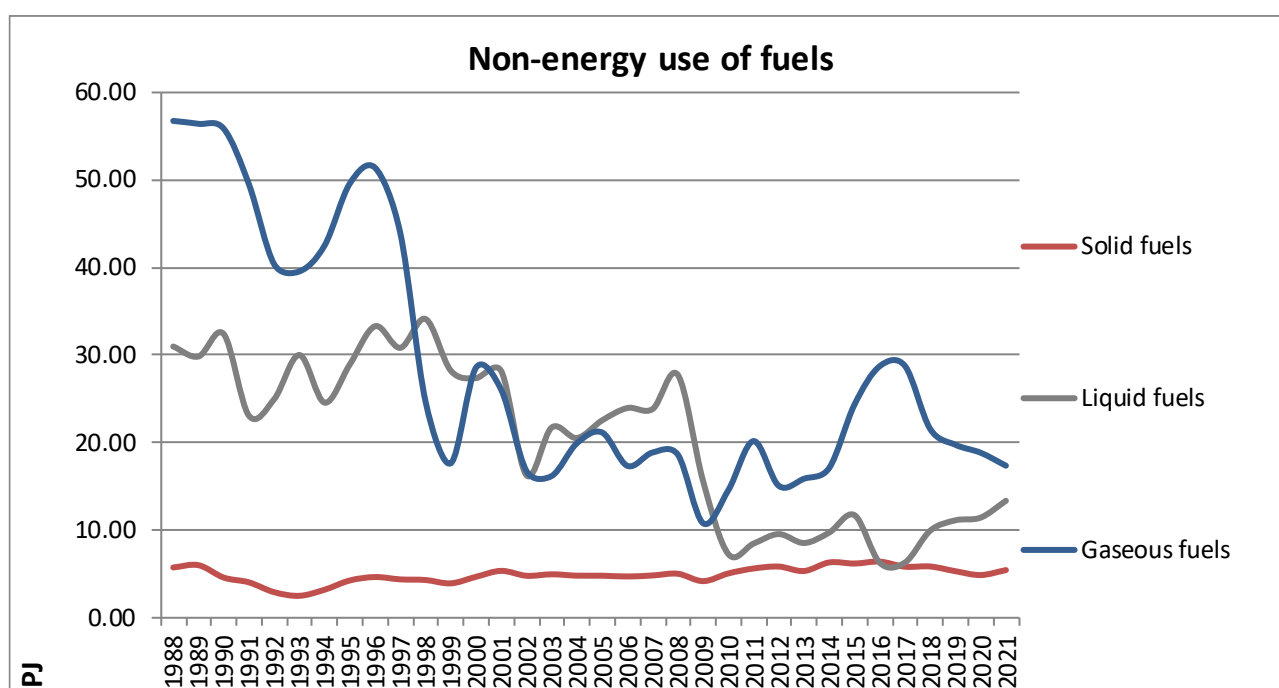


Figure 21 Non-energy use of fuels

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. This excludes emissions from lubricants used in 2-stroke engines, which are reported under the Energy sector (CRF 1.A.3.b.iv), which are less than 2% from the emissions from all lubricants. 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 21 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	49.65
2000	4.67	27.35	28.58
2005	4.80	22.54	21.15

PJ	Solid fuels	Liquid fuels	Gaseous fuels
2010	5.07	7.27	14.57
2011	5.64	8.47	20.18
2012	5.87	9.55	15.06
2013	5.35	8.54	15.87
2014	6.35	9.73	17.12
2015	6.22	11.71	24.36
2016	6.45	6.28	28.75
2017	5.85	6.31	28.77
2018	5.88	9.94	21.56
2019	5.33	11.12	19.75
2020	4.88	11.43	18.85
2021	5.46	13.35	17.36

3.3.4 CO₂ CAPTURE FROM FLUE GASES AND SUBSEQUENT CO₂ STORAGE

CO₂ capture from flue gases and CO₂ 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 1990-2021. 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 22 presents the key source categories of 1 A Fuel Combustion Activities.

Table 22 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
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 CO₂, CH₄ and N₂O 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 CO₂, CH₄ and N₂O 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:

$$\text{Emissions}_{GHG} = \text{Fuel Consumption} \cdot \text{Emission Factor}_{GHG}$$

where:

Emissions_{GHG} = emissions of a given GHG by type of fuel (kg GHG)

Fuel Consumption = amount of fuel combusted (TJ)

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

Tier 2 Methodology

The same equation is used for the CO₂ 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 CO₂ 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 CH₄ and N₂O emissions. The country-specific carbon content of fuels was calculated based on the country-specific CO₂ emission factors using the following equation:

$$C = \text{Emission Factor} / (44/12)$$

where:

C = carbon content of fuel in t/TJ

Emission Factor = emission factor for CO₂ 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 23 Default Emission factors for CO₂ for different fuels

Fuel	EF C t/TJ	EF CO ₂ 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

Fuel	EF C t/TJ	EF CO ₂ t/TJ (excl. oxidation factor)
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
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 25 and Table 26.

3.3.8.2.2 Country specific emission factors for CO₂ for solid fuels

Emission data reported under the European Emission Trading Scheme

A total of 132 operators have provided their verified CO₂ emission reports required under the EU ETS for the years 2007-2021. 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 102 operators reporting in 2021, 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 2018/2066 on the monitoring and reporting of greenhouse gas emissions) and which were within the default IPCC ranges for the respective fuel. The EFs including oxidation factor are calculated as the total sum of the verified CO₂ emissions divided by the total amount of the respective fuel as reported by the operators. For the years 2007 to 2021 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 24 Country-specific carbon content for solid fuels [t/TJ]

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke	Refinery gas
1988-2006	28.1856	29.5664	26.7573	25.7857	15.6544
2007	27.4792	29.3911	27.3114	26.1149	15.6544
2008	28.8427	29.8238	26.9270	25.9131	15.6544
2009	28.6586	29.5021	26.7776	25.3961	15.6544
2010	27.9950	29.5215	26.3476	25.6574	15.6544
2011	27.7125	29.3377	26.5553	25.1971	15.6544
2012	27.2728	29.3820	26.8637	25.5126	15.6544
2013	27.2555	29.3129	26.5746	25.6736	15.6544
2014	27.4779	29.3766	26.1637	25.8451	17.1280
2015	27.5376	29.3360	25.9361	25.7868	15.3577
2016	29.3428	29.4636	26.0945	25.9060	15.3524
2017	29.5507	29.2726	25.4187	25.7673	15.4696
2018	29.9937	28.4366	24.9509	25.6125	15.2767
2019	29.0681	29.1563	24.9035	25.5579	15.7952
2020	29.3064	28.5466	23.6826	25.6505	15.5696
2021	28.6252	28.6423	24.5867	25.6852	15.7336

The following emission factors excluding oxidation factor were calculated:

Table 25 Country-specific EFs excl. oxidation factor for CO₂ for solid fuels [t/TJ]

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke	Refinery gas
1988-2006	103.3470	108.4102	98.1099	94.5477	57.3994
2007	100.7572	107.7673	100.1419	95.7545	57.3994
2008	105.7566	109.3540	98.7324	95.0147	57.3994
2009	105.0817	108.1742	98.1845	93.1192	57.3994
2010	102.6484	108.2456	96.6078	94.0772	57.3994
2011	101.6126	107.5715	97.3695	92.3894	57.3994
2012	100.0003	107.7340	98.5004	93.5463	57.3994
2013	99.9368	107.4805	97.4401	94.1364	57.3994

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke	Refinery gas
2014	100.7522	107.7140	95.9336	94.7654	62.8025
2015	100.9712	107.5652	95.0989	94.5517	56.3114
2016	107.5904	108.0331	95.6798	94.9888	56.2921
2017	108.3525	107.3327	93.2018	94.4801	56.7220
2018	109.9769	104.2675	91.4866	93.9125	56.0144
2019	106.5831	106.9063	91.3130	93.7125	57.9159
2020	107.4568	104.6709	86.8363	94.0517	57.0886
2021	104.9591	105.0219	90.1511	94.1791	57.6900

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 26 Country-specific EFs incl. oxidation factor for CO₂ for solid fuels [t/TJ]

Fuel	Anthracite	Lignite	Other Bituminous Coal	Petroleum Coke	Refinery gas
1988-2006	98.4802	105.8747	95.6910	94.5161	57.3994
2007	97.5236	104.9506	98.3294	95.7225	57.3994
2008	100.7763	106.8890	96.2981	94.9830	57.3994
2009	99.6547	105.5404	95.1683	93.0881	57.3994
2010	97.3953	105.8315	93.4475	94.0458	57.3994
2011	96.6057	105.1891	95.0759	92.3586	57.3994
2012	96.3049	105.3618	96.4435	93.5150	57.3994
2013	95.8515	104.8037	95.3831	94.1049	57.3994
2014	96.6008	104.6660	94.1733	94.7434	62.8025
2015	98.2139	104.3856	93.4664	94.5258	56.3114
2016	104.9487	104.5859	93.8423	94.9704	56.2921
2017	105.5266	104.0991	90.1683	94.4578	56.7220
2018	105.1822	101.3470	88.5682	93.8869	56.0144
2019	102.9444	104.1995	88.1773	93.6844	57.9159
2020	103.6573	101.7753	83.4055	94.0091	57.0886
2021	101.7021	102.2390	86.2875	94.1418	57.6900

The national emission estimates were prepared using country-specific emission factors, including oxidation factor for anthracite, lignite, other bituminous coke petroleum coke, and refinery gas. 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 (EU) 2018/2066 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 25) or the default emission factors (Table 23). 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 CO₂ for gaseous fuels

As CO₂ 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 2007-2021;
- Petroceltic Bulgaria EOOD and Oil and Gas Exploration and Production AD - the companies licensed for oil and gas extraction for the period 2004-2021 and 1999-2021 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, N₂ and CO₂ 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 27 Country-specific carbon contents and EFs for CO₂ 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
2018	15.1470	55.5390
2019	15.1539	55.5644
2020	15.1388	55.5090
2021	15.1299	55.4764

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 CH₄ 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 28 Emission factors for CH₄ 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

Fuel	Energy Industries	Manufacturing Industries and Construction	Commercial / Institutional	Residential and Agriculture / Forestry / Fishing
Bitumen	3	3	10	10
Lubricants	3	3	10	10
Petroleum Coke	3	3	10	10
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 N₂O 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 29 Emission factors for N₂O 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

3.3.8.3 Choice of emission factors for mobile sources

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

3.3.8.4 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 1990-2021. 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].

3.3.8.4.1 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 30 Selected Net Calorific Values for 2021

Fuel	Public electricity and heat production [TJ/Gg]	Industry [TJ/Gg]
Liquid fuels		
Crude oil		42.538
Gasoline		42.926
Jet Kerosene		43.120
Gas/Diesel Oil		41.915
Residual Fuel Oil		40.000
LPG		46.000
Naphtha		43.961
Bitumen		40.449
Lubricants		40.200
Petroleum Coke		32.590
Refinery Feedstocks		42.190
Refinery Gas		47.385
White Spirit SBP		40.200
Paraffin Wax		40.200
Other Petroleum Products		40.200
Solid fuels		
Anthracite	21.818	28.680
Coking Coal	-	-
Other Bituminous Coal	15.480	23.022
Lignite and Sub-bituminous Coal	6.888	7.333
BKB & Patent Fuel	9.887	10.833
Coke Oven / Gas Coke	-	28.500
Gaseous fuels		
Natural Gas, 20°C [TJ/1000 m3]		0.034215
Natural Gas, 15°C [TJ/1000 m3]		0.034797

For all NCVs please consult Annex IV.

3.3.8.5 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, CO₂ emissions released from these processes are reported as an information item, as the released CO₂ is considered naturally absorbed. Yet, this is not applicable for the methane and N₂O 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 2006-2021 and for gaseous biofuels is reported for 2008-2021.

For the estimate of the CH₄ and N₂O emissions the EFs from 2006 IPCC Guidelines, Vol. 2, Ch. 2, Table 2.2-2.5 were applied.

3.3.8.6 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 CO₂ emissions from biomass fraction must not be included in the national totals.

3.3.8.7 Uncertainties in CRF 1.A

STATIONARY COMBUSTION

3.3.8.7.1 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, other bituminous coal and coke oven coke) are imported, predominantly from Russia, Ukraine and South Africa. 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%

3.3.8.7.2 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.

3.3.8.8 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 CO₂ 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.

3.3.8.8.1 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.

3.3.8.8.2 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.

3.3.8.9 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 24.

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.

For the 2021 submission were made some revisions of the National Energy Balances, which were reflected in the GHG inventory. In addition, a review of the calculation files revealed a technical error related to calculation of GHG emissions from industrial waste combustion, which has been corrected.

For the 2023 submissions was identified and corrected an error in the calculations – the 2019 country-specific emission factors were erroneously applied for the 2020 calculations, which lead to the recalculation of the emissions in most subcategories. Additional recalculations were introduced due to revisions in the national energy balances reflecting net calorific values, statistical differences and non-energy use of natural gas as well as for some liquid fuels (kerosene, gas-diesel oil and bitumen).

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

No specific improvements for this subcategory are planned.

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

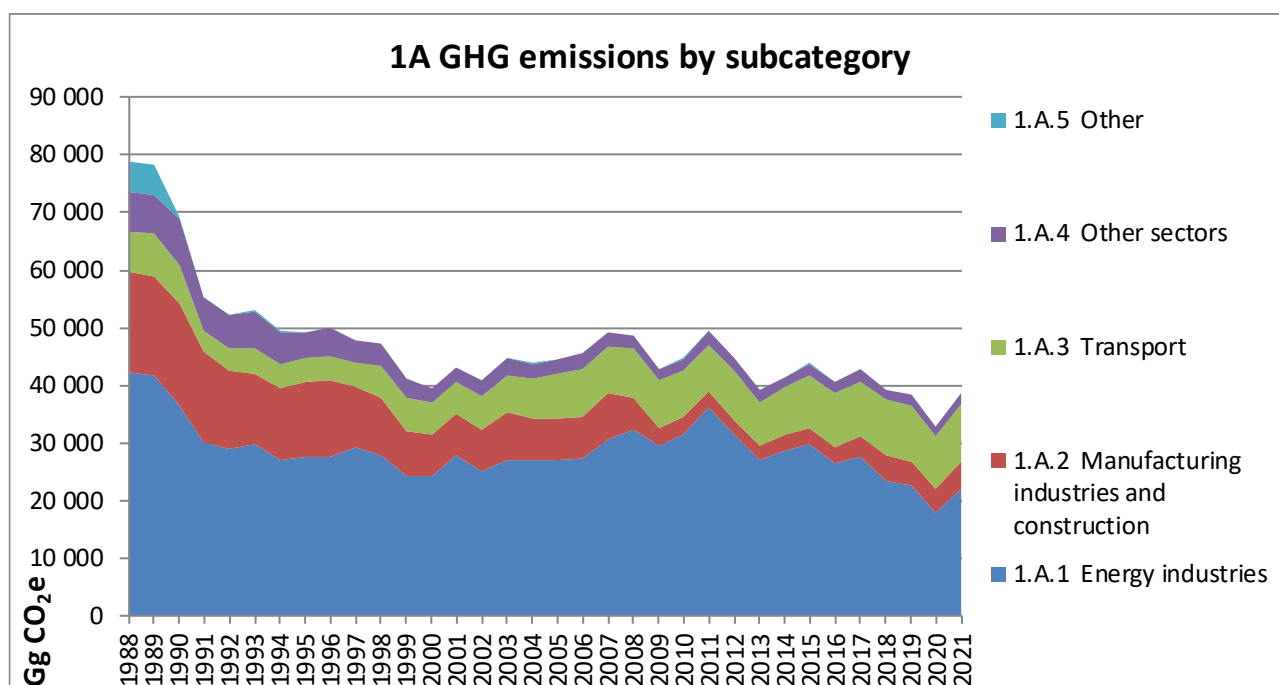


Figure 22 Total GHG emissions from Fuel combustion by subcategory

Energy Industries are the main source of GHG emissions from fuel combustion with 57.2% of the sector emissions for 2021. Transport is the second most important source with 25.7% of the sector emissions, followed by Manufacturing industries and construction with 11.8%.

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 2020 there is a decrease of the emissions from fuel combustion of 14.1% compared to 2019 due to the pandemic situation, which resulted in a decrease of electricity production and transport activities. In 2021 due to the recovery of the economy, the trend reversed, which led to an increase of 17.5% compared to 2020.

Manufacturing industry and construction is the sector, which changed drastically – compared to 1988 the emissions decreased by 73.9% in 2021. 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 slightly increased. Since 2017 there is also 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. In 2021 there was a significant increase of solid fuels used for electricity generation due to post-pandemic economy recovery.

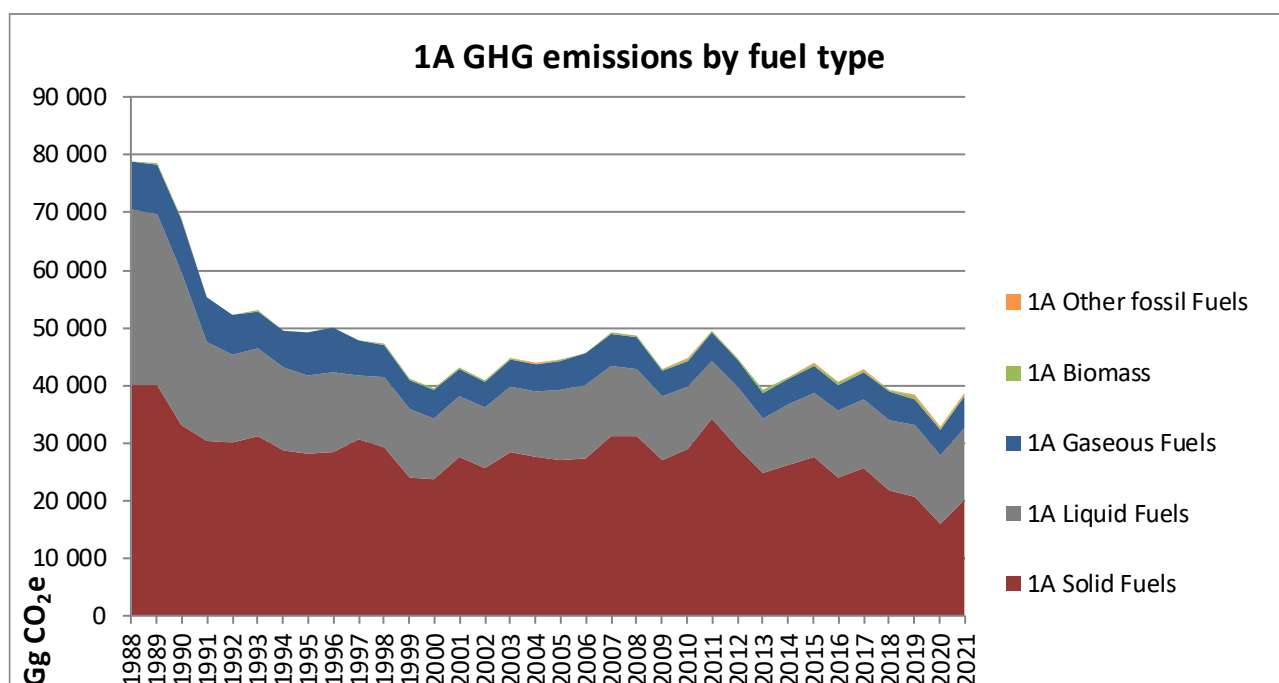


Figure 23 Total GHG emissions from Fuel combustion by fuel type

In 2021, 52.1% of the emissions from fuel combustion were from solid fuels, 32.1% were from liquid fuels, and 14.0% 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 fuels due to the increase of transport sector, and a slight increase of gaseous fuels due to the on-going gasification of industrial plants, residential sector and transport.

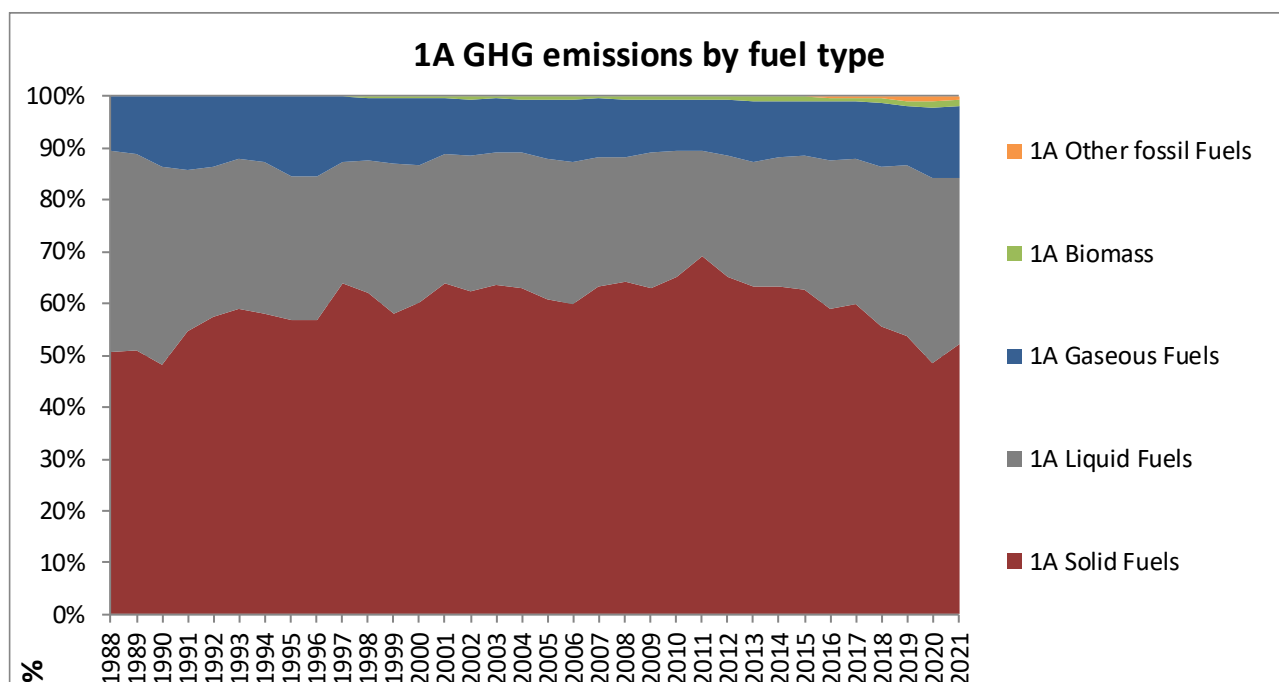


Figure 24 Total GHG emissions from Fuel combustion by fuel type

Table 31 CO₂ emissions in 1.A. Fuel Combustion

CO ₂ (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	77 924.43	30 120.74	39 467.58	8 336.10	889.3920	NO
1990	68 148.24	26 010.57	32 856.19	9 281.48	808.7520	NO
1995	48 702.08	13 382.51	27 731.81	7 587.76	945.9520	NO

CO ₂ (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2000	38 925.64	10 270.64	23 549.84	5 105.16	2 580.2560	NO
2005	43 887.87	11 843.93	26 878.52	5 162.62	3 262.2153	2.8073
2010	43 979.37	10 677.20	28 827.99	4 445.63	4 277.0262	28.5474
2011	48 748.75	9 857.41	33 972.88	4 889.51	4 540.4123	28.9425
2012	44 117.08	10 358.45	28 930.94	4 774.46	5 091.3434	53.2415
2013	38 520.14	9 281.08	24 589.36	4 578.78	5 270.8384	70.9248
2014	40 933.51	10 270.41	26 123.38	4 475.36	5 028.9443	64.3638
2015	43 143.32	11 186.54	27 254.76	4 614.34	5 381.4604	87.6851
2016	39 955.90	11 539.40	23 729.49	4 561.65	5 697.2729	125.3597
2017	42 085.61	11 807.61	25 414.03	4 721.93	5 776.4423	142.0447
2018	38 643.65	11 997.88	21 709.66	4 769.87	7 554.9381	166.2327
2019	37 640.15	12 473.54	20 425.25	4 429.67	8 269.8747	311.6908
2020	32 244.81	11 534.89	15 900.60	4 539.12	8 373.2128	270.2046
2021	37 959.21	12 241.22	20 026.82	5 406.82	9 219.3463	284.3508
Decrease 1988-2021	51.3%	59.4%	49.3%	35.1%	-936.6%	-
Decrease 1990-2021	44.3%	52.9%	39.0%	41.7%	-1039.9%	-
Decrease 2020-2021	-17.7%	-6.1%	-26.0%	-19.1%	-10.1%	-5.2%

Table 32 CH₄ emissions in 1.A. Fuel Combustion

CH ₄ (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	18.3953	3.8227	12.0393	0.1510	2.3823	NO
1990	15.5404	3.8150	9.3878	0.1712	2.1663	NO
1995	11.5100	2.4511	6.7247	0.1408	2.1933	NO
2000	11.6134	1.6547	3.3707	0.0967	6.4913	NO
2005	12.8893	1.4533	3.4212	0.1470	7.8668	0.0010
2010	13.5016	1.1705	2.7783	0.2272	9.3151	0.0105
2011	14.5256	1.0590	3.4149	0.2400	9.8025	0.0093
2012	15.0458	1.0395	3.2582	0.2501	10.4833	0.0148
2013	14.0794	0.8980	2.7207	0.2633	10.1794	0.0180
2014	12.9968	0.9690	2.0056	0.2882	9.7162	0.0178
2015	13.1035	0.9883	2.0552	0.2917	9.7432	0.0251
2016	13.5871	0.9351	2.2399	0.2706	10.1000	0.0415
2017	14.3290	0.8701	2.3960	0.2701	10.7427	0.0500
2018	14.3491	0.8079	1.8221	0.2763	11.3816	0.0613
2019	14.2431	0.7743	1.6522	0.2816	11.4195	0.1154
2020	15.3172	0.7088	1.5702	0.2713	12.6834	0.0836
2021	15.4111	0.7414	2.1165	0.2982	12.1643	0.0907
Decrease 1988-2021	16.2%	80.6%	82.4%	-97.5%	-410.6%	-
Decrease 1990-2021	0.8%	80.6%	77.5%	-74.2%	-461.5%	-
Decrease 2020-2021	-0.6%	-4.6%	-34.8%	-9.9%	4.1%	-8.6%

Table 33 N₂O emissions in 1.A. Fuel Combustion

N ₂ O (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	1.7542	1.1337	0.5737	0.0151	0.0318	NO
1990	1.6857	1.1635	0.4765	0.0168	0.0289	NO
1995	1.0654	0.6174	0.4005	0.0137	0.0338	NO
2000	0.9663	0.5263	0.3386	0.0092	0.0922	NO
2005	1.0672	0.5499	0.3909	0.0097	0.1165	0.0001
2010	1.0006	0.4164	0.4218	0.0093	0.1516	0.0015
2011	1.0901	0.4221	0.4955	0.0100	0.1612	0.0013
2012	1.0378	0.4266	0.4201	0.0098	0.1791	0.0022
2013	0.9475	0.3911	0.3592	0.0095	0.1850	0.0028
2014	0.9879	0.4166	0.3821	0.0094	0.1771	0.0027
2015	1.0509	0.4516	0.3965	0.0095	0.1894	0.0038
2016	0.9999	0.4423	0.3449	0.0094	0.1973	0.0061
2017	1.0377	0.4484	0.3709	0.0097	0.2014	0.0073
2018	1.0790	0.4712	0.3246	0.0098	0.2646	0.0089
2019	1.0998	0.4860	0.2977	0.0092	0.2908	0.0162

N ₂ O (Gg)	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2020	1.0200	0.4662	0.2379	0.0095	0.2945	0.0119
2021	1.1445	0.4984	0.2978	0.0111	0.3241	0.0129
Decrease 1988-2021	34.8%	56.0%	48.1%	26.2%	-920.5%	-
Decrease 1990-2021	32.1%	57.2%	37.5%	33.7%	-1022.2%	-
Decrease 2020-2021	-12.2%	-6.9%	-25.2%	-17.9%	-10.1%	-8.2%

Table 34 GHG emissions in 1.A. Fuel Combustion

GHG (Gg)	TJ	1.A. Fuel Combustion	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1988	953 494.87	78 907.07	30 554.14	39 939.52	8 344.38	69.0232	NO
1990	855 437.57	69 039.07	26 452.66	33 232.88	9 290.77	62.7649	NO
1995	604 559.01	49 307.33	13 627.77	28 019.29	7 595.37	64.9009	NO
2000	490 859.86	39 503.93	10 468.85	23 735.00	5 110.34	189.7433	NO
2005	548 883.21	44 528.13	12 044.14	27 080.54	5 169.19	231.3895	2.8728
2010	545 088.48	44 615.08	10 830.56	29 023.14	4 454.09	278.0422	29.2443
2011	595 128.09	49 436.73	10 009.67	34 205.91	4 898.49	293.1120	29.5548
2012	554 988.70	44 802.48	10 511.57	29 137.57	4 783.63	315.4404	54.2662
2013	498 385.90	39 154.48	9 420.07	24 764.42	4 588.19	309.6065	72.1969
2014	521 825.49	41 552.82	10 418.78	26 287.39	4 485.35	295.6895	65.6046
2015	552 212.22	43 784.07	11 345.83	27 424.31	4 624.47	300.0197	89.4365
2016	526 094.96	40 593.56	11 694.58	23 888.25	4 571.21	311.3089	128.2078
2017	550 662.83	42 753.07	11 962.98	25 584.47	4 731.56	328.5706	145.4810
2018	538 980.94	39 323.91	12 158.48	21 851.94	4 779.69	363.4019	170.4055
2019	530 369.49	38 323.97	12 637.71	20 555.26	4 439.47	372.1344	319.3957
2020	479 915.44	32 931.71	11 691.54	16 010.75	4 548.72	404.8479	275.8546
2021	552 258.88	38 685.55	12 408.29	20 168.48	5 417.60	400.7041	290.4730
Decrease 1988-2021	42.1%	51.0%	59.4%	49.5%	35.1%	-480.5%	-
Decrease 1990-2021	35.4%	44.0%	53.1%	39.3%	41.7%	-538.4%	-
Decrease 2020-2021	-15.1%	-17.5%	-6.1%	-26.0%	-19.1%	1.0%	-5.3%

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.

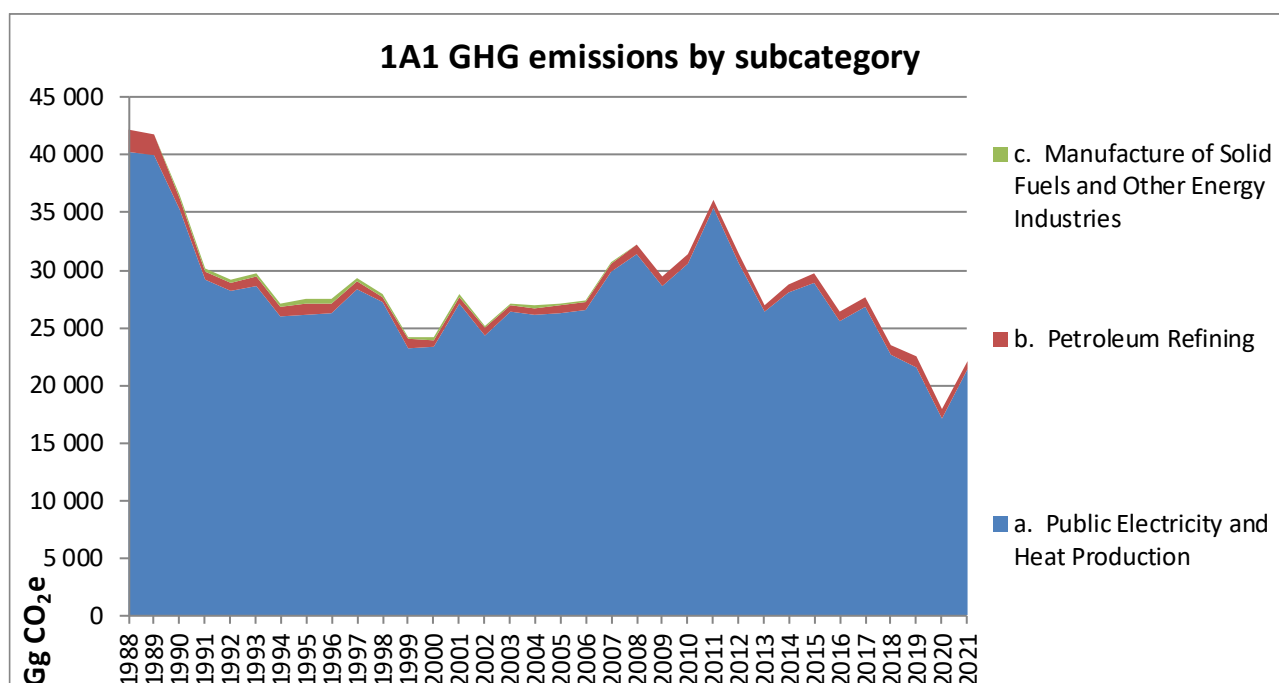


Figure 25 Total GHG emissions from 1.A.1 Energy industries by subcategory

For 2021 the general trend in CRF category 1.A.1 is a decrease in the emissions of 47.6% compared to base year and an increase of 23.6% 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.

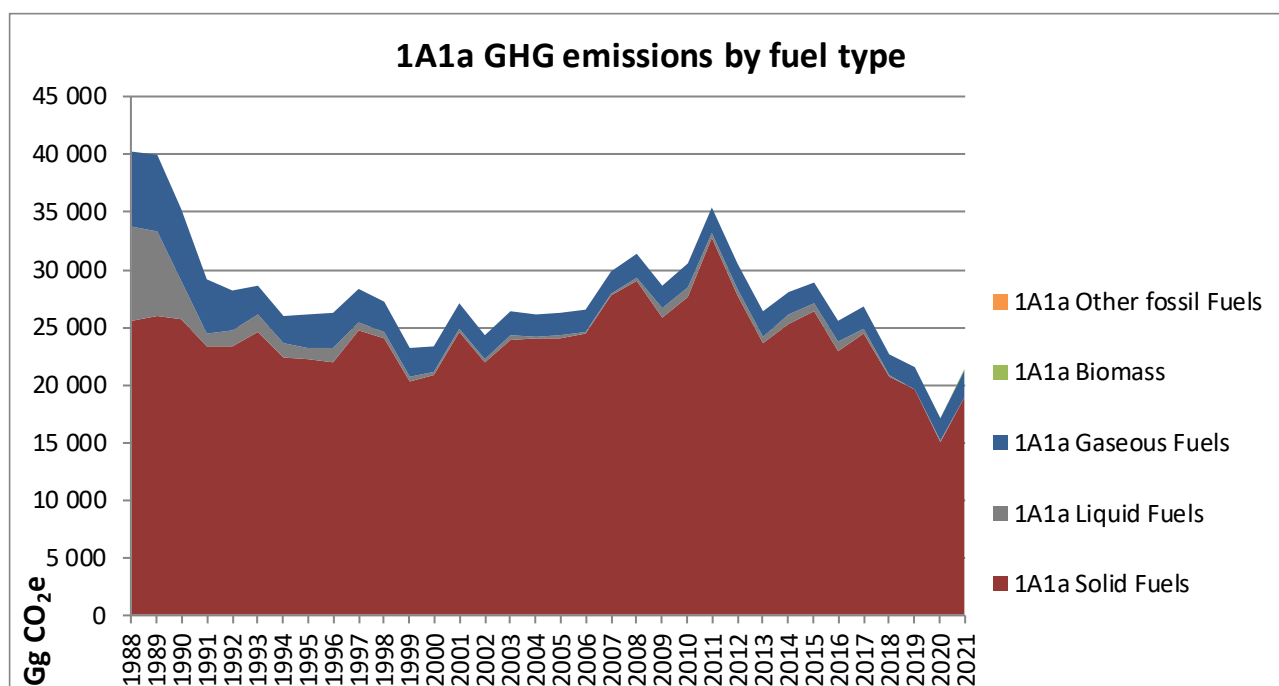


Figure 26 GHG emissions from 1.A.1.a Public Electricity and Heat Production

The share of CRF category 1.A.1.a from the total GHG emissions is 39.7% for the year 2021. The share of this subcategory from CRF category 1.A Fuel combustion is 55.3% for the year 2021. The increase

of the emissions from this subcategory is due to the increase of electricity and heat production from combustible fuels caused by the increase of electricity exports.

The consumption of liquid fuels in this subcategory results in a rather peculiar case study. Due to the relatively large past 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 CO₂ EF for petroleum coke varies in the range of 92-96 t/TJ, which is significantly higher than the average EF of liquid fuels (usually around 74-77 t/TJ). After 2017 petroleum coke consumption in main activity plants has decreased significantly, shifting mostly to autoproducer plants.

Table 35 CO₂ 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	26 070.04	901.28	22 197.91	2 970.85	0.1120	NO
2000	23 228.36	291.18	20 772.70	2 164.48	NO	NO
2005	26 174.65	335.05	23 885.03	1 954.57	NO	NO
2010	30 479.68	839.55	27 482.65	2 157.47	9.0720	NO
2011	35 265.16	423.22	32 557.09	2 284.85	30.4640	NO
2012	30 482.08	625.82	27 634.52	2 221.74	17.6960	NO
2013	26 226.51	668.18	23 449.64	2 108.69	19.0036	NO
2014	27 992.52	744.56	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
2018	22 564.42	59.70	20 658.12	1 846.59	1 845.4130	NO
2019	21 392.89	48.72	19 504.59	1 839.57	2 295.7260	NO
2020	16 981.29	38.50	15 021.63	1 921.16	2 063.5225	NO
2021	21 232.04	68.39	18 811.85	2 351.80	3 346.5239	NO
Decrease 1988-2021	47.1%	99.2%	26.0%	63.9%	-	-
Decrease 1990-2021	39.6%	97.9%	26.6%	62.6%	-	-
Decrease 2020-2021	-25.0%	-77.6%	-25.2%	-22.4%	-62.2%	-

Table 36 CH₄ 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	0.3038	0.0350	0.2149	0.0538	0.0000	NO
2000	0.2507	0.0113	0.2002	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
2018	0.7154	0.0023	0.2048	0.0332	0.4750	NO
2019	0.8178	0.0019	0.1884	0.0331	0.5944	NO
2020	0.7165	0.0015	0.1486	0.0346	0.5318	NO
2021	1.1051	0.0027	0.1849	0.0424	0.8751	NO
Decrease 1988-2021	-62.0%	99.2%	24.4%	64.0%	-	-
Decrease 1990-2021	-125.5%	97.9%	26.1%	62.8%	-	-
Decrease 2020-2021	-54.2%	-77.3%	-24.4%	-22.5%	-64.5%	-

Table 37 N₂O emissions in 1.A.1.a. Public Electricity and Heat Production

N ₂ O (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

N ₂ O (Gg)	CRF 1.A.1.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
1990	0.4118	0.0252	0.3752	0.0114	NO	NO
1995	0.3348	0.0070	0.3224	0.0054	0.0000	NO
2000	0.3065	0.0023	0.3003	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
2018	0.3743	0.0005	0.3073	0.0033	0.0633	NO
2019	0.3655	0.0004	0.2826	0.0033	0.0792	NO
2020	0.2975	0.0003	0.2229	0.0035	0.0709	NO
2021	0.3988	0.0005	0.2774	0.0042	0.1166	NO
Decrease 1988-2021	9.9%	99.2%	24.4%	64.0%	-	-
Decrease 1990-2021	3.2%	97.9%	26.1%	62.8%	-	-
Decrease 2020-2021	-34.0%	-77.3%	-24.4%	-22.5%	-64.6%	-

Table 38 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	280 421.90	26 177.41	904.24	22 299.36	2 973.80	0.0019	NO
2000	243 184.91	23 325.96	292.13	20 867.19	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	30 610.40	841.89	27 608.74	2 159.61	0.1573	NO
2011	362 152.24	35 418.12	424.40	32 706.07	2 287.11	0.5282	NO
2012	314 348.18	30 612.18	627.49	27 760.44	2 223.94	0.3068	NO
2013	273 486.45	26 338.15	669.95	23 557.11	2 110.78	0.3063	NO
2014	290 806.57	28 113.53	746.54	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
2018	256 075.21	22 693.86	59.90	20 754.81	1 848.42	30.7334	NO
2019	243 413.34	21 522.25	48.88	19 593.52	1 841.39	38.4622	NO
2020	202 934.92	17 087.87	38.62	15 091.77	1 923.06	34.4115	NO
2021	258 904.98	21 378.51	68.61	18 899.15	2 354.12	56.6297	NO
Decrease 1988-2021	44.8%	47.0%	99.2%	26.0%	63.9%	-	-
Decrease 1990-2021	36.3%	39.5%	97.9%	26.6%	62.6%	-	-
Decrease 2020-2021	-27.6%	-25.1%	-77.6%	-25.2%	-22.4%	-64.6%	-

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.

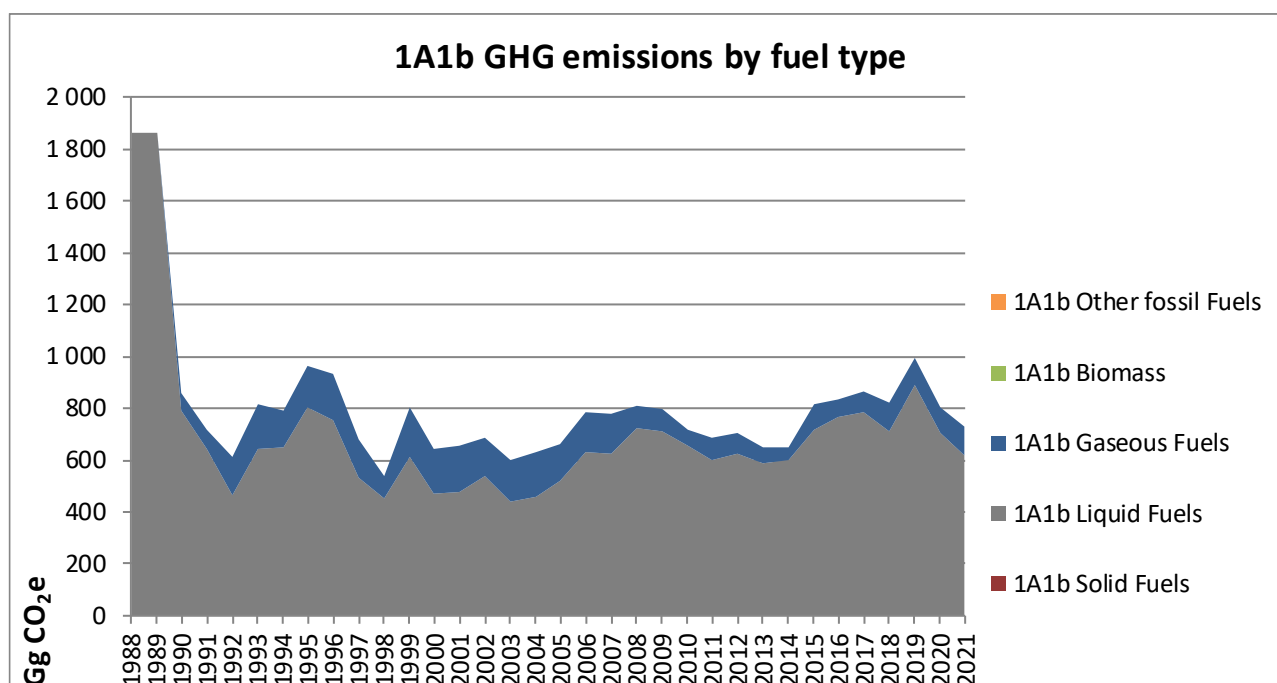


Figure 27 GHG emissions from CRF 1.A.1.b Petroleum refining

For the year 2021 the share of this subcategory from sector 1A Fuel Combustion is 1.9%, 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. The decrease of emissions from fuels after 2020 is due mostly to the pandemic situation.

Table 39 CO₂ 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	859.81	791.15	NO	68.66	NO	NO
1995	963.04	798.99	NO	164.06	NO	NO
2000	641.36	468.22	NO	173.15	NO	NO
2005	660.66	516.13	NO	144.53	NO	NO
2010	715.04	655.18	NO	59.86	NO	NO
2011	682.66	596.96	NO	85.70	NO	NO
2012	704.95	622.83	NO	82.12	NO	NO
2013	646.84	588.94	NO	57.90	NO	NO
2014	649.71	598.37	NO	51.34	NO	NO
2015	814.97	717.90	NO	97.08	NO	NO
2016	832.67	762.97	NO	69.70	NO	NO
2017	862.10	785.04	NO	77.06	NO	NO
2018	820.62	711.33	NO	109.29	NO	NO
2019	991.48	888.49	NO	102.99	NO	NO
2020	803.05	701.36	NO	101.69	NO	NO
2021	728.71	617.18	NO	111.53	NO	NO
Decrease 1988-2021	60.8%	66.8%	-	-	-	-
Decrease 1990-2021	15.2%	22.0%	-	-62.4%	-	-
Decrease 2020-2021	9.3%	12.0%	-	-9.7%	-	-

Table 40 CH₄ 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

CH ₄ (Gg)	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	0.0159	0.0139	NO	0.0020	NO	NO
2019	0.0174	0.0155	NO	0.0019	NO	NO
2020	0.0143	0.0125	NO	0.0018	NO	NO
2021	0.0130	0.0109	NO	0.0020	NO	NO
Decrease 1988-2021	82.0%	84.8%	-	-	-	-
Decrease 1990-2021	41.9%	48.0%	-	-61.6%	-	-
Decrease 2020-2021	9.3%	12.1%	-	-9.7%	-	-

Table 41 N₂O emissions in CRF 1.A.1.b Petroleum refining

N ₂ O (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
2018	0.0018	0.0016	NO	0.0002	NO	NO
2019	0.0018	0.0016	NO	0.0002	NO	NO
2020	0.0015	0.0013	NO	0.0002	NO	NO
2021	0.0013	0.0011	NO	0.0002	NO	NO
Decrease 1988-2021	90.7%	92.1%	-	-	-	-
Decrease 1990-2021	62.2%	66.7%	-	-61.6%	-	-
Decrease 2020-2021	8.2%	10.8%	-	-9.7%	-	-

Table 42 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	861.42	792.69	NO	68.73	NO	NO
1995	15 051.80	964.92	800.70	NO	164.22	NO	NO
2000	10 206.50	642.54	469.22	NO	173.32	NO	NO
2005	10 679.95	661.91	517.24	NO	144.67	NO	NO
2010	12 061.03	716.01	656.10	NO	59.92	NO	NO
2011	11 623.22	683.53	597.75	NO	85.78	NO	NO
2012	11 922.62	705.86	623.66	NO	82.20	NO	NO
2013	10 957.69	647.64	589.68	NO	57.96	NO	NO
2014	10 286.56	650.42	599.03	NO	51.39	NO	NO
2015	14 089.36	815.96	718.79	NO	97.17	NO	NO
2016	14 416.58	833.67	763.90	NO	69.77	NO	NO
2017	14 807.18	863.14	786.00	NO	77.14	NO	NO
2018	14 382.69	821.56	712.16	NO	109.40	NO	NO

GHG (Gg)	TJ	CRF 1.A.1.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2019	17 159.19	992.44	889.35	NO	103.09	NO	NO
2020	14 086.26	803.85	702.06	NO	101.79	NO	NO
2021	12 658.21	729.43	617.79	NO	111.64	NO	NO
Decrease 1988-2021	47.3%	60.9%	66.9%	-	-	-	-
Decrease 1990-2021	6.2%	15.3%	22.1%	-	-62.4%	-	-
Decrease 2020-2021	10.1%	9.3%	12.0%	-	-9.7%	-	-

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).

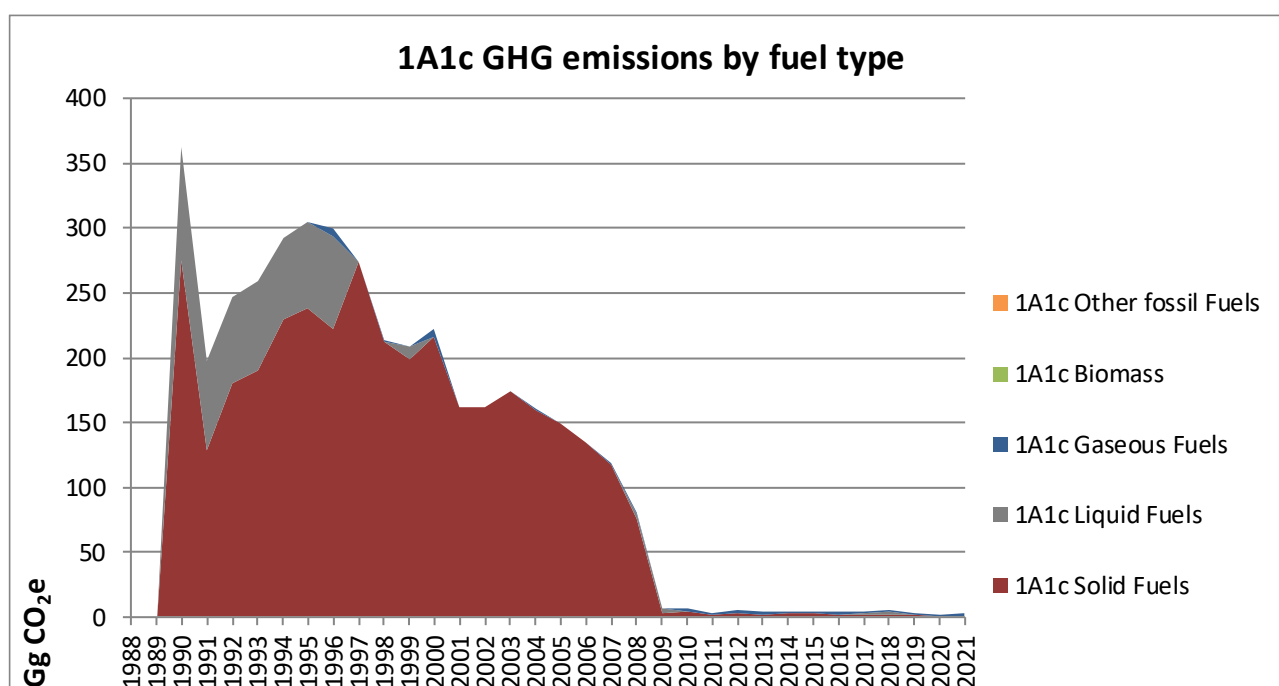


Figure 28 GHG emissions from 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

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 43 CO₂ 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
2018	5.69	3.37	1.39	0.94	NO	NO
2019	3.51	1.16	1.09	1.25	NO	NO
2020	2.16	0.70	0.16	1.30	NO	NO
2021	2.47	0.54	0.08	1.85	NO	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	99.3%	99.4%	100.0%	-	-	-
Decrease 2020-2021	38.1%	39.5%	84.7%	-3.9%	-	-

Table 44 CH₄ 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
2018	0.0002	0.0001	0.0000	0.0000	NO	NO
2019	0.0001	0.0000	0.0000	0.0000	NO	NO
2020	0.0000	0.0000	0.0000	0.0000	NO	NO
2021	0.0000	0.0000	0.0000	0.0000	NO	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	99.5%	99.7%	100.0%	-	-	-
Decrease 2020-2021	-13.2%	26.3%	49.6%	-42.8%	-	-

Table 45 N₂O emissions in CRF 1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

N ₂ O (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

N ₂ O (Gg)	CRF 1.A.1.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	0.0000	0.0000	0.0000	0.0000	NO	NO
2019	0.0000	0.0000	0.0000	0.0000	NO	NO
2020	0.0000	0.0000	0.0000	0.0000	NO	NO
2021	0.0000	0.0000	0.0000	0.0000	NO	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	99.6%	99.8%	99.9%	-	-	-
Decrease 2020-2021	11.7%	28.6%	49.6%	-42.8%	-	-

Table 46 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
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
2018	77.38	5.71	3.38	1.40	0.94	NO	NO
2019	50.23	3.52	1.17	1.10	1.25	NO	NO
2020	35.77	2.17	0.71	0.16	1.30	NO	NO
2021	42.46	2.47	0.54	0.08	1.85	NO	NO
Decrease 1988-2021	-	-	-	-	-	-	-
Decrease 1990-2021	99.4%	99.3%	99.4%	100.0%	-	-	-
Decrease 2020-2021	-18.7%	-14.1%	23.6%	49.4%	-42.7%	-	-

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).

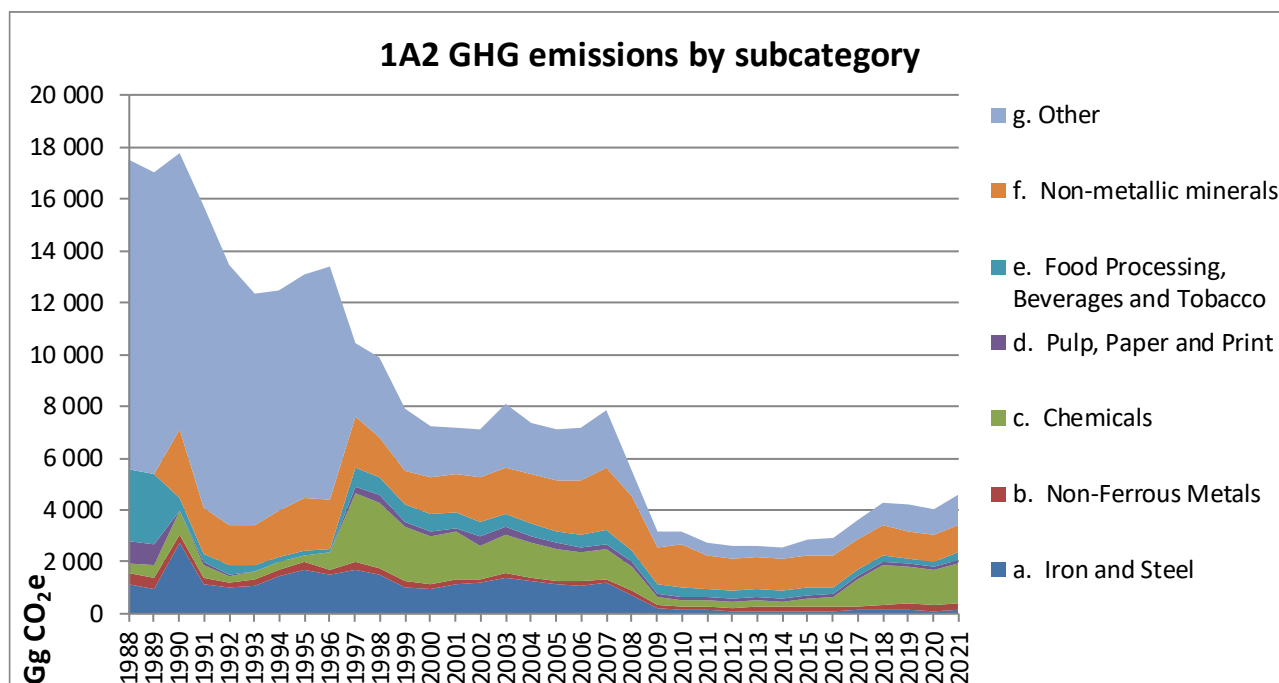


Figure 29 Total GHG emissions from 1.A.2 Manufacturing Industries and Construction by subcategory

Following the restructuring of the industry sector of the country, the general trend in CRF category 1.A.2 shows an emission decrease of 73.9% compared to base year and an increase of 13.9% 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 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.

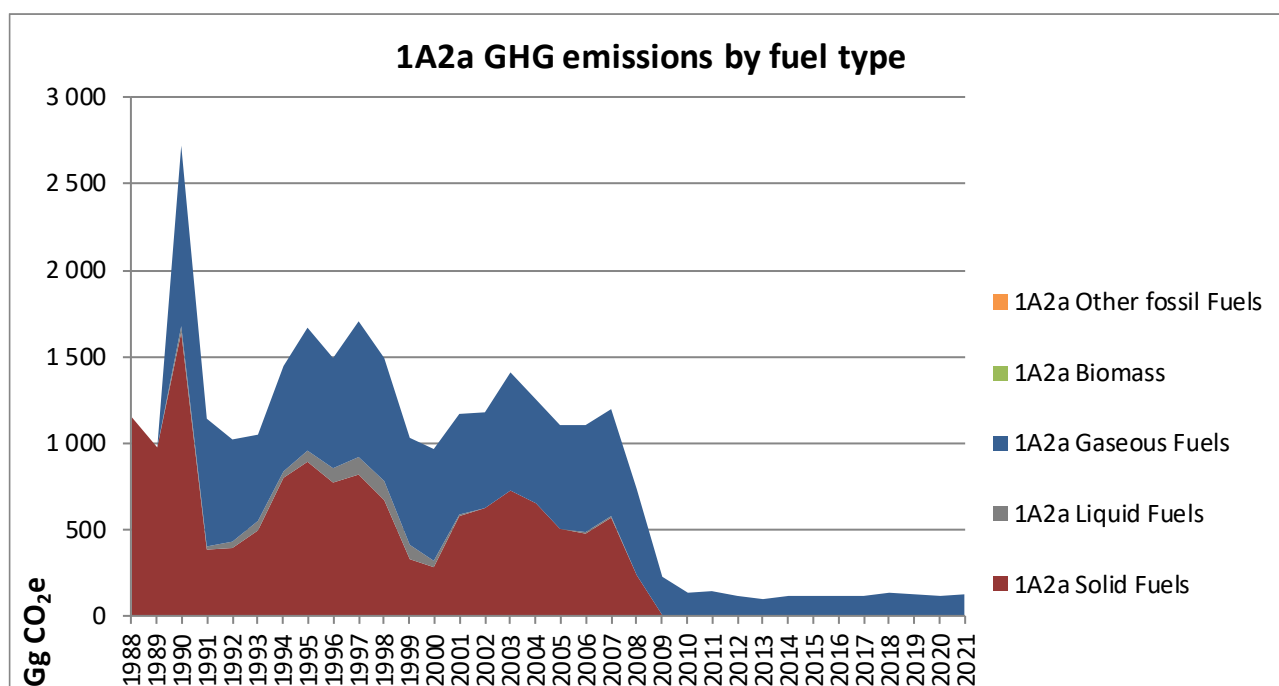


Figure 30 GHG emissions from 1.A.2.a. Iron and Steel

For the year 2021 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 47 CO₂ 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
2016	113.61	NO	NO	113.61	0.2240	NO
2017	118.61	0.79	0.24	117.58	0.1718	NO
2018	129.70	0.65	0.09	128.95	0.0887	NO
2019	120.87	0.56	0.09	120.21	0.1449	NO
2020	114.89	0.54	0.05	114.30	0.0951	NO
2021	123.43	0.70	0.05	122.67	0.0665	NO
Decrease 1988-2021	89.2%	-	100.0%	-	-	-
Decrease 1990-2021	95.4%	98.1%	100.0%	88.2%	-	-
Decrease 2020-2021	-7.4%	-28.3%	-20.0%	-7.3%	30.0%	-

Table 48 CH₄ 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
2018	0.0024	0.0000	0.0000	0.0023	0.0000	NO
2019	0.0022	0.0000	0.0000	0.0022	0.0000	NO
2020	0.0021	0.0000	0.0000	0.0021	0.0000	NO
2021	0.0023	0.0000	0.0000	0.0022	0.0000	NO
Decrease 1988-2021	97.0%	-	100.0%	-	-	-
Decrease 1990-2021	98.7%	98.9%	100.0%	88.2%	-	-
Decrease 2020-2021	-7.2%	-52.1%	-20.0%	-7.4%	30.0%	-

Table 49 N₂O emissions in CRF 1.A.2.a. Iron and Steel

N ₂ O (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
2018	0.0002	0.0000	0.0000	0.0002	0.0000	NO
2019	0.0002	0.0000	0.0000	0.0002	0.0000	NO
2020	0.0002	0.0000	0.0000	0.0002	0.0000	NO
2021	0.0002	0.0000	0.0000	0.0002	0.0000	NO
Decrease 1988-2021	97.9%	-	100.0%	-	-	-
Decrease 1990-2021	99.1%	99.1%	100.0%	88.2%	-	-
Decrease 2020-2021	-7.3%	-74.0%	-20.0%	-7.4%	30.0%	-

Table 50 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
2018	2 333.44	129.83	0.65	0.10	129.08	0.0015	NO
2019	2 174.36	120.99	0.56	0.09	120.33	0.0025	NO
2020	2 068.76	115.00	0.54	0.05	114.41	0.0016	NO
2021	2 222.86	123.55	0.70	0.06	122.79	0.0012	NO
Decrease 1988-2021	86.4%	89.2%	-	100.0%	-	-	-
Decrease 1990-2021	93.7%	95.5%	98.1%	100.0%	88.2%	-	-
Decrease 2020-2021	-7.4%	-7.4%	-28.4%	-20.0%	-7.3%	30.0%	-

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.

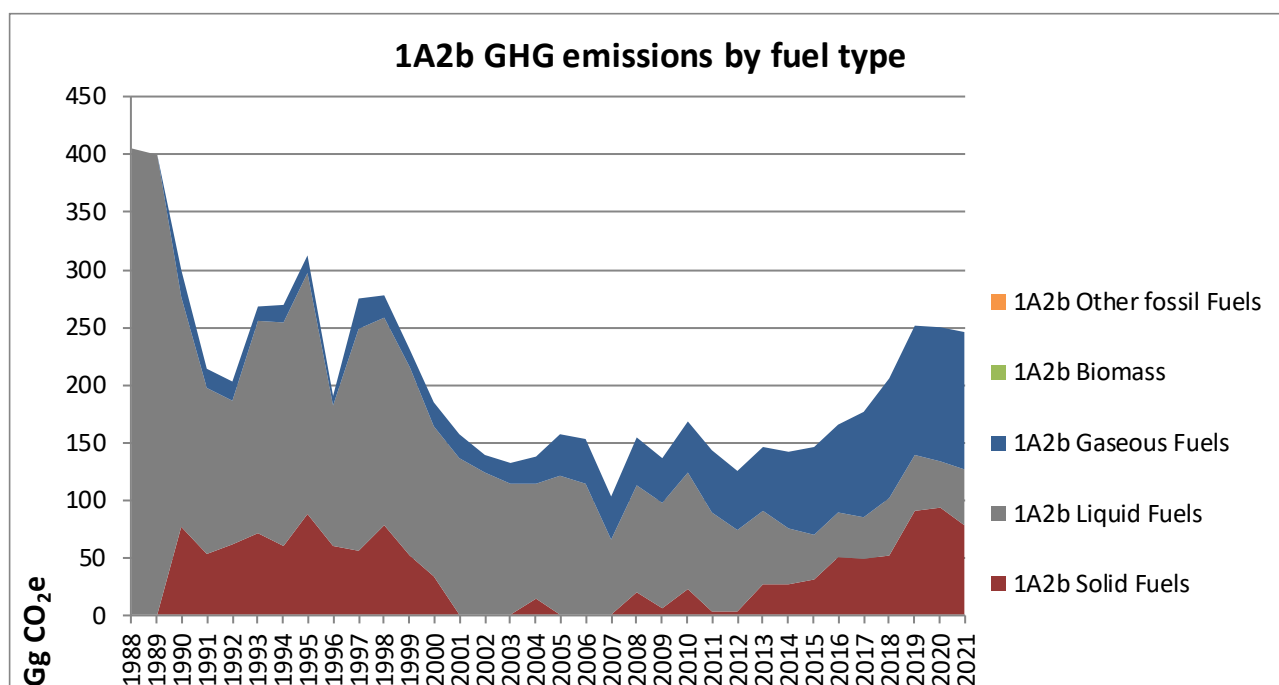


Figure 31 GHG emissions from CRF 1.A.2.b. Non-Ferrous Metals

The share of this subcategory from sector 1.A is 0.6% for the year 2021, which is equivalent to 0.5% of the total GHG emissions.

Table 51 CO₂ 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	157.17	120.36	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
2018	204.98	50.59	50.80	103.60	NO	NO
2019	251.18	49.40	89.38	112.41	0.0448	NO
2020	249.06	40.47	92.63	115.96	0.0081	NO
2021	245.78	48.14	77.49	120.15	0.0451	NO

CO ₂ (Gg)	CRF 1.A.2.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
Decrease 1988-2021	39.2%	88.1%	-	-	-	-
Decrease 1990-2021	17.8%	75.8%	-1.3%	-413.5%	-	-
Decrease 2020-2021	1.3%	-19.0%	16.3%	-3.6%	-459.7%	-

Table 52 CH₄ 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
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
2018	0.0083	0.0017	0.0047	0.0019	NO	NO
2019	0.0121	0.0017	0.0084	0.0020	0.0000	NO
2020	0.0121	0.0014	0.0087	0.0021	0.0000	NO
2021	0.0111	0.0017	0.0072	0.0022	0.0000	NO
Decrease 1988-2021	29.8%	89.4%	-	-	-	-
Decrease 1990-2021	28.5%	78.7%	-0.3%	-410.9%	-	-
Decrease 2020-2021	8.4	-23.1%	16.3%	-3.7%	-459.7%	-

Table 53 N₂O emissions in CRF 1.A.2.b. Non-Ferrous Metals

N ₂ O (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
2018	0.0012	0.0003	0.0007	0.0002	NO	NO
2019	0.0018	0.0003	0.0013	0.0002	0.0000	NO
2020	0.0018	0.0003	0.0013	0.0002	0.0000	NO
2021	0.0016	0.0003	0.0011	0.0002	0.0000	NO
Decrease 1988-2021	48.5%	89.7%	-	-	-	-
Decrease 1990-2021	39.7%	79.4%	-0.3%	-410.9%	-	-
Decrease 2020-2021	7.9%	-24.8%	16.3%	-3.7%	-459.7%	-

Table 54 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	2 238.90	157.59	120.74	NO	36.85	NO	NO
2010	2 347.07	168.43	101.94	22.34	44.14	0.0019	NO
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
2018	3 021.83	205.55	50.72	51.13	103.70	NO	NO
2019	3 514.94	252.02	49.54	89.96	112.52	0.0008	NO
2020	3 494.89	249.89	40.58	93.23	116.08	0.0001	NO
2021	3 526.01	246.54	48.28	77.99	120.27	0.0008	NO
Decrease 1988-2021	33.1%	39.2%	88.1%	-	-	-	-
Decrease 1990-2021	6.6%	17.9%	75.9%	-1.3%	-413.5%	-	-
Decrease 2020-2021	-0.9%	1.3%	-19.0%	16.3%	-3.6%	-459.7%	-

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.

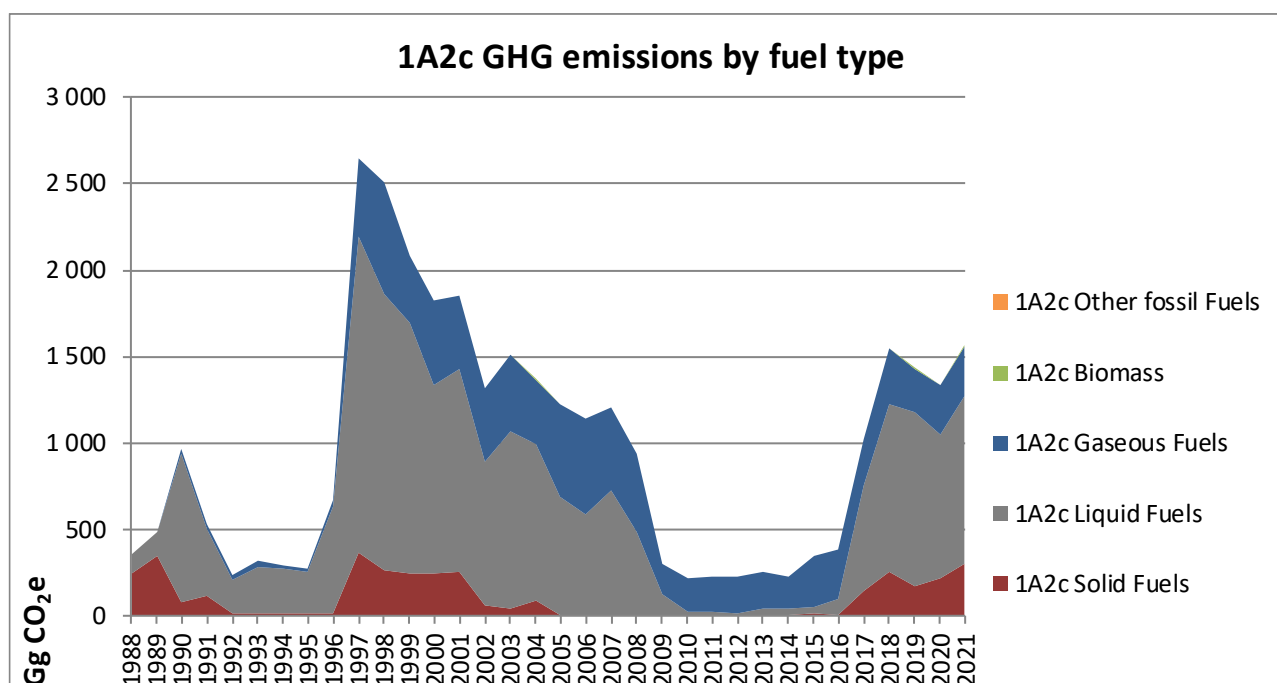


Figure 32 GHG emissions from CRF 1.A.2.c. Chemicals

The share of this subcategory from sector 1.A is 4.0% for the year 2021, which is equivalent to 2.9% 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 55 CO₂ 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	965.52	854.91	80.38	30.23	NO	NO
1995	267.25	238.18	11.56	17.51	0.2240	NO
2000	1 820.83	1 089.77	239.06	492.01	7.9520	NO
2005	1 221.59	684.19	2.21	535.19	189.3920	NO
2010	215.65	24.13	NO	191.52	0.2240	NO
2011	223.71	17.94	NO	205.77	0.1120	NO
2012	225.87	12.46	NO	213.41	0.2240	NO
2013	248.39	38.39	NO	210.00	3.9200	NO
2014	223.43	37.74	2.36	183.33	31.8080	NO
2015	344.97	39.93	12.30	292.74	50.7360	NO
2016	378.74	90.82	0.48	287.44	3.6960	NO
2017	1 020.50	602.41	143.16	274.93	64.1869	NO
2018	1 538.58	971.40	249.36	317.82	30.9213	NO
2019	1 427.41	1 002.41	168.66	256.34	59.2321	NO
2020	1 327.38	833.97	214.60	278.81	51.8222	NO
2021	1 555.85	965.00	301.42	289.44	40.0677	NO
Decrease 1988-2021	-336.3%	-726.2%	-25.7%	-	-	-
Decrease 1990-2021	-61.1%	-12.9%	-275.0%	-857.6%	-	-
Decrease 2020-2021	-17.2%	-15.7%	-40.5%	-3.8%	22.7%	-

Table 56 CH₄ 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	0.0557	0.0177	0.0158	0.0050	0.0172	NO
2018	0.0723	0.0301	0.0281	0.0057	0.0083	NO
2019	0.0702	0.0307	0.0190	0.0046	0.0159	NO
2020	0.0695	0.0248	0.0257	0.0050	0.0139	NO
2021	0.0799	0.0290	0.0349	0.0052	0.0107	NO
Decrease 1988-2021	-194.2%	-512.8%	-55.8%	-	-	-
Decrease 1990-2021	-164.5%	-30.9%	-364.9%	-852.9%	-	-
Decrease 2020-2021	-14.9%	-16.6%	-35.8%	-3.9%	22.7%	-

Table 57 N₂O emissions in CRF 1.A.2.c. Chemicals

N ₂ O (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	0.0034	0.0024	0.0005	0.0023	NO
2018	0.0118	0.0059	0.0042	0.0006	0.0011	NO
2019	0.0114	0.0060	0.0029	0.0005	0.0021	NO
2020	0.0109	0.0047	0.0039	0.0005	0.0019	NO
2021	0.0127	0.0055	0.0052	0.0005	0.0014	NO
Decrease 1988-2021	-195.7%	-486.5%	-55.8%	-	-	-
Decrease 1990-2021	-171.4%	-57.9%	-364.9%	-852.9%	-	-
Decrease 2020-2021	-16.4%	-17.3%	-35.8%	-3.9%	22.7%	-

Table 58 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	967.67	856.51	80.90	30.26	NO	NO
1995	3 762.88	268.03	238.85	11.64	17.53	0.0039	NO
2000	27 881.70	1 825.64	1 092.23	240.77	492.50	0.1379	NO

GHG (Gg)	TJ	CRF 1.A.2.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2005	21 813.74	1 227.05	685.82	2.22	535.72	3.2839	NO
2010	3 821.21	215.90	24.19	NO	191.71	0.0039	NO
2011	3 996.80	223.95	17.98	NO	205.97	0.0019	NO
2012	4 032.82	226.13	12.50	NO	213.62	0.0039	NO
2013	4 442.69	248.74	38.45	NO	210.21	0.0680	NO
2014	4 187.91	224.23	37.79	2.37	183.52	0.5515	NO
2015	6 506.90	346.29	40.00	12.38	293.03	0.8797	NO
2016	6 773.86	379.20	90.93	0.49	287.72	0.0641	NO
2017	14 256.00	1 024.43	603.85	144.27	275.20	1.1130	NO
2018	19 692.97	1 543.90	973.91	251.32	318.14	0.5362	NO
2019	18 410.42	1 432.56	1 004.96	169.98	256.59	1.0270	NO
2020	17 943.89	1 332.37	836.00	216.39	279.08	0.8986	NO
2021	20 387.61	1 561.65	967.37	303.85	289.73	0.6947	NO
Decrease 1988-2021	-434.0%	-335.5%	-725.4%	-25.9%	-	-	-
Decrease 1990-2021	-38.0%	-61.4%	-12.9%	-275.6%	-857.6%	-	-
Decrease 2020-2021	-13.6%	-17.2%	-15.7%	-40.4%	-3.8%	22.7%	-

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 enfold emissions from the fuel combustion in pulp, paper and print industries.

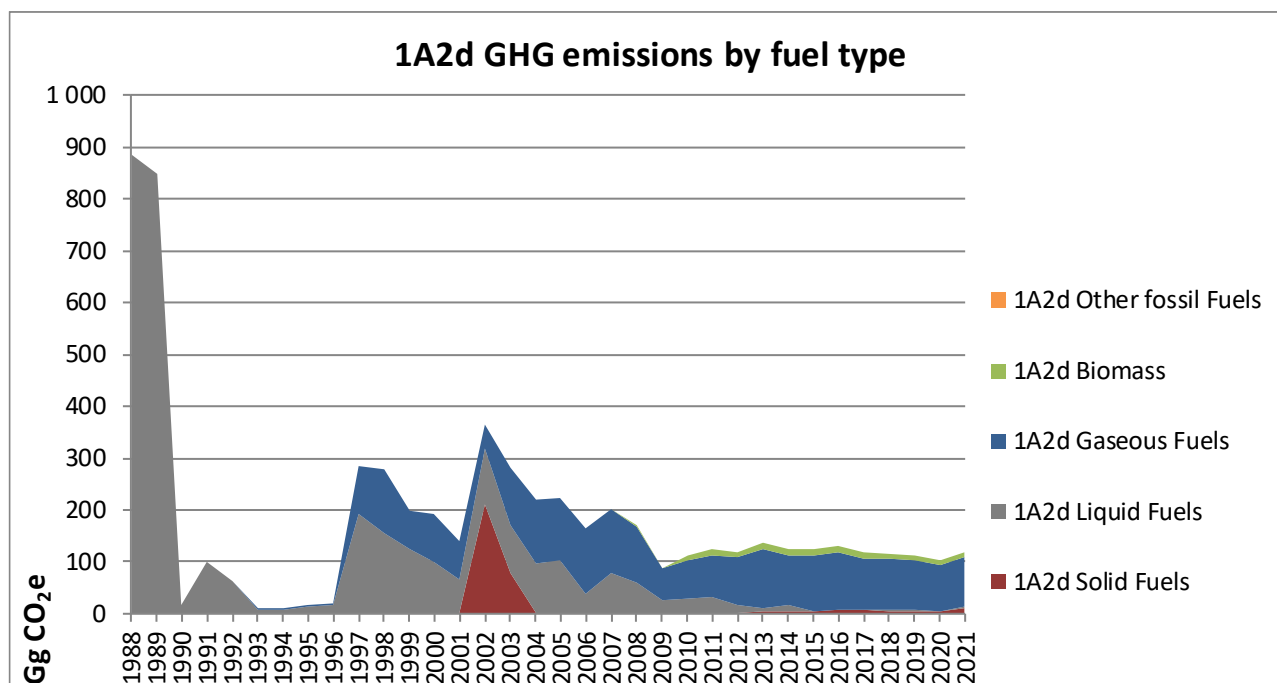


Figure 33 GHG emissions from CRF 1.A.2.d. Pulp, Paper and Print

The share of this subcategory from sector 1.A is 0.3% for 2021, which is equivalent to 0.2% of the total GHG emissions.

Table 59 CO₂ 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
2018	106.78	1.40	4.88	100.50	549.1898	NO
2019	102.19	2.77	4.18	95.24	595.6262	NO
2020	94.63	1.37	4.14	89.12	539.8357	NO
2021	110.25	1.47	11.32	97.45	439.3720	NO
Decrease 1988-2021	87.5%	99.8%	-	-	-	-
Decrease 1990-2021	-608.7%	90.5%	-	-	-	-
Decrease 2020-2021	-16.5%	-7.6%	-173.6%	-9.4%	18.6%	-

Table 60 CH₄ 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

CH ₄ (Gg)	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	0.1494	0.0000	0.0005	0.0018	0.1471	NO
2019	0.1617	0.0001	0.0004	0.0017	0.1595	NO
2020	0.1466	0.0000	0.0004	0.0016	0.1446	NO
2021	0.1208	0.0000	0.0013	0.0018	0.1177	NO
Decrease 1988-2021	-253.2%	99.9%	-	-	-	-
Decrease 1990-2021	-19579.7	94.0%	-	-	-	-
Decrease 2020-2021	17.6%	-12.3%	-220.8%	-9.4%	18.6%	-

Table 61 N₂O emissions in CRF 1.A.2.d. Pulp, Paper and Print

N ₂ O (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
2018	0.0199	0.0000	0.0001	0.0002	0.0196	NO
2019	0.0215	0.0000	0.0001	0.0002	0.0213	NO
2020	0.0195	0.0000	0.0001	0.0002	0.0193	NO
2021	0.0161	0.0000	0.0002	0.0002	0.0157	NO
Decrease 1988-2021	-134.9%	99.9%	-	-	-	-
Decrease 1990-2021	-12990.7	95.2%	-	-	-	-
Decrease 2020-2021	17.6%	-15.6%	-220.8%	-9.4%	18.6%	-

Table 62 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

GHG (Gg)	TJ	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	6 782.83	116.44	1.41	4.91	100.60	9.5226	NO
2019	7 112.42	112.65	2.78	4.21	95.34	10.3277	NO
2020	6 486.99	104.11	1.37	4.17	89.21	9.3604	NO
2021	5 832.91	118.06	1.48	11.41	97.55	7.6184	NO
Decrease 1988-2021	48.8%	86.7%	99.8%	-	-	-	-
Decrease 1990-2021	-2750.9	-656.4%	90.5%	-	-	-	-
Decrease 2020-2021	10.1%	-13.4%	-7.6%	-173.9%	-9.4%	18.6%	-

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

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

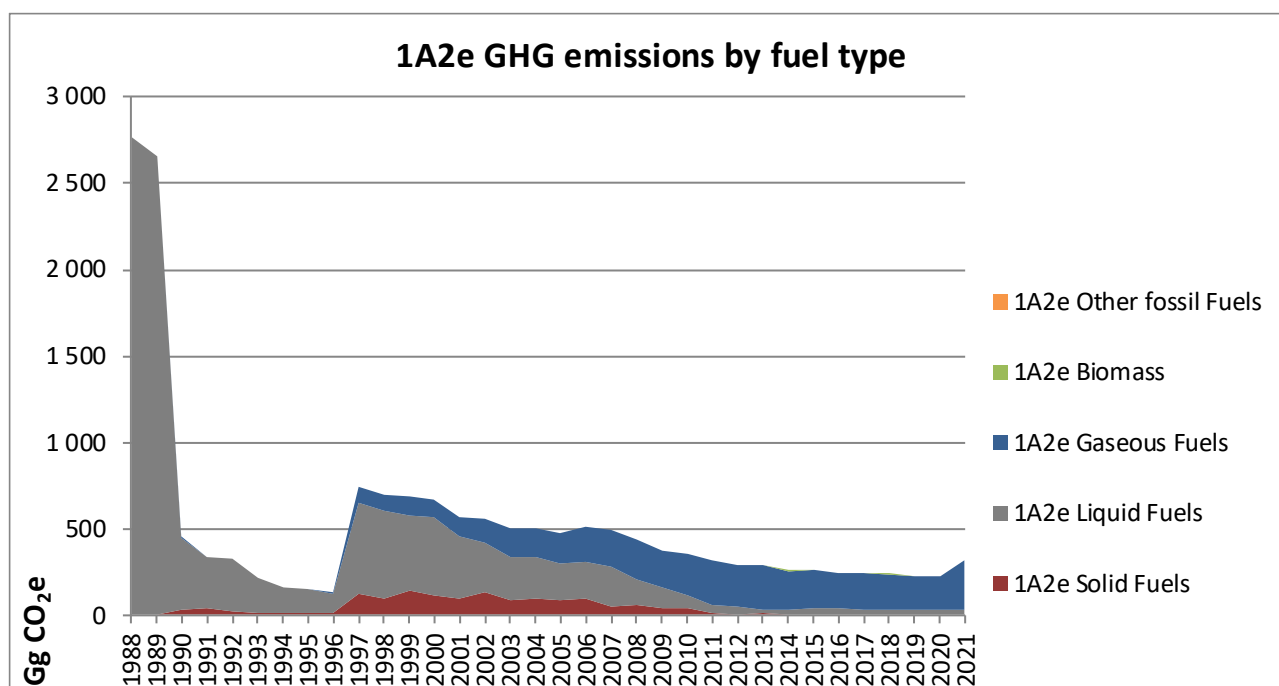


Figure 34 GHG emissions from 1.A.2.e. Food Processing, Beverages and Tobacco

The share of this subcategory from sector 1.A is 0.8% for 2021, which is equivalent to 0.6% of total GHG emissions.

Table 63 CO₂ 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	476.12	204.15	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

CO ₂ (Gg)	CRF 1.A.2.e.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	238.42	25.51	2.83	210.08	123.9194	NO
2019	228.03	26.71	5.66	195.66	67.7597	NO
2020	222.88	25.23	3.60	194.04	173.7579	NO
2021	318.01	22.76	4.09	291.17	114.1050	NO
Decrease 1988-2021	88.5%	99.2%	-	-	-	-
Decrease 1990-2021	29.9%	94.4%	87.6%	-2448.0%	-	-
Decrease 2020-2021	-42.7%	9.8%	-13.5%	-50.1%	34.3%	-

Table 64 CH₄ 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
2000	0.0408	0.0176	0.0114	0.0019	0.0099	NO
2005	0.0256	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
2018	0.0360	0.0008	0.0003	0.0038	0.0311	NO
2019	0.0211	0.0009	0.0006	0.0035	0.0161	NO
2020	0.0512	0.0008	0.0004	0.0035	0.0465	NO
2021	0.0370	0.0007	0.0005	0.0052	0.0306	NO
Decrease 1988-2021	65.7%	99.3%	-	-	-	-
Decrease 1990-2021	-87.3%	95.5%	85.5%	-2435.5%	-	-
Decrease 2020-2021	27.8%	6.9%	-10.1%	-50.1%	34.3%	-

Table 65 N₂O emissions in 1.A.2.e. Food Processing, Beverages and Tobacco

N ₂ O (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
2018	0.0047	0.0002	0.0000	0.0004	0.0041	NO
2019	0.0027	0.0002	0.0001	0.0004	0.0021	NO
2020	0.0068	0.0001	0.0001	0.0003	0.0062	NO

N ₂ O (Gg)	CRF 1.A.2.d.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2021	0.0048	0.0001	0.0001	0.0005	0.0041	NO
Decrease 1988-2021	77.8%	99.4%	-	-	-	-
Decrease 1990-2021	-27.4%	95.9%	85.5%	-2435.5%	-	-
Decrease 2020-2021	28.9%	5.6%	-10.1%	-50.1%	34.3%	-

Table 66 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	7 078.26	477.95	204.81	90.57	182.22	0.3379	NO
2010	6 082.06	355.62	70.79	40.15	244.10	0.5729	NO
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
2018	5 359.80	240.72	25.57	2.85	210.29	2.0119	NO
2019	4 639.86	229.38	26.78	5.70	195.85	1.0411	NO
2020	5 446.92	226.17	25.30	3.63	194.23	3.0128	NO
2021	6 633.48	320.37	22.81	4.12	291.45	1.9785	NO
Decrease 1988-2021	81.6%	88.4%	99.2%	-	-	-	-
Decrease 1990-2021	-10.8%	29.6%	94.4%	87.6%	-2448.0%	-	-
Decrease 2020-2021	-21.8%	-41.6%	9.8%	-13.5%	-50.1%	34.3%	-

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

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

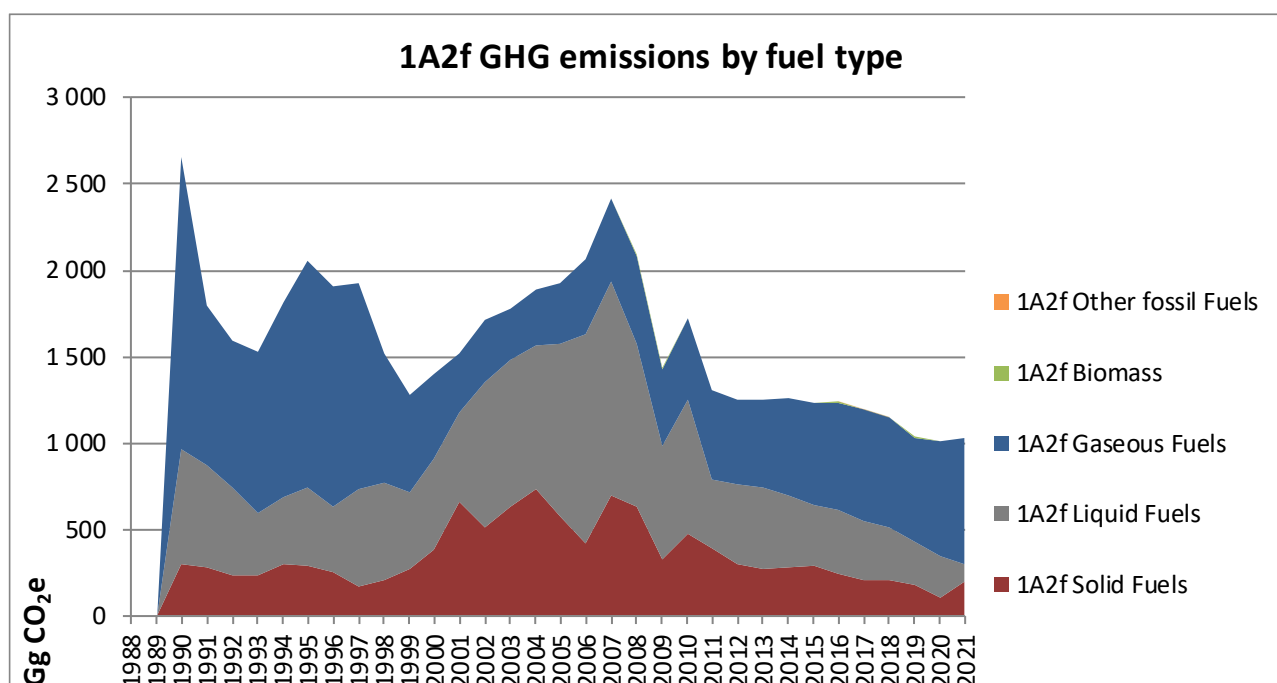


Figure 35 GHG emissions from 1.A.2.f. Non-metallic minerals

The share of this subcategory from sector 1.A is 2.7% for 2021, which is equivalent to 1.9% 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 67 CO₂ 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	1 916.65	987.09	577.05	352.51	1.8953	NO
2010	1 712.41	778.07	470.09	464.26	70.1145	NO
2011	1 304.59	393.31	388.05	523.23	54.6819	NO
2012	1 246.25	468.16	293.77	484.32	106.5080	NO
2013	1 244.78	470.38	272.51	501.88	108.8629	NO
2014	1 254.45	417.00	279.71	557.74	78.3885	NO
2015	1 228.79	354.02	286.60	588.16	90.9762	NO
2016	1 232.14	370.38	239.72	622.05	137.0180	NO
2017	1 194.11	338.65	209.15	646.30	154.8104	NO
2018	1 145.57	306.99	203.34	635.25	231.2777	NO
2019	1 030.12	246.98	177.40	605.74	455.9569	NO
2020	1 006.57	241.65	106.90	658.02	222.9204	NO
2021	1 023.65	97.09	198.42	728.14	218.4346	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	61.3%	85.4%	32.8%	56.8%	-	-
Decrease 2020-2021	-1.7%	59.8%	-85.6%	-10.7%	2.0%	-

Table 68 CH₄ 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	0.0828	0.0151	0.0303	0.0088	0.0285	NO
2013	0.0816	0.0150	0.0284	0.0091	0.0292	NO
2014	0.0735	0.0133	0.0292	0.0101	0.0210	NO
2015	0.0765	0.0113	0.0303	0.0106	0.0244	NO
2016	0.0846	0.0118	0.0250	0.0112	0.0367	NO
2017	0.0865	0.0108	0.0226	0.0116	0.0415	NO
2018	0.1056	0.0099	0.0223	0.0114	0.0619	NO
2019	0.1605	0.0080	0.0195	0.0109	0.1221	NO
2020	0.0916	0.0078	0.0122	0.0119	0.0597	NO
2021	0.0972	0.0031	0.0225	0.0131	0.0585	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	-13.4%	87.8%	24.3%	57.0%	-	-

CH ₄ (Gg)	CRF 1.A.2.f.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
Decrease 2020-2021	-6.2%	60.1%	-84.3%	-10.7%	2.0%	-

Table 69 N₂O emissions in 1.A.2.f. Non-metallic minerals

N ₂ O (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
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	0.0123	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	0.0122	0.0022	0.0034	0.0012	0.0055	NO
2018	0.0147	0.0020	0.0033	0.0011	0.0083	NO
2019	0.0219	0.0016	0.0029	0.0011	0.0163	NO
2020	0.0125	0.0016	0.0018	0.0012	0.0080	NO
2021	0.0131	0.0006	0.0034	0.0013	0.0078	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	-4.2%	87.9%	24.3%	57.0%	-	-
Decrease 2020-2021	-4.5%	60.5%	-84.3%	-10.7%	2.0%	-

Table 70 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	22 845.24	1 923.80	989.76	581.15	352.86	0.0329	NO
2010	22 307.72	1 719.63	780.18	473.51	464.72	1.2157	NO
2011	18 324.45	1 309.96	394.40	390.86	523.75	0.9481	NO
2012	17 834.21	1 251.97	469.44	295.88	484.80	1.8468	NO
2013	17 916.26	1 250.41	471.65	274.49	502.38	1.8876	NO
2014	18 135.10	1 259.52	418.12	281.75	558.29	1.3592	NO
2015	18 222.31	1 234.01	354.98	288.71	588.74	1.5775	NO
2016	18 859.20	1 237.87	371.37	241.46	622.66	2.3758	NO
2017	18 928.94	1 199.92	339.57	210.73	646.94	2.6843	NO
2018	19 068.02	1 152.60	307.82	204.90	635.88	4.0102	NO
2019	19 631.23	1 040.66	247.65	178.76	606.34	7.9060	NO
2020	17 713.51	1 012.59	242.31	107.75	658.67	3.8653	NO
2021	18 412.78	1 029.98	97.35	199.98	728.86	3.7875	NO
Decrease 1988-2021	-	-	-	-	-	-	-
Decrease 1990-2021	56.4%	61.2%	85.4%	32.7%	56.8%	-	-
Decrease 2020-2021	-3.9%	-1.7%	59.8%	-85.6%	-10.7%	2.0%	-

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)

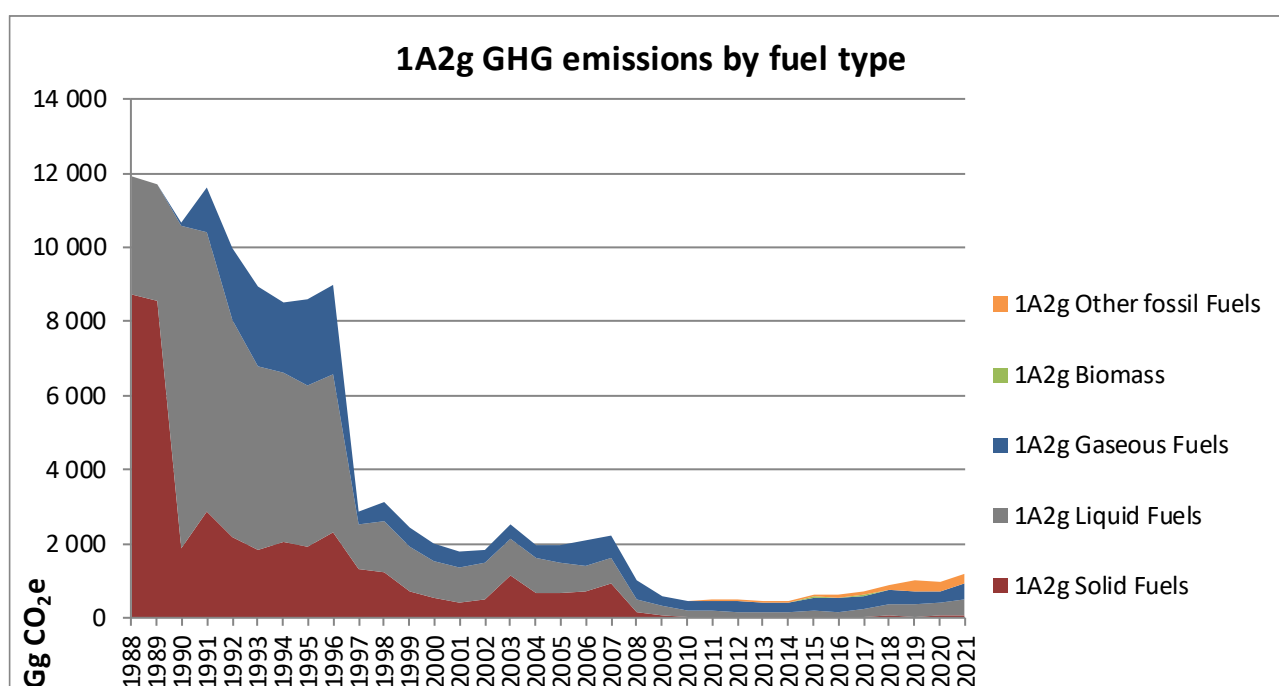


Figure 36 GHG emissions from 1.A.2.g. Other industries

The share of this subcategory from sector 1.A is 3.0% for 2021, which is equivalent to 2.2% 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 71 CO₂ 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	11 822.55	3 155.83	8 666.72	NO	NO	NO
1990	10 579.09	8 631.98	1 858.13	88.98	NO	NO
1995	8 571.82	4 311.84	1 909.43	2 350.55	134.9600	NO
2000	1 974.33	990.07	510.62	473.64	128.1280	NO
2005	1 949.59	768.21	679.80	498.78	117.1520	2.8073
2010	444.56	167.11	12.26	240.13	163.8182	25.0545

CO ₂ (Gg)	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2011	469.10	179.77	10.36	252.56	155.6198	26.4152
2012	461.40	124.04	12.67	284.96	220.0744	39.7299
2013	448.46	127.13	12.94	256.82	281.3230	51.5697
2014	441.79	139.72	9.81	242.82	335.6318	49.4349
2015	613.94	157.05	15.81	372.78	352.0846	68.2941
2016	624.92	143.13	13.24	365.28	338.2638	103.2707
2017	706.40	206.29	24.35	357.68	335.4148	118.0783
2018	867.74	295.83	56.18	373.02	339.9084	142.7187
2019	984.97	311.84	32.71	353.98	386.4356	286.4452
2020	953.86	328.79	45.30	334.47	413.9092	245.3005
2021	1 149.94	419.53	57.43	414.39	453.3897	258.5989
Decrease 1988-2021	90.3%	86.7%	99.3%	-	-	-
Decrease 1990-2021	89.1%	95.1%	96.9%	-365.7%	-	-
Decrease 2020-2021	-20.6%	-27.6%	-26.8%	-23.9%	-9.5%	-5.4%

Table 72 CH₄ 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	0.0631	0.0078	0.0011	0.0046	0.0406	0.0091
2012	0.0847	0.0054	0.0013	0.0052	0.0589	0.0140
2013	0.1033	0.0058	0.0014	0.0046	0.0746	0.0169
2014	0.1168	0.0065	0.0010	0.0044	0.0880	0.0170
2015	0.1306	0.0070	0.0017	0.0067	0.0912	0.0241
2016	0.1402	0.0058	0.0014	0.0066	0.0859	0.0405
2017	0.1491	0.0073	0.0026	0.0064	0.0835	0.0491
2018	0.1691	0.0108	0.0063	0.0067	0.0848	0.0605
2019	0.2350	0.0111	0.0037	0.0064	0.0992	0.1146
2020	0.2118	0.0123	0.0054	0.0060	0.1052	0.0829
2021	0.2344	0.0156	0.0066	0.0075	0.1146	0.0900
Decrease 1988-2021	76.8%	88.1%	99.2%	-	-	-
Decrease 1990-2021	54.5%	95.4%	96.2%	-363.4%	-	-
Decrease 2020-2021	-10.7%	-27.1%	-22.6%	-24.0%	-9.0%	-8.6%

Table 73 N₂O emissions in 1.A.2.g. Other industries

N ₂ O (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	0.0404	0.0258	0.0002	0.0004	0.0117	0.0023
2015	0.0422	0.0259	0.0003	0.0007	0.0121	0.0032
2016	0.0398	0.0221	0.0002	0.0007	0.0114	0.0054

N ₂ O (Gg)	CRF 1.A.2.g.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2017	0.0407	0.0220	0.0004	0.0006	0.0111	0.0066
2018	0.0473	0.0264	0.0009	0.0007	0.0113	0.0081
2019	0.0595	0.0298	0.0006	0.0006	0.0132	0.0153
2020	0.0620	0.0355	0.0008	0.0006	0.0140	0.0111
2021	0.0650	0.0360	0.0010	0.0007	0.0153	0.0120
Decrease 1988-2021	78.5%	78.9%	99.2%	-	-	-
Decrease 1990-2021	69.6%	80.8%	96.2%	-363.4%	-	-
Decrease 2020-2021	-5.0%	-1.5%	-22.6%	-24.0%	-8.9%	-8.6%

Table 74 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	129 467.42	11 937.77	3 209.90	8 727.87	NO	NO	NO
1990	134 955.71	10 655.69	8 696.39	1 870.23	89.07	NO	NO
1995	120 844.05	8 615.55	4 338.09	1 922.24	2 352.88	2.3401	NO
2000	28 554.65	1 986.97	996.53	514.11	474.11	2.2216	NO
2005	27 868.06	1 967.24	778.41	684.66	499.27	2.0313	2.8728
2010	8 561.55	455.22	174.00	12.35	240.37	2.7807	25.7211
2011	8 819.60	480.29	187.41	10.43	252.81	2.6243	27.0050
2012	9 383.54	471.47	129.02	12.77	285.24	3.8124	40.6337
2013	9 585.88	461.48	133.88	13.03	257.08	4.8289	52.6650
2014	9 997.93	456.74	147.57	9.88	243.06	5.6921	50.5349
2015	13 073.86	629.77	164.94	15.93	373.15	5.8989	69.8561
2016	13 296.61	640.29	149.86	13.34	365.64	5.5593	105.8944
2017	14 454.73	722.26	213.04	24.53	358.04	5.4010	121.2594
2018	16 299.57	886.08	303.96	56.61	373.39	5.4866	146.6340
2019	18 209.70	1 008.58	321.01	32.96	354.33	6.4175	293.8659
2020	17 533.40	977.62	339.67	45.68	334.80	6.8060	250.6654
2021	20 914.07	1 175.18	430.65	57.89	414.80	7.4152	264.4275
Decrease 1988-2021	83.8%	90.2%	86.6%	99.3%	-	-	-
Decrease 1990-2021	84.5%	89.0%	95.0%	96.9%	-365.7%	-	-
Decrease 2020-2021	-19.3%	-20.2%	-26.8%	-26.7%	-23.9%	-9.0%	-5.5%

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 CH₄ and N₂O 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'.

In 2021 we have identified an omission from last year ETS reports for one operator, which started using RDF fuel and which we had not considered. For the 2021 submission we have corrected the value for 2018.

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 75 Transport sector categories

Number	Category	CO ₂	CH ₄	N ₂ O	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 (CO₂), methane (CH₄) and nitrous oxide (N₂O) – 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 CO₂, whereas for CH₄ and N₂O 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 – 2021 are shown below.

Table 76 Fuels for CRF 1.A.3 Transport in TJ 1988 – 2021

CRF 1A3 Transport	a. Civil Aviation	b. Road Transportation	c. Railways	d. Navigation	e. Other Transport
TJ					
1988	1 083	96 476	NO	NO	NO
1990	700	82 023	4 357	761	1 777
1995	382	56 094	3 106	167	40
2000	239	68 604	1 607	85	6 887
2005	235	97 943	1 227	153	9 042
2010	301	104 167	846	117	5 896
2011	367	104 097	761	127	8 528
2012	342	111 325	931	115	8 519
2013	273	99 904	630	96	7 608
2014	258	113 049	505	116	7 032
2015	264	125 772	673	137	6 141
2016	257	128 114	546	99	6 013
2017	299	129 188	563	88	7 158
2018	302	133 005	462	69	5 751
2019	287	138 224	417	87	2 269
2020	169	130 761	397	65	1 478
2021	199	139 159	429	60	2 264

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.

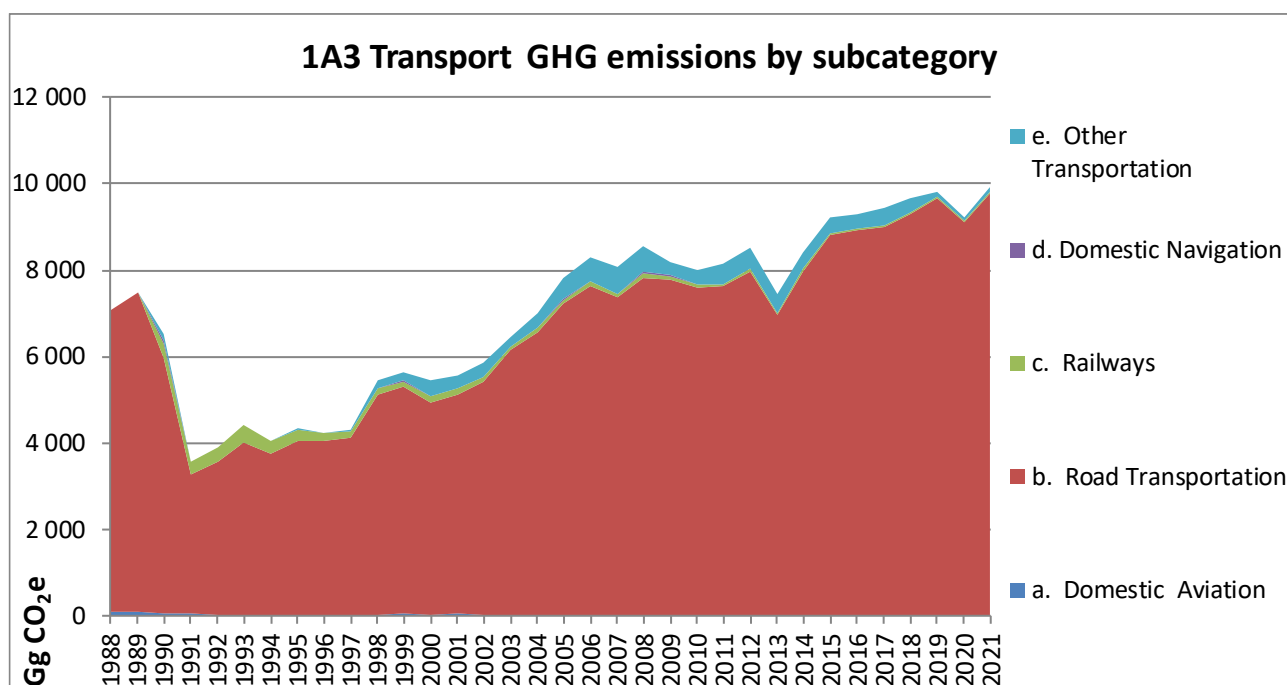


Figure 37 Fuels for CRF 1.A.3 transport for 1988 - 2021

In the period between 1988 and 1991 fuel consumption in the transport sector decreased by 49% 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 77 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	1.1%	98.9%	-	-	-
1990	0.8%	91.5%	4.9%	0.8%	2.0%
1995	0.6%	93.8%	5.2%	0.3%	0.1%
2000	0.3%	88.6%	2.1%	0.1%	8.9%
2005	0.2%	90.2%	1.1%	0.1%	8.3%
2010	0.3%	93.6%	0.8%	0.1%	5.3%
2011	0.3%	91.4%	0.7%	0.1%	7.5%
2012	0.3%	91.8%	0.8%	0.1%	7.0%
2013	0.3%	92.1%	0.6%	0.1%	7.0%
2014	0.2%	93.5%	0.4%	0.1%	5.8%
2015	0.2%	94.6%	0.5%	0.1%	4.6%
2016	0.2%	94.9%	0.4%	0.1%	4.5%
2017	0.2%	94.1%	0.4%	0.1%	5.2%
2018	0.2%	95.3%	0.3%	0.0%	4.1%
2019	0.2%	97.8%	0.3%	0.1%	1.6%
2020	0.1%	98.4%	0.3%	0.0%	1.1%
2021	0.1%	97.9%	0.3%	0.0%	1.6%

3.3.12.2 CRF 1.A.3.a Civil Aviation

3.3.12.2.1 Source description

Until the 2021 submission, category 1.A.3.a Civil Aviation included all domestic civil use of airplanes, but also military use. Starting from the 2021 submission, emissions from military aviation were reallocated under CRF category 1.A.5.b Other mobile. Disaggregation is performed based on fuel consumption for civil aviation, provided by Eurocontrol. The IPCC source category for civil aviation includes emissions from domestic aviation 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 (CO₂), methane (CH₄) and nitrous oxide (N₂O), as well as carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO₂), 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 Emission trend

For 2021 there was a decrease of 84.0% in the emissions from civil aviation compared to the base year, and an increase of 0.2% compared to the year before. In 2021 the sector was responsible for 0.03% of the emissions allocated to 1.A Fuel combustion and for 0.02% 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.

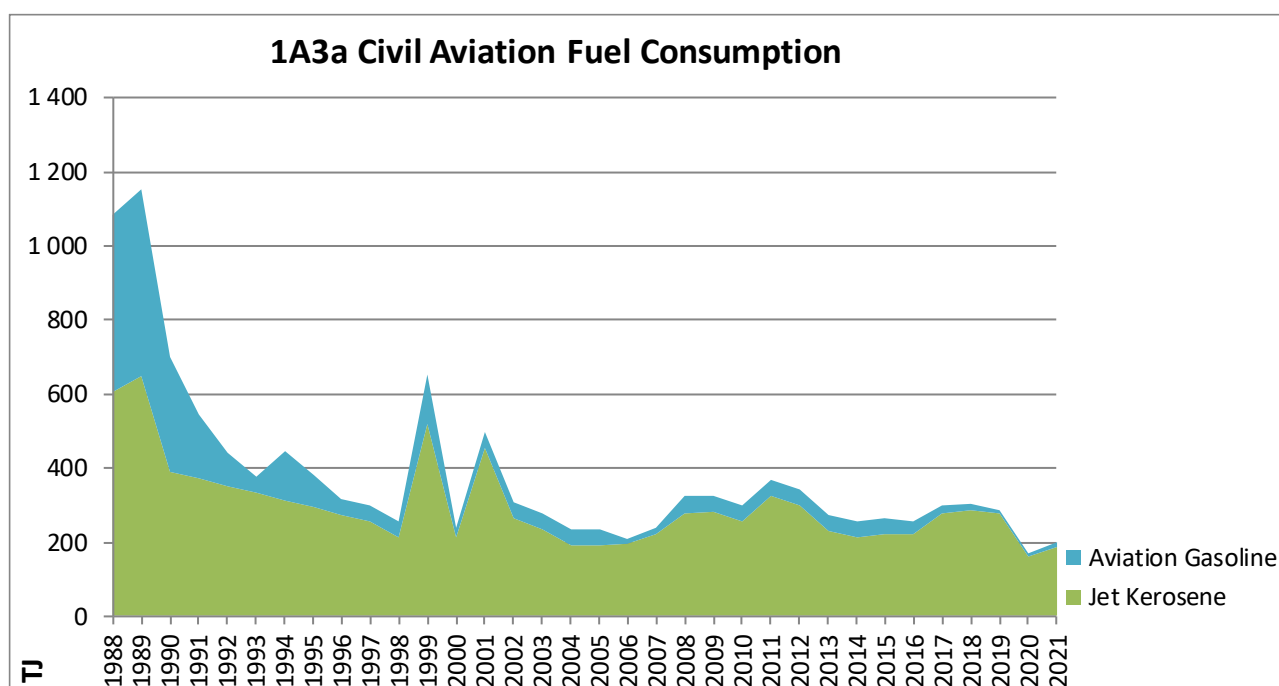


Figure 38 GHG emission in CRF 1.A.3.a Civil aviation – domestic (1988 - 2021)

Table 78 Fuel consumption and emissions from Civil aviation - all fuels

Year	TJ	CO ₂ [Gg]	CH ₄ [Gg]	N ₂ O [Gg]	Total GHG [Gg CO ₂ e]
1988	1 082.52	76.35	0.00	0.00	77.01
1990	700.00	49.37	0.00	0.00	49.80
1995	381.62	27.09	0.00	0.00	27.32
2000	239.08	17.28	0.00	0.00	17.48
2005	235.23	16.88	0.00	0.00	17.07
2010	301.02	21.64	0.00	0.00	21.88
2011	367.19	26.40	0.00	0.00	26.69
2012	341.97	24.57	0.00	0.00	24.84
2013	272.50	19.56	0.00	0.00	19.75
2014	258.02	18.52	0.00	0.00	18.70
2015	264.37	18.97	0.00	0.00	19.16
2016	257.07	18.48	0.00	0.00	18.66
2017	299.26	21.56	0.00	0.00	21.78
2018	301.88	21.74	0.00	0.00	21.95
2019	286.72	20.68	0.00	0.00	20.89
2020	168.74	12.16	0.00	0.00	12.28
2021	199.08	12.16	0.00	0.00	12.30

Table 79 Fuel consumption and emissions from Civil aviation - jet kerosene

Year	TJ	CO ₂ [Gg]	CH ₄ [Gg]	N ₂ O [Gg]	Total GHG [Gg CO ₂ e]
1988	606.21	43.34	0.0003	0.0012	43.71
1990	392.00	28.03	0.0002	0.0008	28.27
1995	293.62	20.99	0.0001	0.0006	21.17
2000	211.89	15.40	0.0015	0.0005	15.58
2005	191.27	13.84	0.0009	0.0005	14.00
2010	257.02	18.59	0.0006	0.0007	18.80
2011	323.19	23.35	0.0009	0.0008	23.62
2012	297.97	21.52	0.0007	0.0008	21.76
2013	228.50	16.52	0.0004	0.0005	16.68
2014	214.02	15.47	0.0005	0.0005	15.62
2015	220.37	15.92	0.0004	0.0005	16.08
2016	222.97	16.12	0.0004	0.0005	16.28
2017	279.11	20.17	0.0004	0.0006	20.37
2018	284.94	20.57	0.0004	0.0006	20.77
2019	275.94	19.93	0.0005	0.0006	20.14
2020	162.06	11.69	0.0002	0.0004	11.81
2021	188.87	13.63	0.0003	0.0004	13.77

Table 80 Fuel consumption and emissions from Civil aviation – aviation gasoline

Year	TJ	CO ₂ [Gg]	CH ₄ [Gg]	N ₂ O [Gg]	Total GHG [Gg CO ₂ e]
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
2018	16.94	1.17	0.00001	0.0000	1.18
2019	10.78	0.75	0.00001	0.0000	0.75
2020	6.69	0.46	0.00000	0.0000	0.47
2021	10.21	0.71	0.00001	0.0000	0.71

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:

$$\text{LTO Emissions} = \text{Number of LTOs} \cdot \text{Emission Factor LTO}$$

$$\text{LTO Fuel Consumption} = \text{Number of LTOs} \cdot \text{Fuel Consumption per LTO}$$

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:

$$\text{Cruise Emissions} = (\text{Total Fuel Consumption} - \text{LTO Fuel Consumption}) \cdot \text{Emission Factor Cruise}$$

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:

$$\text{Total Emissions} = \text{LTO Emissions} + \text{Cruise Emissions}$$

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 1996-2021 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 81 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%.

There is a specific case with the activity data concerning the beginning of the timeseries (1988 to 1996, excluding 1990). For those years, the national energy balances do not provide a disaggregation between international and domestic aviation jet kerosene consumption. In order to ensure consistency for the timeseries, we have interpolated the domestic kerosene consumption between 1990 and 1997; and subtracted this consumption from international kerosene consumption.

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 CO₂: 5%

EF N₂O (for all fuel): -70% / +150%

EF CH₄ (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, CO₂ 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 2023 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 (CO₂), methane (CH₄) and nitrous oxide (N₂O), as well as several other pollutants.

Road transport is defined as a key category, as a result of the considerable amount of CO₂ emissions from the use of diesel, gasoline and LPG presented below.

A unique feature of the Bulgarian vehicle fleet is its age structure. In 2021 about 75.5% of the vehicles were above 15 years old, of which 48.6% are more than 20 years old. New vehicles (1 to 5 years) were 4.5% of the total and 6.8% were aged between 6 and 10 years.

The total number of registered vehicles in Bulgaria for the period 1988 – 2021 is presented in the following table.

Table 82 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
2018	2 773 401	475 045	19 232	112 387	80 813
2019	2 829 998	490 212	19 189	118 738	83 713
2020	2 866 763	500 757	18 050	124 311	85 503
2021	2 830 594	500 404	16 303	129 524	87 173

Road transport accounts for the largest share in total fuel consumption in the Transport subsector. In 2021 road transport was responsible 97.9% of the consumed energy in the sector.

3.3.12.3.2 Emission trend

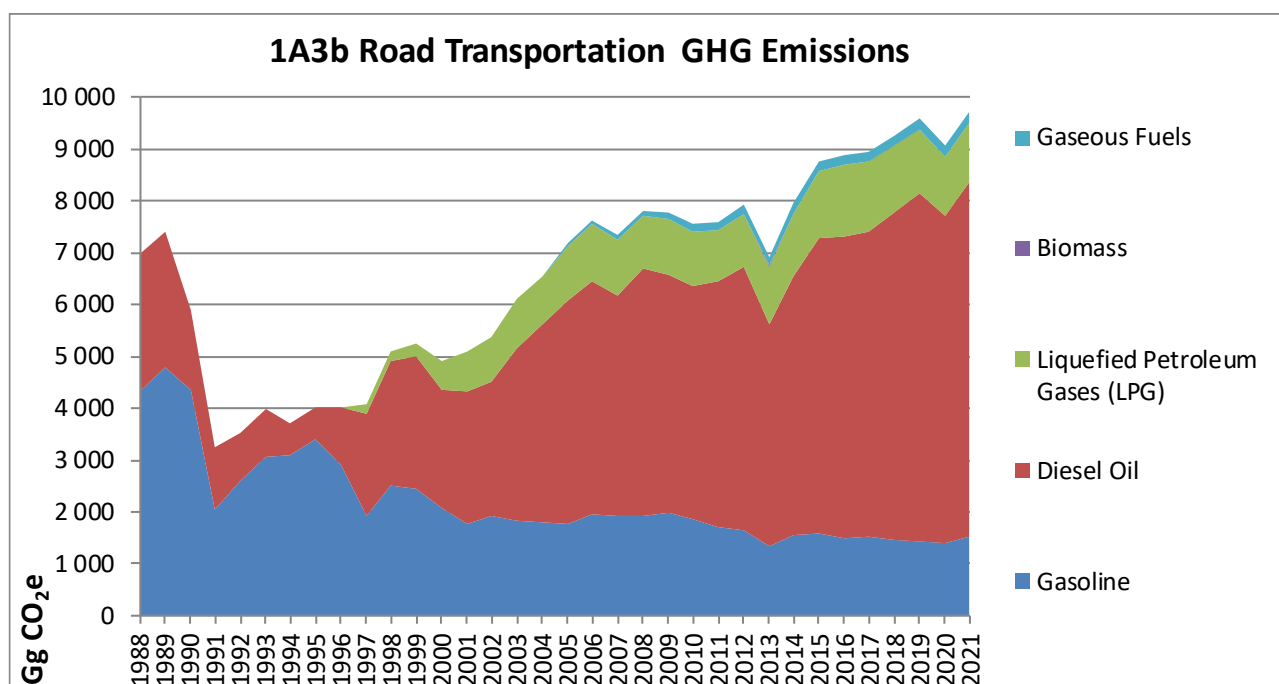


Figure 39 GHG emissions in CRF 1.A.3.b Road transport 1988 - 2021

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 CO₂, followed by CH₄ and N₂O. The CO₂ 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, CO₂ 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. In 2015 the fuel consumption increased significantly and since then it grows steadily.

Overall, the GHG emissions from road transport increased by 39.5% compared to the base year level of 6 988 Gg CO₂e and reached 9 749 Gg CO₂e in 2021.

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 2021 passenger cars accounted for 62.6%, light-duty vehicles were responsible for 16.4%, and heavy-duty vehicles (incl. buses) for 20.6% of road transport GHG CO₂e emissions; and the share of passenger cars was clearly increasing over the time series. The remaining 0.4% were shared among mopeds and motorcycles.

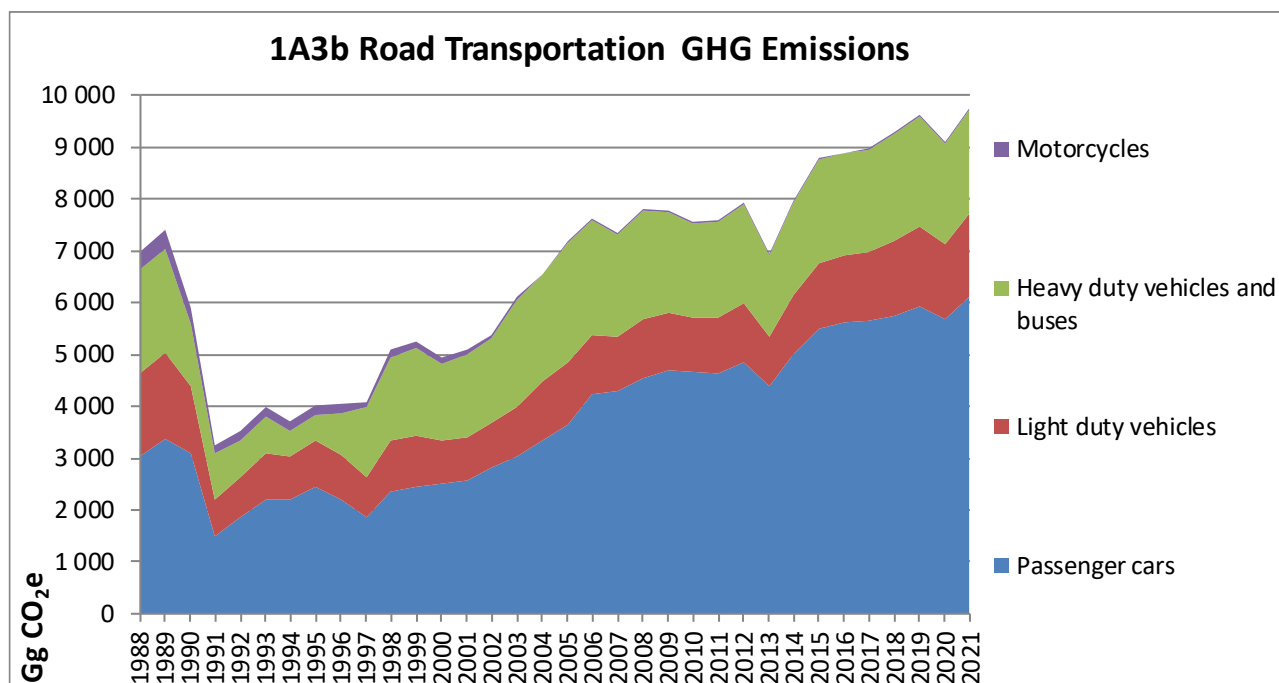


Figure 40 Emissions allocated to vehicle categories for the period 1988-2021

Whereas CO₂ emissions were closely linked to fuel consumption, CH₄ and N₂O 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, N₂O 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, for N₂O emissions there is an upward trend mostly due to the increase of diesel vehicles share.

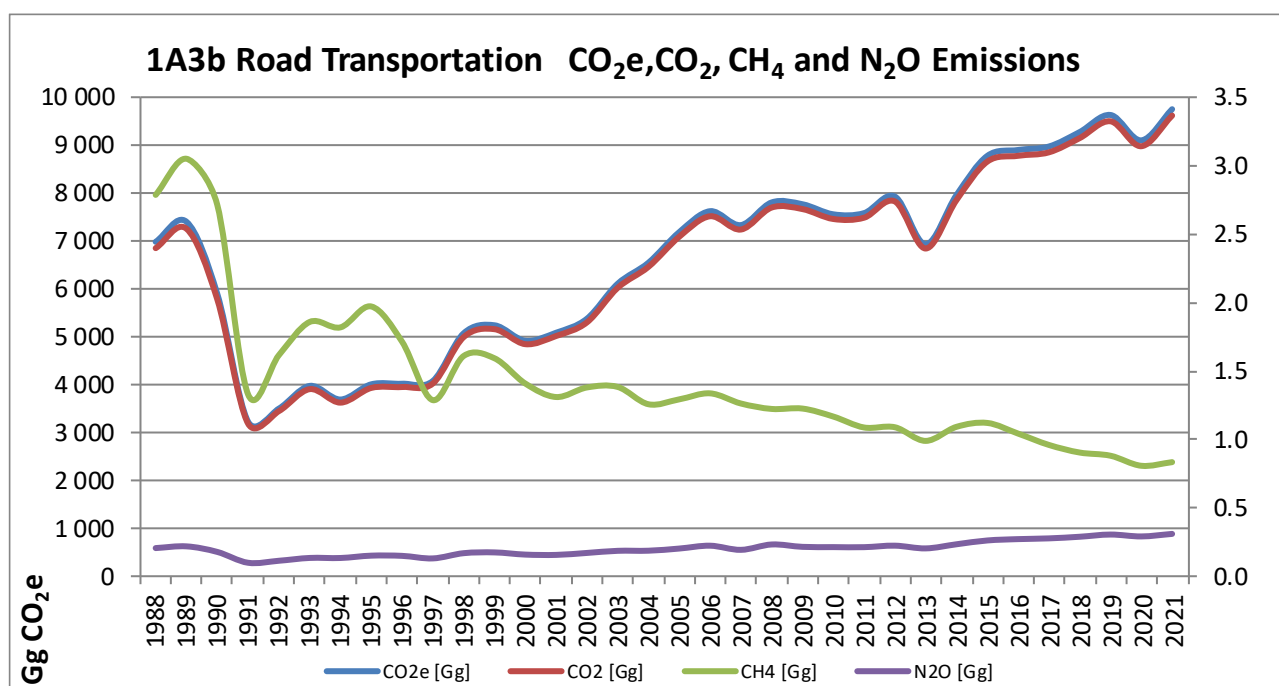


Figure 41 CO₂, CO₂e, CH₄ and N₂O emissions trends for the period 1988-2021

CH₄ 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 CH₄ emissions and results in decreased levels of methane.

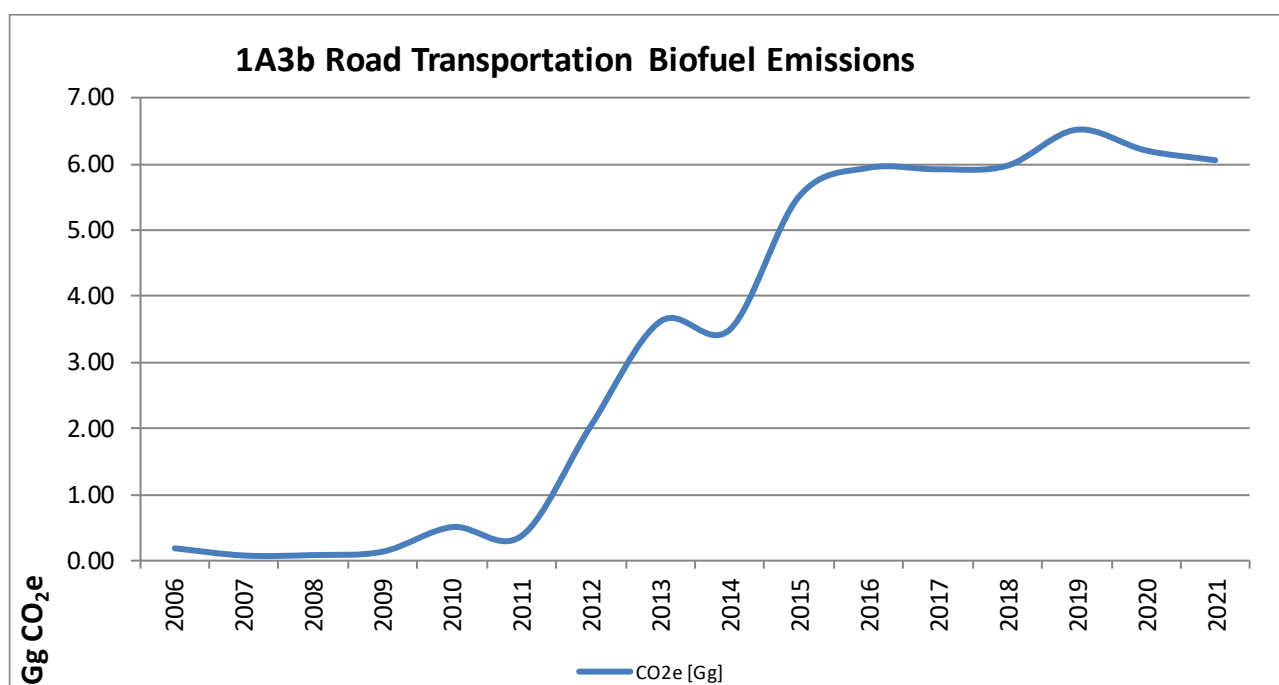


Figure 42 Emissions by biofuels from Road Transport for the period 2006-2020

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. Starting from the 2020 submission biofuel consumption is corrected in order to account for fossil carbon content in biodiesel resulting from methanol use.

3.3.12.3.3 Methods

CO₂ emissions are best calculated based on the amount and type of fuel combusted and its carbon content. The emissions of CH₄ and N₂O 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 CO₂. 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, 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.

For the 2023 submission, the latest COPERT 5.6.1 version was used.

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), CO₂ emissions are calculated based on total fuels sold in the country. The total amount of fuels sold is compared to the amount of fuel 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.

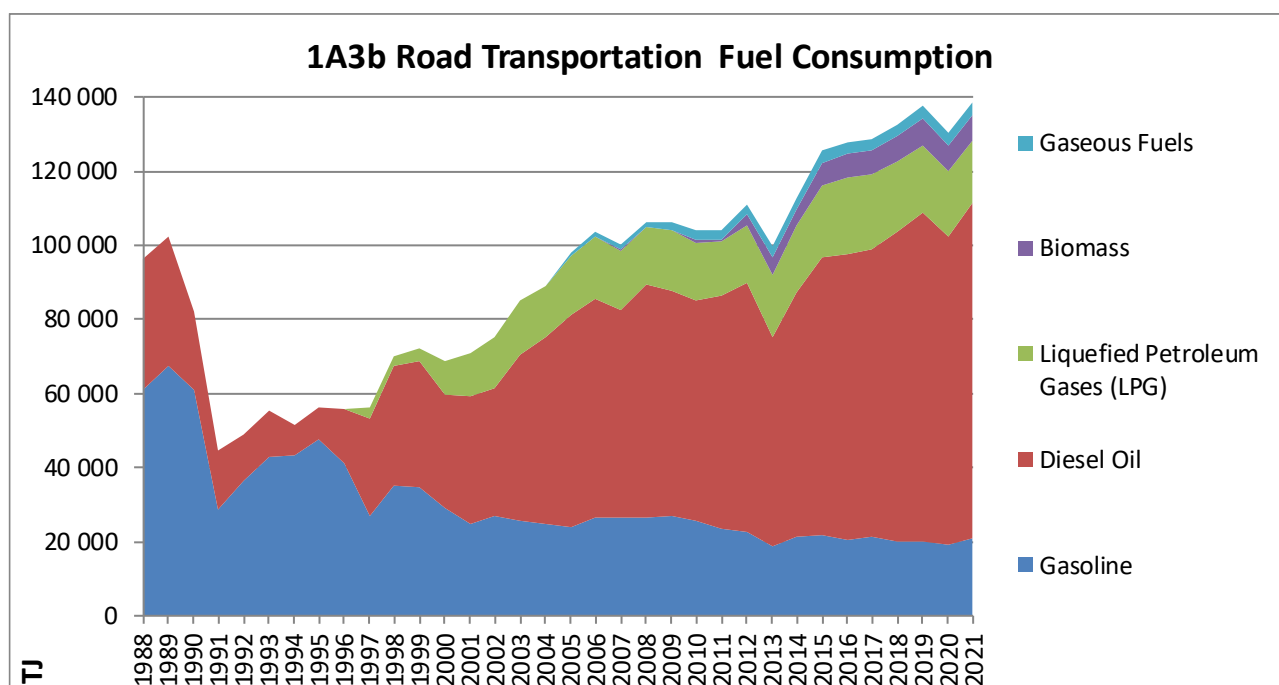


Figure 43 Fuel consumption in CRF 1.A.3.b Road transport (1988 - 2021)

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

Starting from COPERT v. 5.6.1, the average trip length should be provided separately for passenger cars, light commercial vehicles, heavy duty trucks, buses and L-category vehicles. As it was not feasible to calculate national values for these parameters, the COPERT default values were used (12 km for PC and L-category and 44 km for HDV and busses). Time trip duration is estimated at 0.25 and 0.85 hours respectively. Since previously we were applying a value, estimated based on the maps of largest Bulgarian cities, the change of this parameter has led to recalculation of some of the emissions for the entire timeseries.

Minimum and maximum temperatures

Complete, country-specific data on monthly average minimum and maximum temperatures for the whole period of 1988 to 2021 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 2005-2021 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 2006-2021 (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 (Mott MacDonald 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 (Mott MacDonald 2009). These numbers vary back in the years as demonstrated by Breshkov, 2005.

Table 83 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 84 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 km² compared to Austria - 19 km/1000 km² in Slovenia - 14 km/1000 km², and in Lithuania - 6 km/1000 km² (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 – 2021. 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 2005-2021. 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 – 2021 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-stroke 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 CO₂ emissions are calculated on the basis of fuel consumption (Ntziachristos et al., 2008) and that CO₂ 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 CO₂ 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:

$$IEF = \text{Emissions} / \text{Activity data}$$

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 CH₄ 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 85 Implied emission factors of CO₂, N₂O and CH₄ by fuel types

Fuel type	Gasoline			Diesel		
Emissions	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Year	t/TJ	kg/TJ	kg/TJ	t/TJ	kg/TJ	kg/TJ
1988	69.30	41.48	2.16	74.10	7.52	2.10
1990	69.30	41.84	2.21	74.10	7.59	2.01
1995	69.30	40.05	2.83	74.10	7.69	1.66
2000	69.30	34.92	3.57	74.10	7.19	1.38
2005	71.60	25.70	3.81	74.93	6.11	1.31
2010	71.73	20.40	2.68	74.93	4.37	1.58
2011	71.62	19.53	2.61	74.93	4.14	1.64
2012	71.53	18.94	2.50	74.93	3.91	1.68
2013	71.48	18.22	2.37	74.93	3.67	1.74
2014	71.63	17.71	2.31	74.93	3.45	1.83
2015	71.62	16.59	2.15	74.93	3.20	1.92
2016	71.64	15.50	1.98	74.93	2.86	2.04
2017	71.72	14.47	1.77	74.93	2.45	2.19
2018	71.75	13.66	1.65	74.93	2.21	2.27
2019	71.74	12.98	1.56	74.93	2.01	2.36
2020	71.77	12.64	1.51	74.93	1.87	2.41
2021	71.82	12.73	1.52	74.93	1.83	2.41

Table 86 Implied emission factors of CO₂, N₂O and CH₄ by fuel types

Fuel type	LPG			CNG		
Emissions	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
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	19.43	1.27	NO	NO	NO

Fuel type	LPG			CNG		
Emissions	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Year	t/TJ	kg/TJ		t/TJ	kg/TJ	
2005	65.73	17.99	2.23	56.71	50.30	0.57
2010	65.73	16.45	3.07	56.04	44.81	0.57
2011	65.73	16.09	3.13	56.03	49.65	0.54
2012	65.73	15.63	3.04	55.96	51.56	0.52
2013	65.73	15.21	2.95	56.08	53.78	0.51
2014	65.73	14.88	2.95	56.14	56.47	0.49
2015	65.73	14.40	2.87	56.20	57.09	0.47
2016	65.73	13.80	2.79	56.04	53.00	0.48
2017	65.73	13.05	2.64	56.03	50.43	0.47
2018	65.73	12.65	2.58	56.05	49.34	0.46
2019	65.73	12.32	2.54	56.08	47.99	0.45
2020	65.73	12.08	2.49	56.00	44.62	0.45
2021	65.73	12.02	2.54	55.94	43.11	0.46

A new approach was adopted as a result of the ERT recommendation (FCCC/ARR/2014/BGR) to conduct a Tier 2 estimate of CO₂ 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 CO₂ 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 CO₂ emission factors to be adjusted to take account of un-oxidized carbon or carbon emitted as a non-CO₂ 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 Lukoil 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):

AD	+/- %		EF CO ₂	EF N ₂ O	EF CH ₄
		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 (Kioutsoukisa et al., 2010):

Parameter	Uncertainty for countries with poor transport statistics (%)
Fuel consumption and CO ₂	<10
CH ₄	>20
N ₂ O	>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, CO₂ 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 CH₄ 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.

Additionally, following a recommendation from the ERT from the 2016 review cycle, CO₂ 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 2004-2021 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 2021 submission an updated version of the COPERT 5.3 model was introduced, which corrects some errors, including in the algorithm for performing an energy balance and introduces new emission factors. As usual, a complete recalculation of the entire time-series was performed with the updated software.

A methodological change was introduced in the 2020 submission related to emissions from biofuels. Following conversations with Ministry of Environment, National Statistics and producers of biofuels were assessed the types of biofuels, which are imported and produced in Bulgaria. For biogasoline it was confirmed, that both production and imports are bioalcohols and there are no bioethers (MTBE, ETBE or TAE) used for blending, thus all 100% of the emissions related to biogasoline are assumed to be of biogenic origin. For biodiesel it was confirmed with producer that fossil-derived methanol is used in the production. As there was no information on the imports, it was assumed that 100% are also FAME. A default value of 5.4% was assumed for the carbon content of the fossil part (estimated by considering that FAME composition is 50% rapeseed / 30% sunflower / 20% palm oil), which led to recalculation of biodiesel emissions for the entire time series. The emissions from the fossil part of carbon content of FAME were reported under Other fossil fuels in respective subcategories.

For the 2021 submission an updated version of the COPERT 5.4 model was introduced, which corrects some errors, including in the algorithm for performing an energy balance and introduces new emission factors. Additionally, vehicle fleet matrix was expanded in order to include Euro 6d category. As usual, a complete recalculation of the entire time-series was performed with the updated software.

For the 2022 submission we transitioned to the latest version of COPERT (5.5.1), which included correction in the calculation of N₂O emissions for buses and other improvements. This led to significant decrease in N₂O estimates from diesel vehicles for the entire timeseries, compared to 2021 estimates, but still comparable to 2020 estimates. Additionally, for the 2022 submission reallocated the emissions from lubricants consumed in 2-stroke engines to the Energy sector, as they were previously reported under the IPPU sector.

For the 2023 submission was introduced an updated version of the COPERT model (5.6.1), which introduced some changes related to trip length and duration per vehicle category, but also fixed some errors in the software related to N₂O emission estimates. We have also changed the approach for allocation of energy consumption and emissions between fossil fuels and biofuels. Previously, the allocation was performed manually outside of COPERT based on the reported quantities of biofuels as a share of all reported fuels. Currently, the exact energy consumption and emission estimates calculated by COPERT separately for fossil fuels, biofuels (bioethanol and biodiesel, including ETBE and FAME) are reported. As a result of the QAQC procedures, a minor error in the previous submission related to NCVs for 1988, 1989 and 2020 was identified and corrected.

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 our 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 CO₂ emissions when country-specific CO₂ 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 0.1% 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, with the exception of 2020:

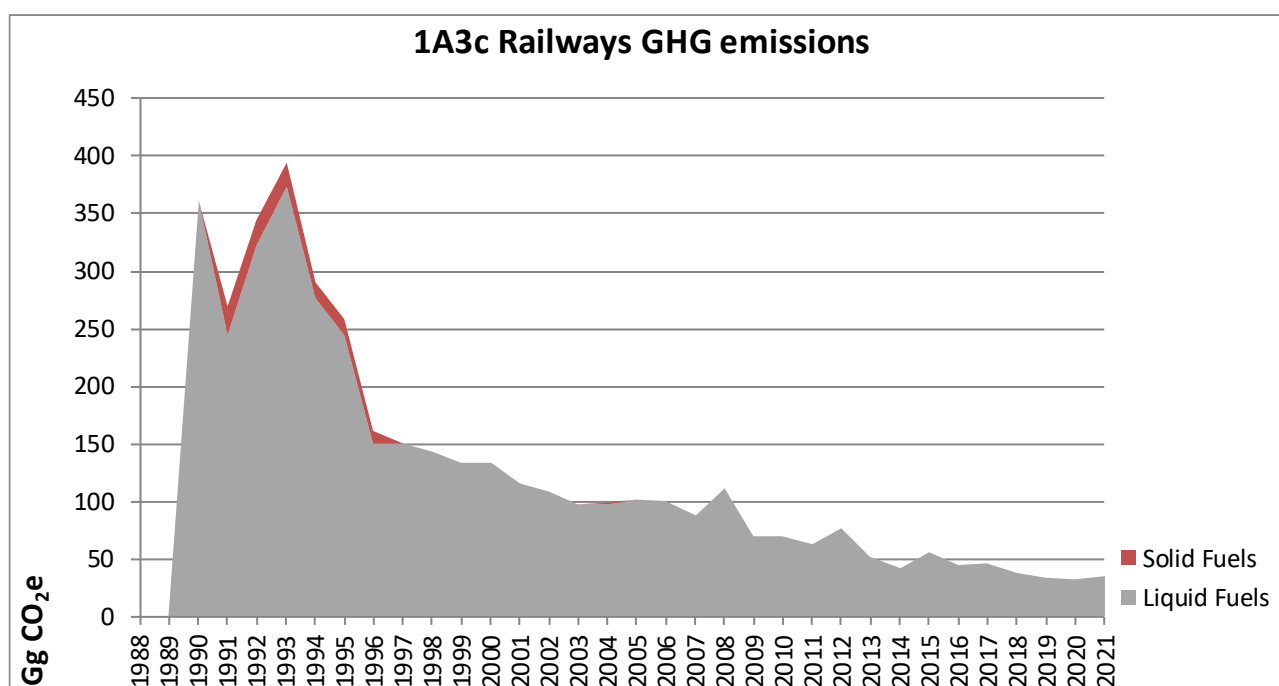


Figure 44 GHG emissions in CRF 1.A.3.c Railway transport (1988 - 2021)

As the figure above demonstrates, emissions from Railway transport in 2021 have plummeted by 90.2% 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:

$$\text{Emissions} = \sum (\text{Fuel}_j \cdot \text{EF}_j)$$

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.

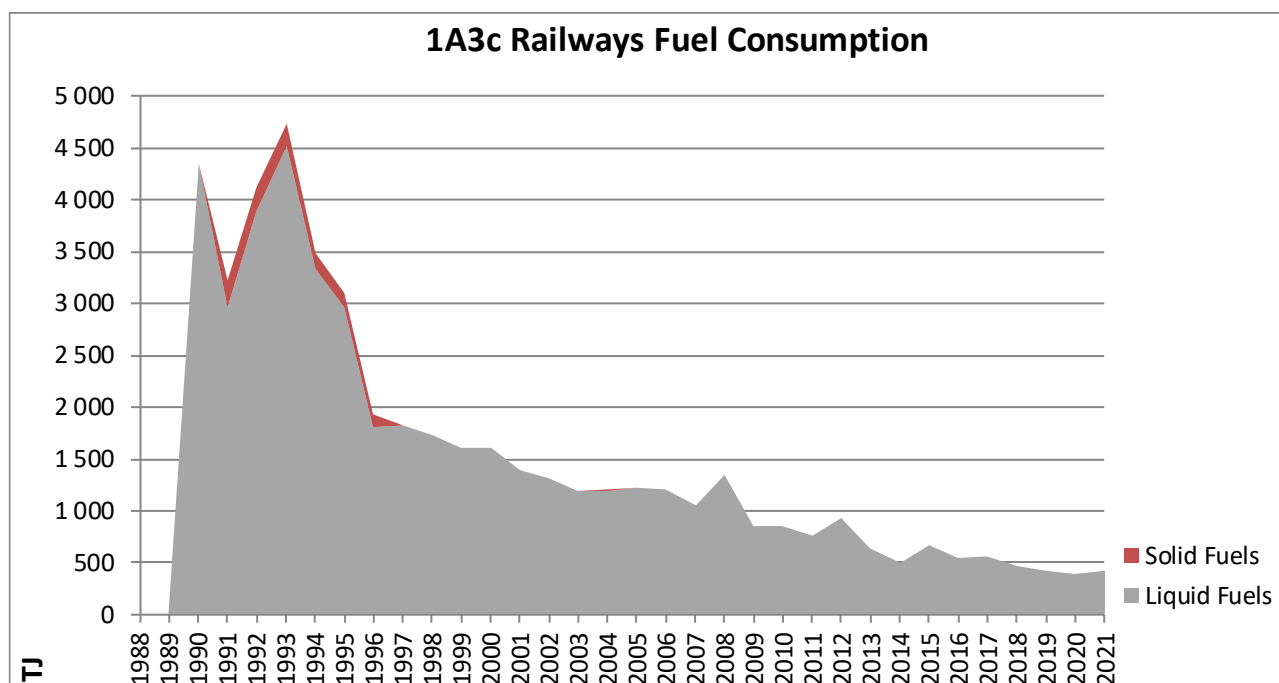


Figure 45 Fuel consumption in CRF 1.A.3.c Railway transport (1988 - 2021)

Table 87 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 ₂ O	N ₂ O emission	EF* CH ₄	CH ₄ emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	NO	NO	42.6	74.10	NO	0.0286	NO	0.00415	NO
1990	103.00	4 356.90	42.3	74.10	322.85	0.0286	0.125	0.00415	0.018
1995	69.00	2 918.70	42.3	74.10	216.28	0.0286	0.083	0.00415	0.012
2000	38.00	1 607.40	42.3	74.10	119.11	0.0286	0.046	0.00415	0.007
2005	29.00	1 226.70	42.3	74.10	90.90	0.0286	0.035	0.00415	0.005
2010	20.00	846.00	42.3	74.10	62.69	0.0286	0.024	0.00415	0.004
2011	18.00	761.40	42.3	74.10	56.42	0.0286	0.022	0.00415	0.003
2012	22.00	930.60	42.3	74.10	68.96	0.0286	0.027	0.00415	0.004
2013	15.00	630.39	42.0	74.10	46.71	0.0286	0.018	0.00415	0.003
2014	12.00	504.61	42.1	74.10	37.39	0.0286	0.014	0.00415	0.002
2015	16.00	672.56	42.0	74.10	49.84	0.0286	0.019	0.00415	0.003
2016	13.00	546.04	42.0	74.10	40.46	0.0286	0.016	0.00415	0.002
2017	13.41	562.99	42.0	74.10	41.72	0.0286	0.016	0.00415	0.002
2018	11.00	462.21	42.0	74.10	34.25	0.0286	0.0132	0.00415	0.002
2019	9.92	416.58	42.0	74.10	30.87	0.0286	0.0119	0.00415	0.002
2020	9.45	396.54	42.0	74.10	29.38	0.0286	0.0113	0.00415	0.002
2021	10.23	428.96	41.9	74.10	31.79	0.0286	0.0123	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 ₂ O	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, CO₂ 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 have been 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.

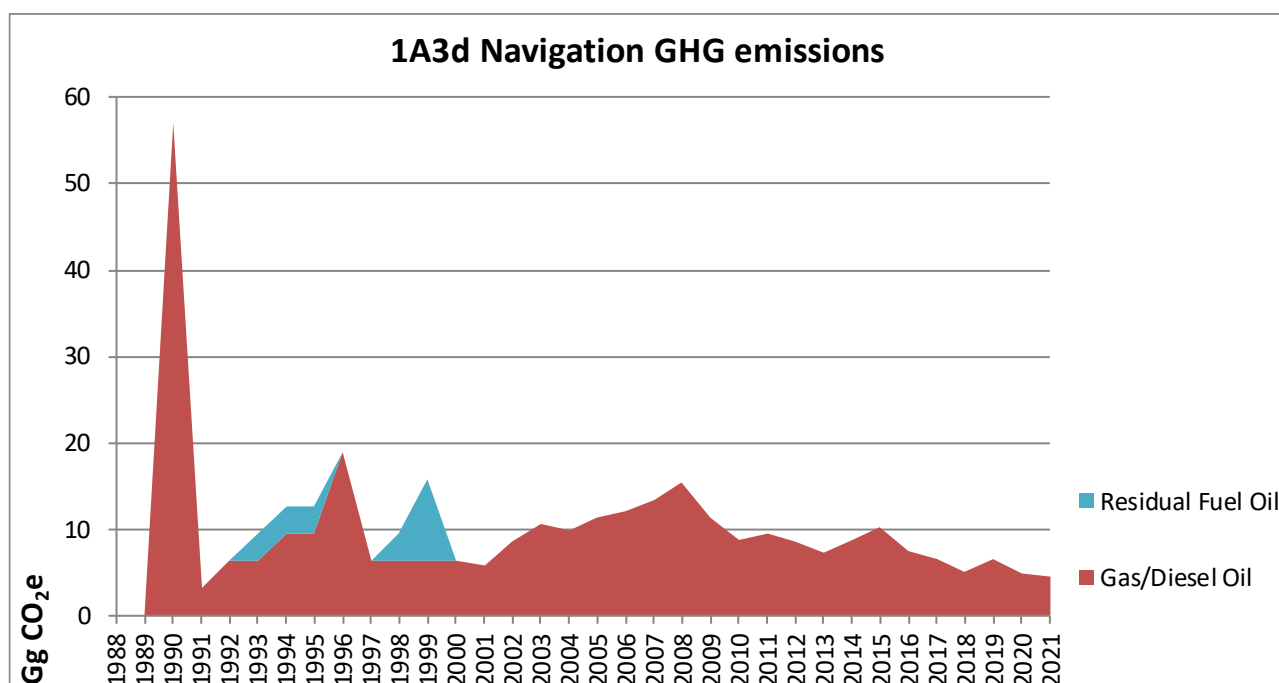


Figure 46 GHG emissions in CRF 1.A.3.d Navigation (1988 – 2021)

3.3.12.5.3 Methods

The 2006 IPCC Guidelines Tier 1 approach has been applied (Equation 3.5.1. Water-Borne Navigation Equation)

$$\text{Emissions} = \Sigma(\text{Fuel Consumed}_{ab} \cdot \text{Emission Factor}_{ab})$$

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 88 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

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
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
2018	0	850	850	205	174 250 000	0.00939	1636
2019	0	1070	1070	205	219 350 000	0.00939	2060
2020	0	810	810	205	166 050 000	0.00939	1559
2021	0	742	742	205	152 110 000	0.00939	1428

3.3.12.5 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 89 Activity data, emissions and emission factors for gas-diesel oil subcategory of 1A3d Navigation

	Gas-Diesel Oil			EF* CO ₂	CO ₂ emission	EF* N ₂ O	N ₂ O emission	EF* CH ₄	CH ₄ emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	NO	NO	42.60	74.10	NO	0.002	NO	0.007	NO
1990	18.00	761.40	42.30	74.10	56.4	0.002	0.0015	0.007	0.0053
1995	3.00	126.90	42.30	74.10	9.4	0.002	0.0003	0.007	0.0009
2000	2.00	84.60	42.30	74.10	6.3	0.002	0.0002	0.007	0.0006
2005	3.61	152.67	42.30	74.10	11.3	0.002	0.0003	0.007	0.0011
2010	2.76	116.76	42.30	74.10	8.7	0.002	0.0002	0.007	0.0008
2011	3.01	127.27	42.30	74.10	9.4	0.002	0.0003	0.007	0.0009
2012	2.71	114.57	42.30	74.10	8.5	0.002	0.0002	0.007	0.0008
2013	2.29	96.27	42.03	74.10	7.1	0.002	0.0002	0.007	0.0007
2014	2.75	115.83	42.05	74.10	8.6	0.002	0.0002	0.007	0.0008
2015	3.26	137.15	42.04	74.10	10.2	0.002	0.0003	0.007	0.0010
2016	2.35	98.80	42.00	74.10	7.3	0.002	0.0002	0.007	0.0007
2017	2.10	88.26	41.99	74.10	6.5	0.002	0.0002	0.007	0.0006
2018	1.64	68.73	42.01	74.10	5.1	0.002	0.0001	0.007	0.0005
2019	2.06	86.50	42.00	74.10	6.4	0.002	0.0002	0.007	0.0006
2020	1.56	65.44	41.97	74.10	4.8	0.002	0.0001	0.007	0.0005
2021	1.43	59.87	41.92	74.10	4.4	0.002	0.0001	0.007	0.0004

Table 90 Activity data, emissions and emission factors for residual fuel oil subcategory of 1A3d Navigation

	Residual Fuel Oil			EF* CO ₂	CO ₂ emission	EF* N ₂ O	N ₂ O emission	EF* CH ₄	CH ₄ emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
1990	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
1995	1.00	40.00	40	77.40	3.1	0.002	0.0001	0.007	0.0003
2000	NO	NO	40	77.40	NO	0.002	NO	0.007	NO

	Residual Fuel Oil			EF* CO ₂	CO ₂ emission	EF* N ₂ O	N ₂ O emission	EF* CH ₄	CH ₄ emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
2005	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2010	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2011	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2012	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2013	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2014	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2015	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2016	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2017	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2018	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2019	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2020	NO	NO	40	77.40	NO	0.002	NO	0.007	NO
2021	NO	NO	40	77.40	NO	0.002	NO	0.007	NO

* For N₂O and CH₄ 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 ₂ O	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, CO₂ 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 2021, 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 91 Activity data, emissions and emission factors for gas-diesel oil

	Gas-Diesel Oil			EF CO ₂	CO ₂ emission	EF N ₂ O	N ₂ O emission	EF CH ₄	CH ₄ emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	NO	NO	42.60	74.10	NO	0.0286	NO	0.00415	NO
1990	42.00	1 776.60	42.30	74.10	131.65	0.0286	0.051	0.00415	0.0074
1995	NO	NO	42.30	74.10	NO	0.0286	NO	0.00415	NO
2000	NO	NO	42.30	74.10	NO	0.0286	NO	0.00415	NO
2005	NO	NO	42.30	74.10	NO	0.0286	NO	0.00415	NO
2010	NO	NO	42.30	74.10	NO	0.0286	NO	0.00415	NO
2011	NO	NO	42.30	74.10	NO	0.0286	NO	0.00415	NO
2012	NO	NO	42.30	74.10	NO	0.0286	NO	0.00415	NO
2013	NO	NO	42.03	74.10	NO	0.0286	NO	0.00415	NO
2014	NO	NO	42.05	74.10	NO	0.0286	NO	0.00415	NO
2015	NO	NO	42.04	74.10	NO	0.0286	NO	0.00415	NO
2016	NO	NO	42.00	74.10	NO	0.0286	NO	0.00415	NO
2017	NO	NO	41.99	74.10	NO	0.0286	NO	0.00415	NO
2018	NO	NO	42.01	74.10	NO	0.0286	NO	0.00415	NO
2019	NO	NO	42.00	74.10	NO	0.0286	NO	0.00415	NO
2020	NO	NO	41.97	74.10	NO	0.0286	NO	0.00415	NO
2021	NO	NO	41.92	74.10	NO	0.0286	NO	0.00415	NO

Table 92 Activity data, emissions and emission factors for residual fuel oil

	Residual fuel oil			EF CO ₂	CO ₂ emission	EF N ₂ O	N ₂ O emission	EF CH ₄	CH ₄ emission
	Gg	TJ	NCV GJ/t	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
1988	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
1990	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
1995	1.00	40.00	40.00	77.40	3.1	0.002	0.0001	0.007	0.0003
2000	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2005	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2010	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2011	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2012	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2013	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2014	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2015	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2016	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2017	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2018	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2019	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2020	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO
2021	NO	NO	40.00	77.40	NO	0.002	NO	0.007	NO

Table 93 Activity data, emissions and emission factors for natural gas

	Natural gas	EF CO ₂	CO ₂ emission	EF N ₂ O	N ₂ O 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
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

	Natural gas	EF CO ₂	CO ₂ emission	EF N ₂ O	N ₂ O emission	EF CH ₄	CH ₄ emission
	TJ	t/TJ	Gg	kg/TJ	Gg	kg/TJ	Gg
2018	5751.0	55.54	319.4	0.10	0.001	1.0	0.006
2019	2268.6	55.56	126.1	0.10	0.000	1.0	0.002
2020	1478.0	55.51	82.0	0.10	0.000	1.0	0.001
2021	2263.7	55.48	125.6	0.10	0.000	1.0	0.002

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 ₂ O	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, CO₂ 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);

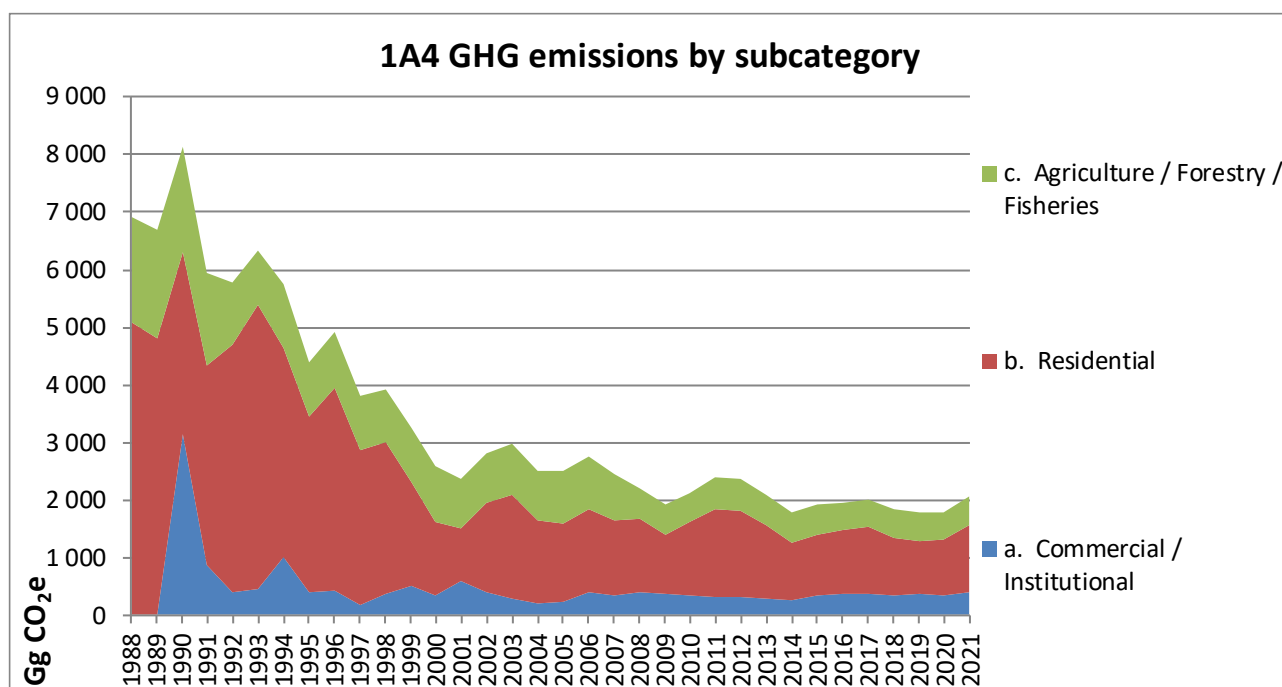


Figure 47 Total GHG emissions from 1.A.4 Other Sectors

The general trend in CRF category 1.A.4 is a decrease of 70.1% compared to base year and an increase of 15.9% 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.

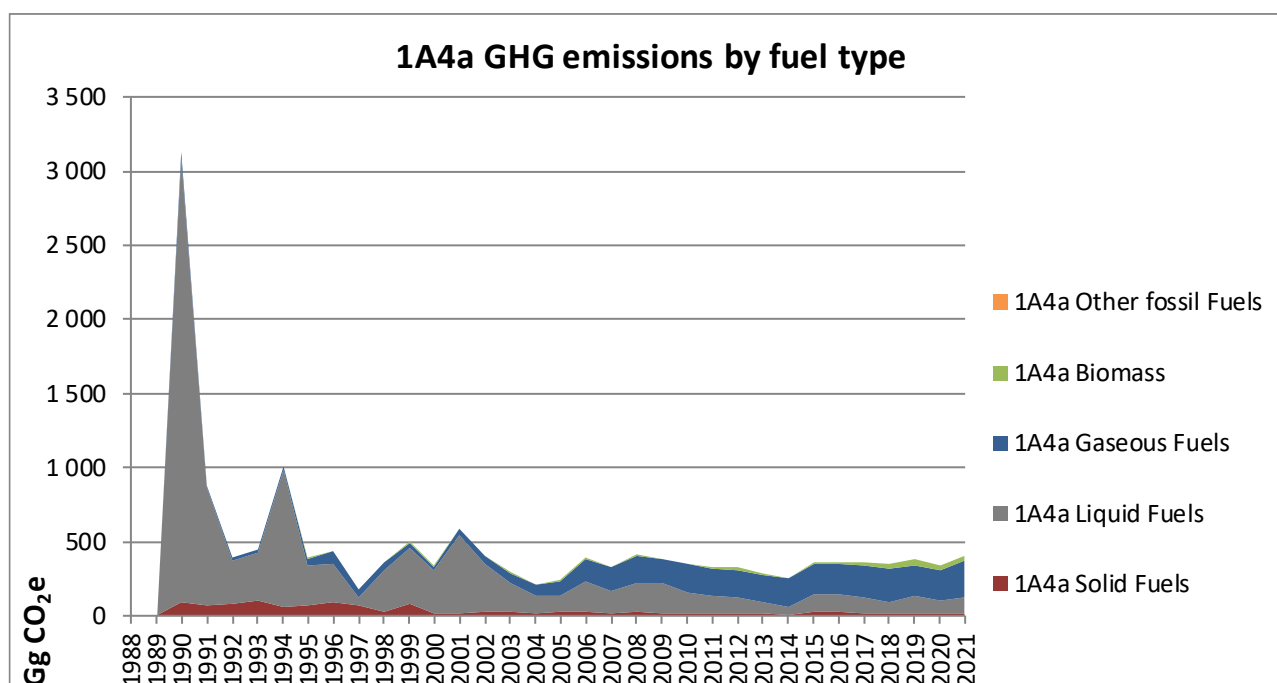


Figure 48 GHG emissions from CRF 1.A.4.a. Commercial/Institutional

The share of this subcategory from sector 1.A is 1.2% for 2021, whereas the share of the total GHG emissions is 0.8%.

For the years before 1990 no consumption is reported in this subcategory. Instead, it is reported under category 1.A.5.

Table 94 CO₂ 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	379.98	262.45	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
2018	314.17	76.57	10.21	227.40	466.9339	NO
2019	338.85	115.25	15.07	208.53	534.9191	NO
2020	303.13	93.64	12.16	197.33	411.3882	NO
2021	364.58	110.02	9.60	244.96	557.7113	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	88.3%	96.3%	89.3%	-482.8%	-	-
Decrease 2020-2021	-20.3%	-17.5%	21.1%	-24.1%	-35.6%	-

Table 95 CH₄ 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	0.3832	0.0350	0.0073	0.0042	0.3366	NO

CH ₄ (Gg)	CRF 1.A.4.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	1.2397	0.0088	0.0011	0.0205	1.2094	NO
2019	1.4357	0.0141	0.0016	0.0188	1.4012	NO
2020	1.0925	0.0114	0.0014	0.0178	1.0619	NO
2021	1.4931	0.0134	0.0011	0.0221	1.4566	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	-263.8%	96.6%	88.0%	-479.9%	-	-
Decrease 2020-2021	-36.7%	-17.5%	22.8%	-24.2%	-37.2%	-

Table 96 N₂O emissions in CRF 1.A.4.a. Commercial/Institutional

N ₂ O (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
2018	0.0168	0.0004	0.0002	0.0004	0.0158	NO
2019	0.0198	0.0008	0.0002	0.0004	0.0184	NO
2020	0.0151	0.0006	0.0002	0.0004	0.0139	NO
2021	0.0204	0.0007	0.0002	0.0004	0.0191	NO
Decrease 1988-2021	-	-	-	-	-	-
Decrease 1990-2021	19.1%	97.0%	88.0%	-479.9%	-	-
Decrease 2020-2021	-35.6%	-17.2%	22.8%	-24.2%	-37.6%	-

Table 97 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	6 199.60	391.87	263.95	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

GHG (Gg)	TJ	CRF 1.A.4.a.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	9 547.41	350.19	76.92	10.28	228.03	34.9544	NO
2019	10 376.18	380.64	115.83	15.19	209.11	40.5188	NO
2020	8 776.53	334.93	94.11	12.25	197.88	30.6868	NO
2021	11 129.43	407.99	110.57	9.67	245.64	42.1092	NO
Decrease 1988-2021	-	-	-	-	-	-	-
Decrease 1990-2021	73.2%	87.0%	96.3%	89.2%	-482.8%	-	-
Decrease 2020-2021	-26.8%	-21.8%	-17.5%	21.1%	-24.1%	-37.2%	-

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.

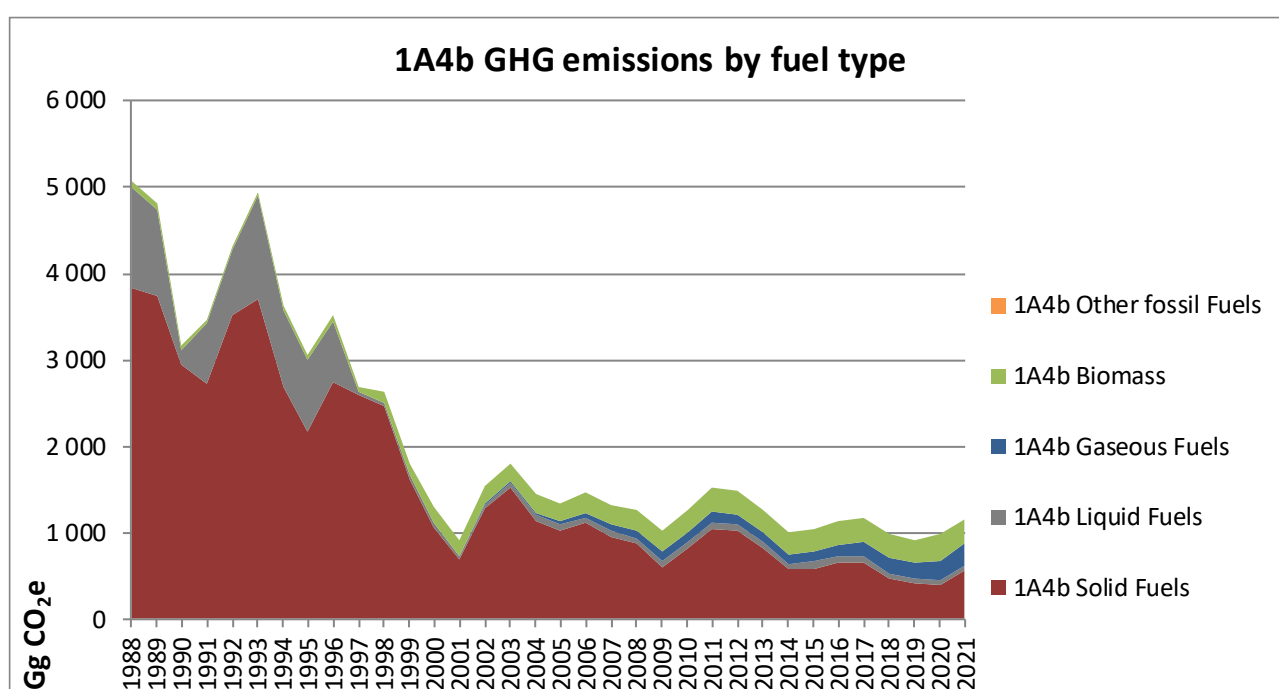


Figure 49 GHG emissions from CRF 1.A.4.b. Residential

The share of this subcategory from sector 1.A is 3.0% for 2021, whereas the share of total GHG emissions is 2.1%. The emissions from this category decreased by 77.2% 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. Liquid fuels previously used for heating were partially substituted with 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 2021 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 smaller extent.

Table 98 CO₂ 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

CO ₂ (Gg)	CRF 1.A.4.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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	1 047.81	61.15	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
2018	674.11	58.46	435.95	179.70	3 463.8040	NO
2019	622.68	52.37	387.07	183.24	3 331.9829	NO
2020	642.97	56.28	363.42	223.27	3 975.2795	NO
2021	837.52	55.80	518.27	263.45	3 521.0980	NO
Decrease 1988-2021	82.2%	95.2%	85.4%	-	-295.9%	-
Decrease 1990-2021	71.0%	64.6%	81.0%	-	-335.4%	-
Decrease 2020-2021	-30.3%	0.9%	-42.6%	-18.0%	11.4%	-

Table 99 CH₄ 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	10.4837	0.0050	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
2018	10.7394	0.0047	1.4405	0.0162	9.2780	NO
2019	10.2306	0.0042	1.2850	0.0165	8.9250	NO
2020	11.9214	0.0047	1.2485	0.0201	10.6481	NO
2021	11.1972	0.0045	1.7374	0.0237	9.4315	NO
Decrease 1988-2021	15.7%	96.6%	83.9%	-	-295.9%	-
Decrease 1990-2021	-6.9%	66.4%	79.1%	-	-335.4%	-
Decrease 2020-2021	6.1%	3.2%	-39.2%	-18.1%	11.4%	-

Table 100 N₂O emissions in CRF 1.A.4.b. Residential

N ₂ O (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

N ₂ O (Gg)	CRF 1.A.4.b.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	0.1313	0.0001	0.0072	0.0003	0.1237	NO
2019	0.1258	0.0001	0.0064	0.0003	0.1190	NO
2020	0.1487	0.0001	0.0062	0.0004	0.1420	NO
2021	0.1350	0.0001	0.0087	0.0005	0.1258	NO
Decrease 1988-2021	-46.6%	98.5%	83.9%	-	-295.9%	-
Decrease 1990-2021	-90.9%	72.4%	79.1%	-	-335.4%	-
Decrease 2020-2021	9.2%	12.5%	-39.2%	-18.1%	11.4%	-

Table 101 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	36 470.41	1 344.27	61.31	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
2018	39 889.81	981.73	58.61	474.11	180.20	268.8159	NO
2019	38 158.63	915.95	52.50	421.11	183.75	258.5857	NO
2020	44 561.29	985.32	56.43	396.49	223.89	308.5101	NO
2021	42 859.62	1 157.68	55.95	564.29	264.18	273.2624	NO
Decrease 1988-2021	29.8%	77.2%	95.2%	85.3%	-	-295.9%	-
Decrease 1990-2021	-14.8%	63.5%	64.6%	80.9%	-	-335.4%	-
Decrease 2020-2021	3.8%	-17.5%	0.9%	-42.3%	-18.0%	11.4%	-

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.

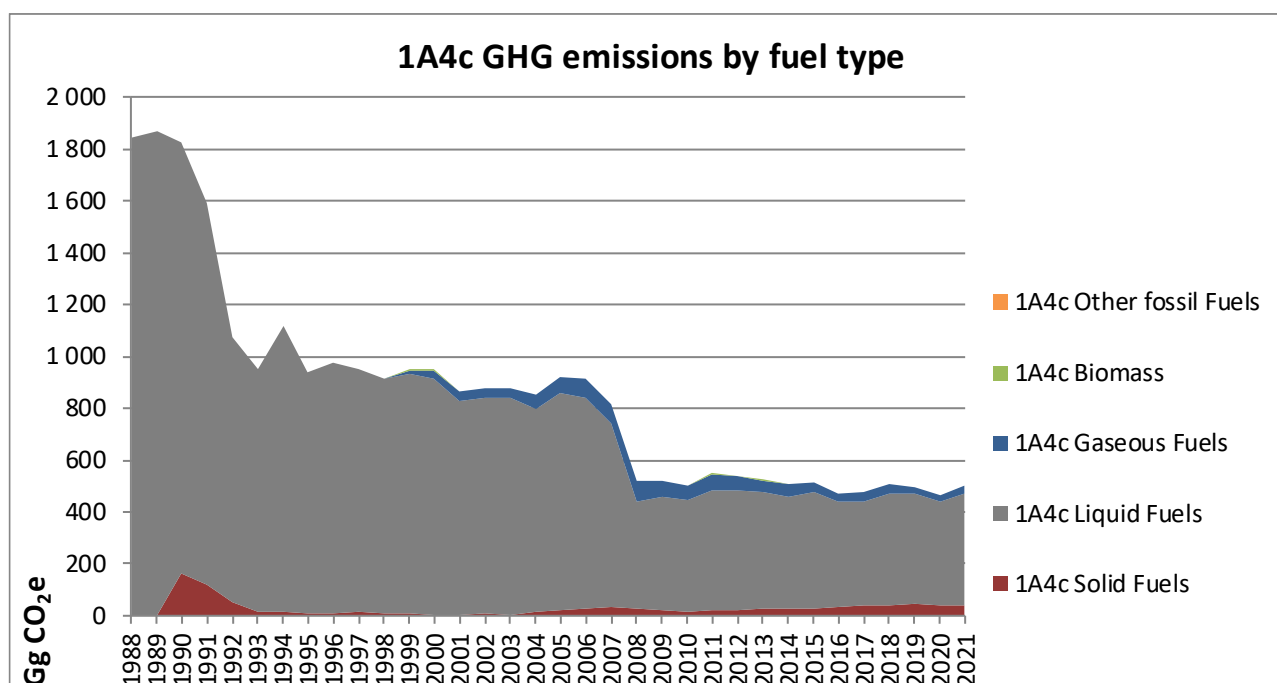


Figure 50 GHG emissions from CRF 1.A.4.c. Agriculture/Forestry/Fisheries

The share of this subcategory from sector 1.A is 1.3% for 2021, whereas the share of total GHG emissions is 0.9%.

Table 102 CO₂ 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	839.84	759.36	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
2018	457.25	387.45	36.52	33.29	20.1370	NO
2019	445.52	383.05	39.35	23.12	19.7729	NO
2020	420.45	358.89	36.02	25.53	20.0372	NO
2021	454.60	388.77	36.81	29.02	30.7705	NO
Decrease 1988-2021	72.6%	76.5%	-	-	-	-
Decrease 1990-2021	72.4%	74.1%	75.6%	-14504.2%	-	-
Decrease 2020-2021	-8.1%	-8.3%	-2.2%	-13.7%	-53.6%	-

Table 103 CH₄ 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
2000	0.2513	0.0537	0.0117	0.0027	0.1833	NO

CH ₄ (Gg)	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
2005	0.1798	0.0485	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
2018	0.1851	0.0219	0.1134	0.0030	0.0469	NO
2019	0.1952	0.0216	0.1257	0.0021	0.0459	NO
2020	0.1791	0.0202	0.1189	0.0023	0.0377	NO
2021	0.1842	0.0219	0.1200	0.0026	0.0397	NO
Decrease 1988-2021	-86.7%	77.8%	-	-	-	-
Decrease 1990-2021	66.5%	75.6%	73.9%	-14432.6%	-	-
Decrease 2020-2021	-2.8%	-8.2%	-0.9%	-13.7%	-5.3%	-

Table 104 N₂O emissions in CRF 1.A.4.c. Agriculture/Forestry/Fisheries

N ₂ O (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
2018	0.1478	0.1465	0.0006	0.0001	0.0006	NO
2019	0.1467	0.1454	0.0006	0.0000	0.0006	NO
2020	0.1376	0.1365	0.0006	0.0000	0.0005	NO
2021	0.1493	0.1481	0.0006	0.0001	0.0005	NO
Decrease 1988-2021	75.6%	75.8%	-	-	-	-
Decrease 1990-2021	73.0%	73.1%	73.9%	-14432.6%	-	-
Decrease 2020-2021	-8.4%	-8.5%	-0.9%	-13.7%	-6.5%	-

Table 105 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	11 763.22	922.33	838.19	20.68	61.53	1.9296	NO
2010	6 540.96	502.85	427.47	17.33	56.84	1.2169	NO
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

GHG (Gg)	TJ	CRF 1.A.4.c.	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels
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
2018	6 429.00	505.91	431.65	39.52	33.38	1.3587	NO
2019	6 221.16	494.11	426.91	42.67	23.19	1.3304	NO
2020	5 948.13	465.94	400.07	39.17	25.60	1.0937	NO
2021	6 610.95	503.68	433.44	39.98	29.10	1.1530	NO
Decrease 1988-2021	70.4%	72.7%	76.5%	-	-	-	-
Decrease 1990-2021	69.6%	72.4%	74.0%	75.5%	-14504.0%	-	-
Decrease 2020-2021	-11.1%	-8.1%	-8.3%	-2.1%	-13.7%	-5.4%	-

3.3.14 OTHER (CRF 1.A.5)

CRF category 1.A.5 Other includes stationary and mobile emissions sources not included elsewhere. The energy balance reports data under category 'Not elsewhere specified (other)' only for 1988 and 1989, which is mostly natural gas. Table 106 presents the reported emissions from other stationary sources (CRF category 1.A.5.a).

Table 106 GHG emissions in CRF 1.A.5.a. Other Stationary

GHG (Gg)	TJ	CO ₂	CH ₄	N ₂ O
1988	75 318.93	5 093.82	0.1926	0.0329
1990	NO	NO	NO	NO
1995	NO	NO	NO	NO
2000	NO	NO	NO	NO
2005	NO	NO	NO	NO
2010	NO	NO	NO	NO
2011	NO	NO	NO	NO
2012	NO	NO	NO	NO
2013	NO	NO	NO	NO
2014	NO	NO	NO	NO
2015	NO	NO	NO	NO
2016	NO	NO	NO	NO
2017	NO	NO	NO	NO
2018	NO	NO	NO	NO
2019	NO	NO	NO	NO
2020	NO	NO	NO	NO
2021	NO	NO	NO	NO
Decrease 1988-2021	-	-	-	-
Decrease 1990-2021	-	-	-	-
Decrease 2020-2021	-	-	-	-

Starting from the 2021 submission, emissions from military aviation were reallocated from CRF subcategory 1.A.3.a Civil Aviation to 1.A.5.b Other mobile. As the precise quantities of fuel consumed for military aviation is confidential data, it has been calculated as the difference between the total domestic consumption of jet kerosene and the jet kerosene consumed for domestic aviation based on data provided by Eurocontrol.

Table 107 GHG emissions in CRF 1.A.5.b. Other Mobile

GHG (Gg)	TJ	CO ₂	CH ₄	N ₂ O
1988	1 854.22	132.58	0.0009	0.0037
1990	1 199.00	85.73	0.0006	0.0024
1995	898.10	64.21	0.0004	0.0018

GHG (Gg)	TJ	CO ₂	CH ₄	N ₂ O
2000	648.11	46.34	0.0003	0.0013
2005	326.17	23.32	0.0002	0.0007
2010	344.98	24.67	0.0002	0.0007
2011	536.81	38.38	0.0003	0.0011
2012	132.03	9.44	0.0001	0.0003
2013	244.50	17.48	0.0001	0.0005
2014	129.98	9.29	0.0001	0.0003
2015	295.63	21.14	0.0001	0.0006
2016	594.03	42.47	0.0003	0.0012
2017	563.31	40.28	0.0003	0.0011
2018	431.84	30.88	0.0002	0.0009
2019	15.04	1.08	0.0000	0.0000
2020	13.99	1.00	0.0000	0.0000
2021	12.93	0.92	0.0000	0.0000
Decrease 1988-2021	99.3%	99.3%	99.3%	99.3%
Decrease 1990-2021	98.9%	98.9%	98.9%	98.9%
Decrease 2020-2021	7.5%	7.5%	7.5%	7.5%

3.4 FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS (CRF 1.B)

Fugitive emissions from fuels are responsible for 3.2% of total GHG emissions for 2021. The fugitive emissions from gas and oil have a share of approx. 1.6% of total GHG emissions, whereas the fugitive emissions of solid fuels are approx. 1.7% of total GHG emissions.

3.4.1 COAL MINING AND HANDLING (CRF 1.B.1)

This category includes methane and carbon dioxide fugitive 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 mostly through surface mining, although some underground mining still exists. 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 0.2% in 2018. In 2019 the last underground mine was closed down and therefore from the annual production amounts of 28.0 million tons in 2019, none were produced through underground mining.

Solid fuel transformation is also a source of fugitive emissions from coke and charcoal production, even though the 2006 IPCC guidelines are not very explicit regarding this subcategory. Updated methodologies and emission factors are provided in the 2019 Refinement to the 2006 IPCC Guidelines. 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 17 kt at the beginning of the time series to 2.1 kt in 2019. The activity data and the emission estimates are presented in Table 99.

Under this category are also included fugitive emissions from abandoned underground mines. Emissions from abandoned underground mines have been estimated based on national data, implementing a Tier 3 approach. Detailed information on the past and current state of all abandoned mines is presented in Table 95. The information has been collected, including type and historic quantities of coal mined, mine depth, estimate of the average emissions prior of closure, year of closure, method of closure and current state (flooded or non-flooded). From the 21 mines closed in the period 1942–2017, 19 were found to be non-flooded and thus a source of fugitive emissions. Based on the type of coal mined and year of closure, for each individual mine was calculated an annual emission

factor according to Equation 4.1.12 and parameters from Table 4.1.9 of 2019 Refinement to the 2006 IPCC Guidelines. The annual emission factor is presented in Table 107 below. Emission rate at closure was calculated based on mined quantities, type and rank of coal, as well as historic information on mine gassiness.

Table 108 Information about Abandoned underground mines by region

Coal region	Year of closure	Coal rank	Gassy/no n-gassy	Flooded/no n-flooded	Mine depth (m)	Average emissions prior of closure (Gg)
Lignite coal						
Kaninski region	1996		non-gassy	flooded	30-100	0.023
Kyustendilski region	1998	Category I - up to 5 m ³ /t		flooded	100-180	0.462
Zapadno-Marishki region	2003	Assumed 2.5 m ³ /t	non-gassy		30-250	3.044
Brown / Sub-bituminous						
Oranovo-Simitliiski region	2019	Category I - up to 5 m ³ /t			0-470	0.549
Pirinski region	2003	Category I - up to 5 m ³ /t			60-340	1.662
Chernomorski / Burgaski region	1942-2003	Assumed 2.5 m ³ /t	non-gassy		140-320	0.375
Pernishki region	2002	Category I - up to 5 m ³ /t			50-150	8.854
Bobov dolski region	2017	Category I - up to 5 m ³ /t			350-400	7.863
Babino	2016	Super category - over 15 m ³ /t				3.605
Black / Other bituminous coal						
Vidinski region	1969	Assumed 10 m ³ /t	gassy		unknown	0.157
Balkanski region	2015	Super category - over 15 m ³ /t			0-300	2.646
Anthracite coal						
Svogenski region	2005	Assumed 2.5 m ³ /t	non-gassy		30-200	0.177

Table 109 Applied coefficients according to Table 4.1.9 of the 2019 Refinement to the 2006 IPCC Guideline

Coal Rank	a	b
Anthracite	1.72	-0.58
Bituminous	3.72	-0.42
Sub-bituminous	0.27	-1.00

Table 110 Calculated emission factors according to equation 4.1.12 of the 2019 Refinement to the 2006 IPCC Guideline

Years since closure	Anthracite	Bituminous	Sub-bituminous
1	0.560	0.521	0.787
2	0.421	0.408	0.649
3	0.348	0.350	0.552
4	0.302	0.313	0.481
5	0.269	0.287	0.426
6	0.245	0.266	0.382
7	0.225	0.250	0.346
8	0.210	0.237	0.316
9	0.197	0.226	0.292
10	0.186	0.217	0.270

Years since closure	Anthracite	Bituminous	Sub-bituminous
11	0.176	0.208	0.252
12	0.168	0.201	0.236
13	0.161	0.194	0.222
14	0.154	0.189	0.209
15	0.148	0.183	0.198
16	0.143	0.178	0.188
17	0.138	0.174	0.179
18	0.134	0.170	0.171
19	0.130	0.166	0.163
20	0.126	0.163	0.156
21	0.123	0.159	0.150
22	0.120	0.156	0.144
23	0.117	0.154	0.139
24	0.114	0.151	0.134
25	0.111	0.148	0.129
26	0.109	0.146	0.125
27	0.107	0.144	0.121
28	0.104	0.142	0.117
29	0.102	0.139	0.113
30	0.100	0.138	0.110
31	0.099	0.136	0.107
32	0.097	0.134	0.104
33	0.095	0.132	0.101
34	0.094	0.131	0.098
35	0.092	0.129	0.096
36	0.091	0.127	0.093
37	0.089	0.126	0.091
38	0.088	0.125	0.089
39	0.086	0.123	0.087
40	0.085	0.122	0.085
41	0.084	0.121	0.083
42	0.083	0.120	0.081
43	0.082	0.118	0.079
44	0.081	0.117	0.078
45	0.080	0.116	0.076
46	0.079	0.115	0.075
47	0.078	0.114	0.073
48	0.077	0.113	0.072
49	0.076	0.112	0.070
50	0.075	0.111	0.069
51	0.074	0.110	0.068
52	0.073	0.109	0.066
53	0.073	0.108	0.065
54	0.072	0.108	0.064
55	0.071	0.107	0.063
56	0.070	0.106	0.062
57	0.070	0.105	0.061
58	0.069	0.104	0.060
59	0.068	0.104	0.059
60	0.068	0.103	0.058
61	0.067	0.102	0.057
62	0.066	0.102	0.056
63	0.066	0.101	0.056
64	0.065	0.100	0.055
65	0.065	0.100	0.054
66	0.064	0.099	0.053
67	0.063	0.098	0.052
68	0.063	0.098	0.052
69	0.062	0.097	0.051
70	0.062	0.097	0.050

Years since closure	Anthracite	Bituminous	Sub-bituminous
71	0.061	0.096	0.050
72	0.061	0.095	0.049
73	0.060	0.095	0.048
74	0.060	0.094	0.048
75	0.059	0.094	0.047
76	0.059	0.093	0.046
77	0.059	0.093	0.046
78	0.058	0.092	0.045
79	0.058	0.092	0.045
80	0.057	0.091	0.044

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 112 and Table 113.

The current natural gas consumption is about 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 CH₄ and CO₂ fugitive emissions from the transmission and distribution gas networks are estimated based on the length of transmission and distribution networks, as per advice given by the 2019 Refinement to the 2006 IPCC Guidelines.

The production of crude oil in Bulgaria is in very limited amounts equal to 0.5% of the total consumption in 2021, with only one production company operating. Generally, there is a decreasing trend in the local production of crude oil.

Table 111 Activity data and CH₄ 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	Abandoned underground mines	AD	Post-mining emissions	Mining emissions	AD	Emissions	AD	Emissions
	kt	Gg	Gg	Gg	kt	Gg	Gg	kt	Gg	kt	Gg
1988	4098	6.86	49.42	0.00	30049	2.01	24.16	1400	0.0686	18	0.4796
1990	3848	6.45	46.41	0.00	27827	1.86	22.37	1854	0.0908	20	0.5203
1995	3381	5.66	40.77	0.00	27449	1.84	22.07	1693	0.0830	20	0.5177
2000	1621	2.72	19.55	0.00	24811	1.66	19.95	1325	0.0649	8	0.2080
2005	585	0.98	7.06	1.68	24110	1.62	19.38	1051	0.0515	24	0.6240
2010	744	1.25	8.97	0.96	28649	1.92	23.03	NO	NO	17	0.4420
2011	872	1.46	10.52	0.89	36250	2.43	29.15	NO	NO	16	0.4160
2012	688	1.15	8.30	0.82	32732	2.19	26.32	NO	NO	4	0.1040
2013	550	0.92	6.63	0.77	28071	1.88	22.57	NO	NO	5	0.1300
2014	472	0.79	5.69	0.72	30796	2.06	24.76	NO	NO	6	0.1560
2015	447	0.75	5.39	0.67	35412	2.37	28.47	NO	NO	6	0.1560
2016	270	0.45	3.26	0.64	30961	2.07	24.89	NO	NO	4	0.1040
2017	134	0.23	1.62	0.60	34143	2.29	27.45	NO	NO	2	0.0635
2018	51	0.09	0.61	0.57	30212	2.02	24.29	NO	NO	2	0.0530
2019	NO	NO	NO	0.54	28001	1.88	22.51	NO	NO	2	0.0547
2020	NO	NO	NO	0.52	22298	1.49	17.93	NO	NO	2	0.0597
2021	NO	NO	NO	0.50	28289	1.90	22.74	NO	NO	3	0.0754

Table 112 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. Exploration 2. Production 3. Transport	4. Refining / Storage	1. Exploration 2. Production 3. Processing	4. Transmission	4. Storage	5. Distribution	1. B. 2. c. 1 Venting		1. B. 2. c. 2 Flaring	
							i. Oil	ii. Gas	i. Oil	ii. Gas
	10 ³ m ³	10 ³ m ³	10 ⁶ m ³	km	10 ⁶ m ³	km	10 ³ m ³	10 ⁶ m ³	TJ	
1988	C	15319.3	C	1234	291.8	50	IE	IE	0.0	IE
1990	C	9666.7	C	1469	219.5	50	IE	IE	0.0	IE
1995	C	9314.7	C	2044	285.4	50	IE	IE	908.1	IE
2000	C	6193.5	C	2645	351.6	300	IE	IE	859.5	IE
2005	C	7207.5	C	2645	263.3	1577	IE	IE	871.2	IE

2010	C	6381.1	C	2645	299.9	3493	IE	IE	1422.9	IE
2011	C	5924.2	C	2645	367.7	3656	IE	IE	1438.2	IE
2012	C	6869.5	C	2645	346.8	3873	IE	IE	1334.7	IE
2013	C	6552.4	C	2645	238.5	4035	IE	IE	1384.2	IE
2014	C	6007.0	C	2645	273.2	4224	IE	IE	1380.6	IE
2015	C	7036.1	C	2765	291.2	4334	IE	IE	4857.3	IE
2016	C	7293.7	C	2765	342.2	4444	IE	IE	8301.6	IE
2017	C	7907.2	C	2765	325.1	4724	IE	IE	9191.2	IE
2018	C	6852.9	C	2788	324.3	4916	IE	IE	7443.6	IE
2019	C	7977.5	C	2800	358.4	5157	IE	IE	8941.4	IE
2020	C	5670.2	C	3275	413.0	5292	IE	IE	8174.3	IE
2021	C	4857.6	C	3276	470.3	5461	IE	IE	6653.3	IE

Table 113 CH₄ 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. Exploration	2. Production	3. Transport	4. Refining / Storage	1. Exploration	2. Production	3. Processing	4. Transmission	4. Storage	5. Distribution	1. B. 2. c. 1 Venting		1. B. 2. c. 2 Flaring	
											i. Oil	ii. Gas	i. Oil	ii. Gas
1988	0.0019	0.2713	0.0023	0.4596	0.0006	0.0598	0.0059	2.5667	0.0846	0.0115	IE	IE	0.0000	IE
1990	0.0014	0.2035	0.0017	0.2900	0.0008	0.0804	0.0080	3.0555	0.0637	0.0115	IE	IE	0.0000	IE
1995	0.0010	0.1458	0.0013	0.2794	0.0030	0.2870	0.0285	4.2515	0.0828	0.0115	IE	IE	0.0009	IE
2000	0.0010	0.1424	0.0012	0.1858	0.0009	0.0861	0.0086	5.5016	0.1020	0.0690	IE	IE	0.0009	IE
2005	0.0007	0.1017	0.0009	0.2162	0.0316	1.3744	0.2998	5.5016	0.0763	0.3627	IE	IE	0.0009	IE
2010	0.0005	0.0780	0.0007	0.1986	0.0044	0.2069	0.0416	5.5016	0.0870	0.8034	IE	IE	0.0014	IE
2011	0.0005	0.0746	0.0006	0.1854	0.0262	1.1260	0.2485	5.5016	0.1066	0.8409	IE	IE	0.0014	IE
2012	0.0006	0.0814	0.0007	0.2134	0.0230	0.9915	0.2183	5.5016	0.1006	0.8908	IE	IE	0.0013	IE
2013	0.0007	0.0950	0.0008	0.2050	0.0174	0.7945	0.1653	5.5016	0.0692	0.9281	IE	IE	0.0014	IE
2014	0.0006	0.0882	0.0008	0.1877	0.0118	0.5827	0.1123	5.5016	0.0792	0.9715	IE	IE	0.0014	IE
2015	0.0006	0.0848	0.0007	0.2191	0.0062	0.3538	0.0587	5.7512	0.0845	0.9968	IE	IE	0.0049	IE
2016	0.0006	0.0814	0.0007	0.2276	0.0056	0.3179	0.0530	5.7512	0.0992	1.0221	IE	IE	0.0083	IE
2017	0.0006	0.0811	0.0007	0.2464	0.0048	0.3064	0.0457	5.7512	0.0943	1.0865	IE	IE	0.0092	IE
2018	0.0005	0.0762	0.0007	0.2130	0.0020	0.1727	0.0188	5.7990	0.0941	1.1307	IE	IE	0.0074	IE
2019	0.0005	0.0732	0.0006	0.2476	0.0023	0.1812	0.0222	5.8240	0.1039	1.1861	IE	IE	0.0089	IE
2020	0.0005	0.0711	0.0006	0.1757	0.0034	0.2880	0.0328	6.8120	0.1198	1.2172	IE	IE	0.0082	IE
2021	0.0005	0.0689	0.0006	0.1502	0.0019	0.1157	0.0182	6.8141	0.1364	1.2560	IE	IE	0.0067	IE

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 2019 Refinement to the 2006 IPCC Guidelines, Vol. 2, Ch. 4 have been applied:

$$\text{Emissions} = \text{Raw coal production} \bullet \text{Emission Factor} \bullet \text{Units conversion factor}$$

Relevant values of emission factors from 2019 Refinement to the 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 CO₂, CH₄ and N₂O fugitive emissions from gas and oil systems was conducted by Tier 1 methodology applying Equation 4.2.1 from the 2019 Refinement to the 2006 IPCC Guidelines, Vol. 2, Ch. 4.

$$\text{Emissions}_{\text{gas, industry segment}} = \text{Activity data}_{\text{industry segment}} \bullet \text{EF}_{\text{gas, industry segment}}$$

The appropriate EFs from 2019 Refinement to the 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 : 0.00002 Gg/10 ³ m ³ CO ₂ : 0.0044 Gg/10 ³ m ³ N ₂ O: 3.20E-09 Gg/10 ³ m ³ 2019 Refinement to the 2006 IPCC Guidelines	EF	CH ₄ : 0.000025 Gg/10 ³ m ³ CO ₂ : 0.0000023 Gg/10 ³ m ³ 2019 Refinement to the 2006 IPCC Guidelines
ii. Production		iv. Refining / Storage	
AD	National Energy Balance	AD	National Energy Balance
EF	CH ₄ : 0.00291 Gg/10 ³ m ³ CO ₂ : 0.04499 Gg/10 ³ m ³ N ₂ O: 0.00000067 Gg/10 ³ m ³ 2019 Refinement to the 2006 IPCC Guidelines	EF	CH ₄ : 0.00003 Gg/10 ³ m ³ CO ₂ : 0.00585 Gg/10 ³ m ³ N ₂ O: 8.77E-08 Gg/10 ³ m ³ 2019 Refinement to the 2006 IPCC Guidelines

1. B. 2. b. Natural Gas			
i. Exploration		iv. Transmission	
AD	National Energy Balance	AD	Energy and Water Regulatory Commission
EF	CH ₄ : 0.00006 Gg/10 ⁶ m ³ CO ₂ : 0.00005 Gg/10 ⁶ m ³ N ₂ O: 3.6E-10 Gg/10 ⁶ m ³ 2019 Refinement to the 2006 IPCC Guidelines	EF	CH ₄ : 0.00208 Gg/km/yr CO ₂ : 0.00025 Gg/km/yr 2019 Refinement to the 2006 IPCC Guidelines
ii. Production		iv. Storage	
AD	National Energy Balance	AD	Bulgartransgaz
EF	CH ₄ : 0.00254 Gg/10 ⁶ m ³ CO ₂ : 0.0036 Gg/10 ⁶ m ³ N ₂ O: 0.000000061 Gg/10 ⁶ m ³ 2019 Refinement to the 2006 IPCC Guidelines	EF	CH ₄ : 0.00029 Gg/10 ⁶ m ³ CO ₂ : 0.00004 Gg/10 ⁶ m ³ 2019 Refinement to the 2006 IPCC Guidelines
iii. Processing		v. Distribution	
AD	National Energy Balance	AD	Energy and Water Regulatory Commission
EF	CH ₄ : 0.00057 Gg/10 ⁶ m ³ CO ₂ : 0.00721 Gg/10 ⁶ m ³ N ₂ O: 0.000000079 Gg/10 ⁶ m ³ 2019 Refinement to the 2006 IPCC Guidelines	EF	CH ₄ : 0.00023 Gg/km/yr CO ₂ : 0.00001 Gg/km/yr 2019 Refinement to the 2006 IPCC Guidelines
vi. Other leakage - Natural gas-fuelled vehicles		vi. Other leakage - Appliances	
AD	Ministry of Interior	AD	Energy and Water Regulatory Commission
EF	CH ₄ : 0.0000003 Gg/car/y CO ₂ : 2.300E-09 Gg/car/y	EF	CH ₄ : 0.000004 Gg/appliance/y CO ₂ : 0.000000033 Gg/appliance/y

	2019 Refinement to the 2006 IPCC Guidelines		2019 Refinement to the 2006 IPCC Guidelines
vi. Other leakage – Industrial plants			
AD	National Energy Balance		
EF	CH ₄ : 0.0004 Gg/10 ⁶ m ³ CO ₂ : 0.0000033 Gg/10 ⁶ m ³ 2019 Refinement to the 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	IE	AD	IE
EF	IE According to page 4.47, Vol. 2, Ch. 4 of 2019 Refinement to the 2006 IPCC Guidelines	EF	IE According to page 4.47, Vol. 2, Ch. 4 of 2019 Refinement to the 2006 IPCC Guidelines
ii. Gas		ii. Gas	
AD	IE	AD	IE
EF	IE According to page 4.47, Vol. 2, Ch. 4 of 2019 Refinement to the 2006 IPCC Guidelines	EF	IE According to page 4.47, Vol. 2, Ch. 4 of 2019 Refinement to the 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 Mining CO ₂ : 5.9 m ³ /t Post-Mining CH ₄ : 2.5 m ³ /t 2019 Refinement to the 2006 IPCC Guidelines
ii. Surface Mines	
AD	National Energy Balance
EF	Mining CH ₄ : 1.2 m ³ /t Mining CO ₂ : 0.44 m ³ /t Post-Mining CH ₄ : 0.1 m ³ /t 2019 Refinement to the 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 2019 Refinement to the 2006 IPCC Guidelines

Activity data for crude oil and natural gas has been sourced from the Energy balances, Bulgartransgaz and Energy and Water Regulatory Commission.

Emissions from venting and flaring have been included in the estimates for oil and gas exploration, production and processing, as the updated Tier 1 emission factors are aggregates of venting, flaring, and leak emissions (page 4.47, Vol. 2, Ch. 4 of 2019 Refinement to the 2006 IPCC Guidelines). There is one exception related to emissions from natural gas used for hydrogen production in oil refineries, which have been reported under CRF category 1.B.2.c.2.i as per ERT recommendation E.9 from FCCC/ARR/2016/BGR. The activity data used for this category is the quantity of natural gas used for hydrogen production in refineries. The EFs applied are the same as for stationary combustion (55-56 t CO₂/TJ – country-specific, 1 kg CH₄/TJ - default, 0.1 kg N₂O/TJ- default).

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 m³/t was changed to 1.5 m³/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 m³/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 kgCH₄/km was changed to 2500 kgCH₄/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. The emission trend in this subcategory is rather unstable. A sharp growth can be observed after 2008 when the emissions increase 5 times within one year. In the period 2009-2019, an upward trend can be noticed with a historical high in 2017, due to the increase of the total quantity of refinery intake. For the 2021 submission the Fugitive emission sector the updated methodologies and the default emission factors from 2019 Refinement to the 2006 IPCC Guidelines were applied. The recalculation includes an estimate of the fugitive emissions from abandoned underground mines (1.B.1.a.1.iii) based on detailed national data. Before the 2020 submission emissions from abandoned underground mines have been reported based on proxy data from Hungary.

3.4.7 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No specific improvements for this subcategory are planned. 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, there is no coal production in Bulgaria 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. For those reasons we consider the implementation of a Tier 2 approach to be unreasonable.

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 2021.

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 2021 for each of the IPCC Categories under CRF Sector 2 for which GHG emissions are reported (as given in table 10s1).

Industrial process emissions sector includes emissions from industrial installations, consumption of Solvent Use and halocarbons and SF6 (the fluorinated gases or F-gases).

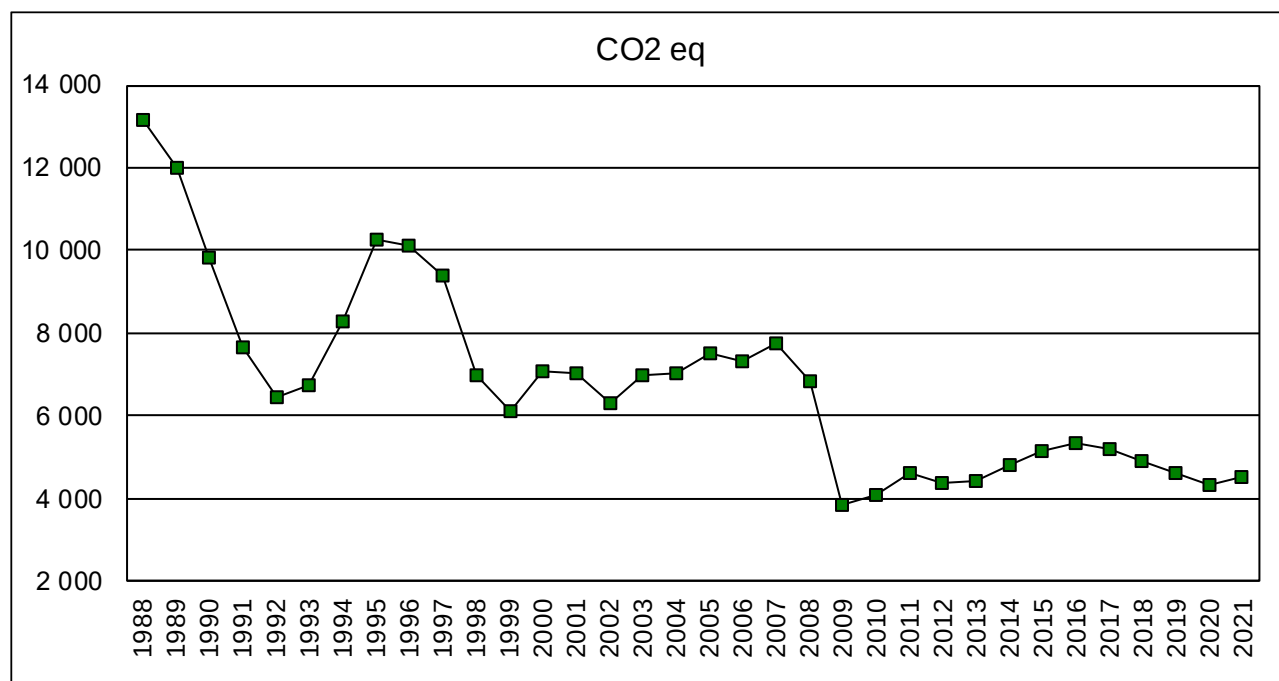
The trends in the sector can be followed in the following table. There are some country specific issues which are described in each subsector where big fluctuations occur.

The results from the evaluations are presented in the following table:

Table 114 GHG Emission trends in CRF 2 IPPU, 1988 – 2021

IPCC category	Emissions [Gg CO ₂ eq]		Share [%]		Trend 1988 – 2021 [%]
	Base year*	2021	Base year*	2021	
2 Industrial processes	13176,76	4533,86	100,00	100,00	-65,59
2.A Mineral Industry	3739,87	2 348,90	27,74	41,17	-37,19
2.B Chemical Industry	5210,66	1 240,17	40,22	21,24	-76,20
2.C Metal Industry	4028,54	132,65	29,85	2,81	-96,71
2.D Non-energy Products from Fuels and Solvent Use	138,57	16,28	1,70	1,58	-88,25
2.E Electronics Industry	NO	NO	NO	NO	NO
2.F Product Uses as Substitutes for ODS	NO	739,43	NO	32,16	100,00
2.G Other Product Manufacture and Use	59,12	56,43	0,48	1,03	-4,55
2.H Other	IE,NA	IE,NA	NO	NO	NO

* Base year 1988

Figure 51 CO₂ Emission trends for CRF Sector 2 IPPU for 1988-2021

The general reduction in the emissions in the later years of the time period is influenced by the introduction of better technologies in some plants and/or due to plant closures in the country.

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 2021.

Table 115 GHG emissions from CRF 2 IPPU by gas in 1988 and 2021

GHG	Base year*	2021	Base year*	2021
	CO ₂ equivalent [Gg CO ₂ eq]		[%]	
Total	13176,76	4316,10	100,00	100,00
CO₂	11367,90	3423,05	86,27	79,31
CH₄	52,13	0,00	0,40	0,0000
N₂O	1964,63	93,14	14,91	2,16
HFCs	0,00	789,77	0,00	18,30
PFCs	0,00	0,01	0,00	0,0002
SF₆	3,40	20,45	0,03	0,47

*1988 for: CO₂, CH₄, N₂O and SF₆.

*1995 for: HFCs and PFCs.

Table 116 GHG Emissions from CRF 2 IPPU by gases 1988 – 2021

GHG emissions [Gg CO ₂ eq]							
Year	Total	CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆
1988	13176,76	11367,90	52,132	1964,63	0,00	0,000	3,40
1989	11983,84	10365,33	57,988	1556,92	0,00	0,000	3,60
1990	9813,72	8271,26	39,914	1680,00	0,00	0,000	3,81
1991	7681,72	6607,52	30,565	1164,93	0,00	0,000	4,03
1992	6436,73	5522,89	28,519	986,92	0,01	0,000	4,26
1993	6738,86	5920,65	32,897	873,57	0,02	0,000	4,51
1994	8280,06	7387,06	44,718	941,40	1,00	0,000	4,77
1995	10270,42	8977,51	48,967	1383,16	3,03	0,000	5,05
1996	10127,69	8797,43	48,194	1423,24	5,31	0,000	5,34
1997	9375,26	8349,28	51,480	1073,05	8,44	0,000	5,65
1998	7004,79	6348,64	44,296	661,05	12,72	0,000	5,98
1999	6138,59	5579,74	37,079	552,51	19,67	0,000	6,32

GHG emissions [Gg CO ₂ eq]							
Year	Total	CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆
2000	7068,26	6258,37	37,616	819,08	32,69	0,000	6,69
2001	7017,89	6191,39	37,926	821,71	46,23	0,000	7,08
2002	6312,18	5597,91	33,940	683,47	60,98	0,000	7,49
2003	6969,48	6205,42	42,282	709,36	77,97	0,000	7,92
2004	7054,87	6152,68	36,398	841,48	104,74	0,000	8,38
2005	7508,22	6489,55	35,122	904,79	166,32	0,000	8,42
2006	7324,00	6588,00	36,044	496,49	245,38	0,000	8,74
2007	7775,61	6905,61	34,914	606,65	282,34	0,000	9,08
2008	6853,52	5878,11	19,412	583,02	425,74	0,021	9,44
2009	3829,94	3143,31	4,871	284,70	418,13	0,056	9,81
2010	4088,91	3399,97	0,016	286,21	415,00	0,064	19,34
2011	4637,71	3922,11	0,005	252,10	473,86	0,056	17,49
2012	4370,29	3714,69	0,001	153,98	502,03	0,047	16,59
2013	4425,33	3553,95	0,001	137,95	727,63	0,039	21,05
2014	4808,59	3777,74	0,001	139,90	889,01	0,033	17,40
2015	5148,63	4311,34	0,000	140,65	693,57	0,028	18,62
2016	5341,63	4495,36	0,000	126,70	714,25	0,023	19,32
2017	5219,43	4394,80	0,00	105,51	712,72	0,03	18,05
2018	4908,82	4059,49	0,00	127,59	717,31	0,01	18,54
2019	4603,42	3695,40	0,00	98,43	801,65	0,01	18,82
2020	4316,10	3423,05	0,00	93,14	789,77	0,01	20,45
2021	4533,86	3695,87	0,00	84,65	739,42	0,01	23,27

The emission trends of the three GHG – CO₂, CH₄ and N₂O, are presented on the following figure.

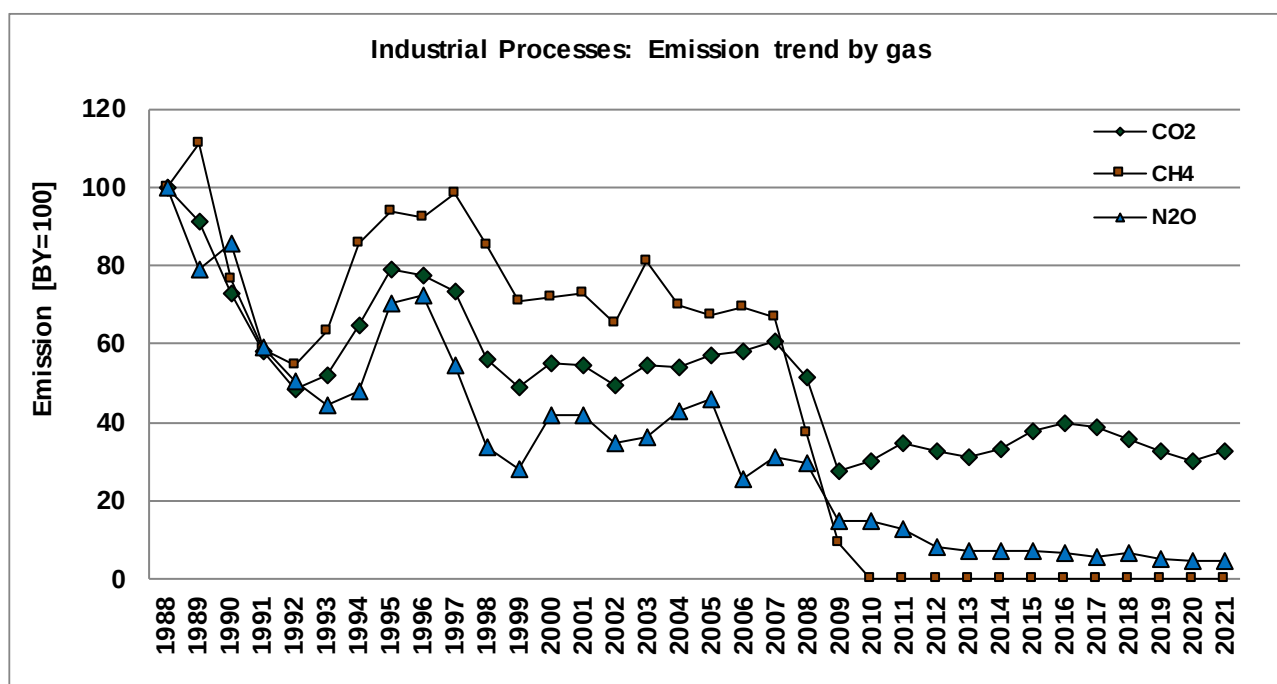


Figure 52 IPPU: Emission trend by gas – CO₂, N₂O, CH₄

The scale is logarithmic so that all the trends could be visible.

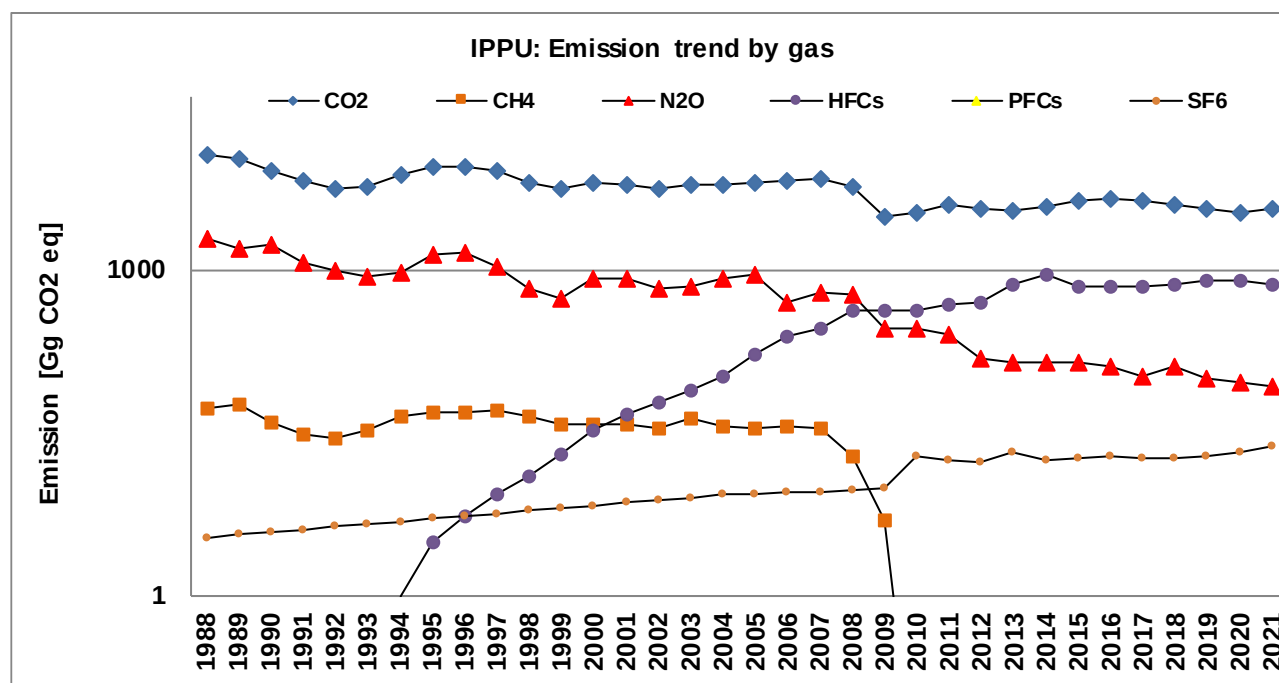


Figure 53 IPPU: Emission trend by gas – CO₂, N₂O, CH₄, HFCs PFCs and SF₆

Emission trends by sources

The main sources of greenhouse gas emissions in the IPPU sector can be followed by the tables and graphics (sector 2.F).

Table 117 GHG Emissions from CRF 2 IPPU by sector 1988 to 2021

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.E Electronic Industry	2.F Product Uses as Substitutes for ODS	2.G Other Product Manufacture and Use	2.H Other
1988	3739,87	5210,66	4028,54	138,57	NO	0,00	59,12	IE,NA
1989	3556,28	5002,64	3252,39	113,75	NO	0,00	58,77	IE,NA
1990	3277,86	4762,46	1632,56	82,11	NO	0,00	58,74	IE,NA
1991	2065,61	3788,21	1713,46	55,66	NO	0,00	58,78	IE,NA
1992	1746,74	2993,09	1594,29	43,87	NO	0,01	58,74	IE,NA
1993	1769,82	2764,59	2087,45	60,44	NO	0,02	56,53	IE,NA
1994	2096,87	3110,18	2943,41	44,49	NO	1,00	84,12	IE,NA
1995	2731,32	4058,51	3364,79	37,04	NO	3,03	75,73	IE,NA
1996	2689,69	4245,18	3065,53	43,65	NO	5,31	78,34	IE,NA
1997	2117,07	3578,70	3584,83	12,01	NO	8,44	74,20	IE,NA
1998	1548,53	2389,59	2966,49	23,17	NO	12,72	64,29	IE,NA
1999	1448,47	1840,65	2729,16	39,31	NO	19,67	61,33	IE,NA
2000	1628,45	2678,52	2634,72	22,59	NO	32,69	71,28	IE,NA
2001	1654,50	2705,68	2531,56	18,07	NO	46,23	61,86	IE,NA
2002	1720,66	2139,33	2301,95	22,85	NO	60,98	66,40	IE,NA
2003	1758,53	2212,32	2831,72	28,00	NO	77,97	60,93	IE,NA
2004	1989,29	2527,27	2346,04	29,68	NO	104,74	57,85	IE,NA
2005	2196,40	2688,58	2373,56	28,26	NO	166,32	55,10	IE,NA
2006	2330,46	2103,14	2559,30	30,30	NO	245,38	55,41	IE,NA
2007	2825,39	2314,96	2269,63	27,64	NO	282,34	55,65	IE,NA
2008	2814,61	2253,14	1280,65	22,07	NO	425,76	57,28	IE,NA
2009	1746,34	1282,65	308,17	19,48	NO	418,19	55,11	IE,NA

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.E Electronic Industry	2.F Product Uses as Substitutes for ODS	2.G Other Product Manufacture and Use	2.H Other
2010	1811,79	1473,70	288,66	28,50	NO	415,06	71,20	IE,NA
2011	1953,77	1801,49	315,88	27,28	NO	473,92	65,37	IE,NA
2012	2056,84	1431,09	290,17	23,83	NO	502,08	66,28	IE,NA
2013	1941,35	1459,72	221,79	18,62	NO	727,66	56,19	IE,NA
2014	2005,29	1590,79	249,29	20,35	NO	889,04	53,84	IE,NA
2015	2385,67	1776,39	224,06	14,24	NO	693,60	54,68	IE,NA
2016	2508,21	1824,87	223,42	18,92	NO	714,28	51,93	IE,NA
2017	2521,48	1735,84	183,08	17,18	NO	712,75	49,11	IE,NA
2018	2478,52	1442,69	186,11	30,19	NO	717,32	53,98	IE,NA
2019	2357,68	1196,75	160,65	32,57	NO	801,67	54,11	IE,NA
2020	2182,15	1116,83	148,93	16,08	NO	789,78	62,33	IE,NA
2021	2348,90	1240,17	132,65	16,28	NO	739,43	56,43	IE,NA

The following figure presents greenhouse gas emissions from IPCC Category 2 IPPU by sub category for the years 1988 to 2021 in both logarithmic and non-logarithmic scale.

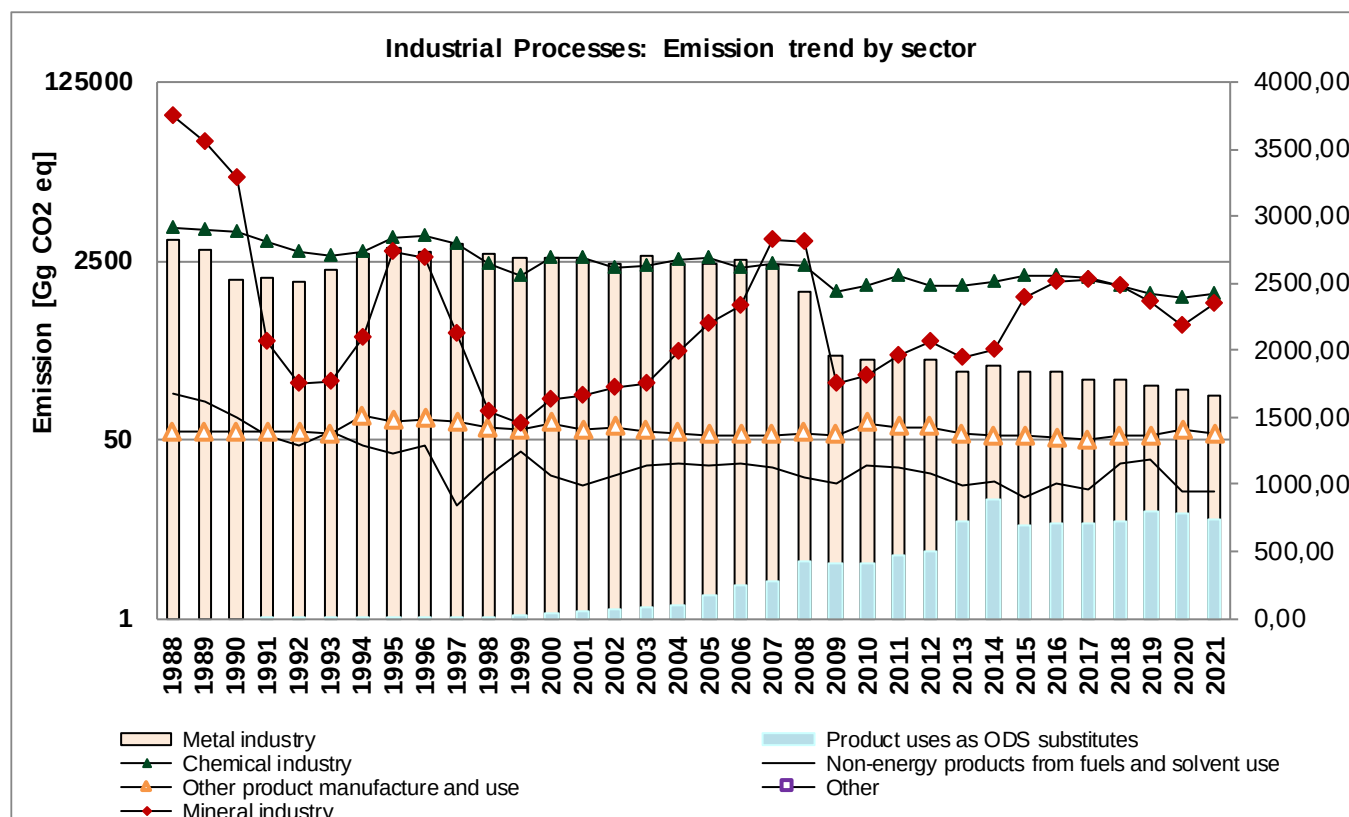


Figure 54 CRF 2 IPPU: Emission trend by sector – [Gg CO₂ eq]

The emissions reduction during the whole time period from 1988 to 2021 is due to mainly economic reasons (economic crisis). There are two similar periods – around 1989 - 1991 and 1997 – 1999. The period around 1989/1991 and 1997/1999 represent the economic crisis time followed by stabilization and increase of the production rates period. In 1996 a privatization process begins in the country which leads to decrease in the production of plants'. This process is followed by restructuring and modernization of the production while at the same time some of the enterprises cease operation, some of them forever. Later 2008 – 2009 the world economic crisis was reflected in the trend of the Bulgarian

industry. In the end of the line in the time series the Covid 19 closure gave reflection on the rates of production in the country due to the specific of the work (the business held the home – office, the manufacture decreased rates in some industrial branches).

The general reduction in the emissions in the years that followed of the time series is influenced also by the introduction of better technologies on plant level or plants closures.

One of the most important factors leading to emission reduction in Metal Industry sector is that the biggest plant from this sector (whose share in the steel production of the country 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 compared to the years between 2008 and 2021 is more than 90%.

The existing ammonia and nitric acid plants ceased operation and this 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. Later in 2010 the market rates were recovered and the production followed it.

In 2018 a slight increase in emissions is observed for the entire IPPU sector. This is mainly due to increase in Product uses as ODS substitutes (Consumption of Halocarbons) category. In 2020 it was followed by a decrease in some sectors provoked by the closedowns because of the Covid 19.

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, is used.

In some categories emission and production data were reported directly by industry or EU ETS, IPPC and/or E-PRTR reports, thus they represent plant and country specific data. Methodologies are described for all IPCC categories in the relevant chapters.

Detailed information on the methodology can be found in the corresponding subchapters.

Emission data reported under the European Emission Trading Scheme - EU ETS

Verified CO₂ emissions reported under the EU ETS were available for the years 2007-2021. 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 is used in some emissions estimation.

Planned Improvements

All planned improvements (described in the following sub-chapters) are described in the relevant subsector.

4.2 MINERAL INDUSTRY (CRF 2.A)

4.2.1 CEMENT PRODUCTION (CRF 2.A.1)

4.2.1.1 Source category description

Period 1988 – 2021 subsector overview. There were 6 existing/operational cement plants in Bulgaria in the beginning of the period. One of the six installations was operational since 1988 till 1996 and decommissioned finally during the last year(1996). One from the five left/operational installations had substantial decrease in production during 2010. This factory completely ceased operation and all equipment was decommissioned in 2011. In 2013 one more installation ceased operation and all the equipment was 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 during the past 10 years. In addition all plants are certified at present according to ISO 9001 and 14 001 standards.

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.

4.2.1.2 Trend description

The periods between 1989/1991 and 1997/1999 represent the economic crisis time followed by stabilization and increase in the production rates. In 1996 a privatization process begun which led to decrease in the plants' production. This process was followed by reconstruction and modernization of the plants and in the same time some of the companies ceased their operation. The reduction in 2020 is because of the Covid – 19 pandemic many bussines have remained closed and reduced their production.

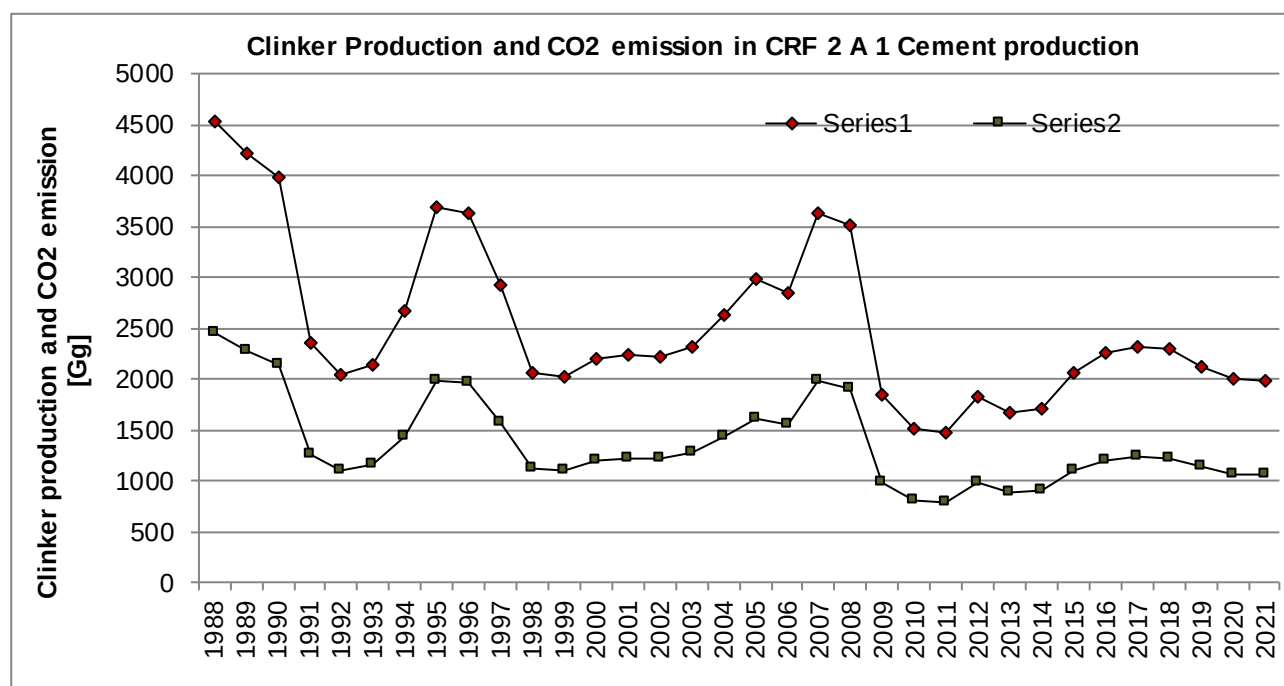


Figure 55 Clinker Production and CO2 emission in CRF 2 A 1 Cement production

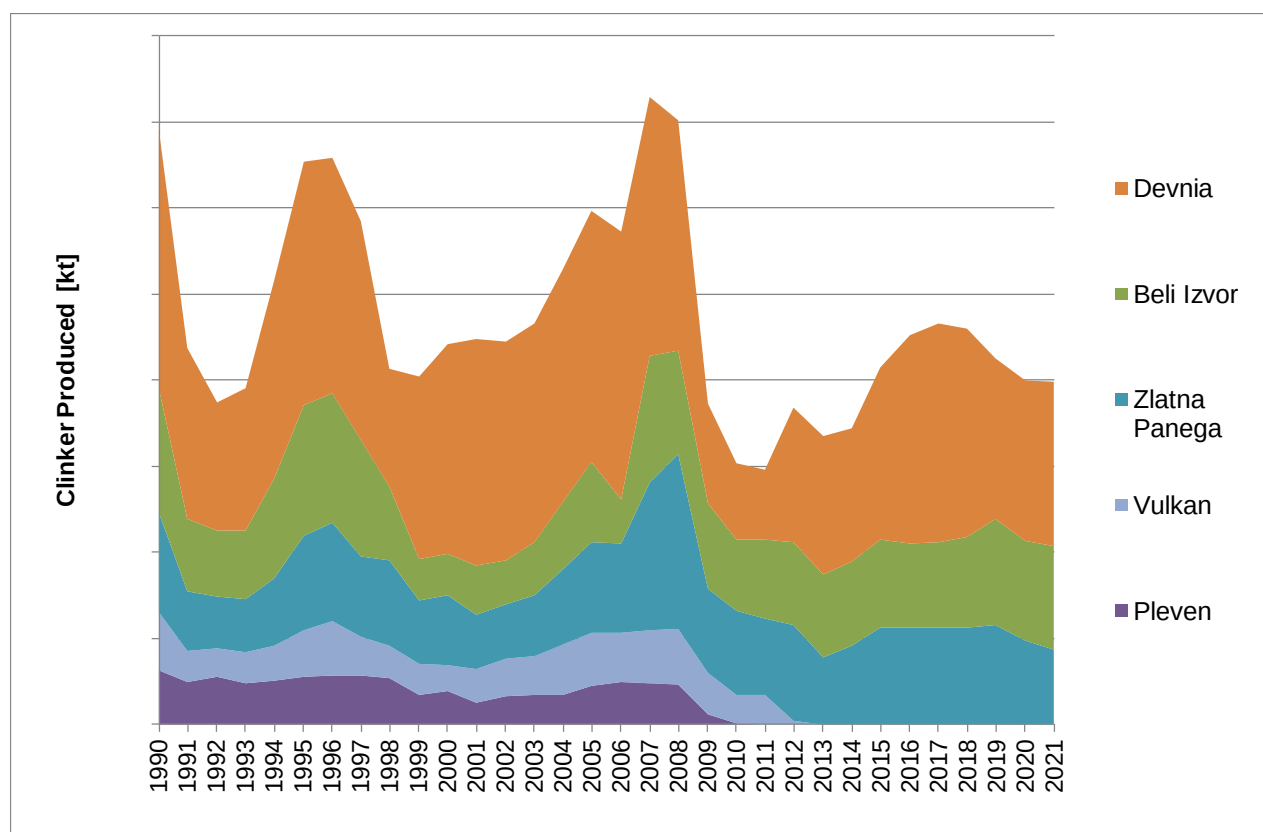


Figure 56 Clinker Production by plant

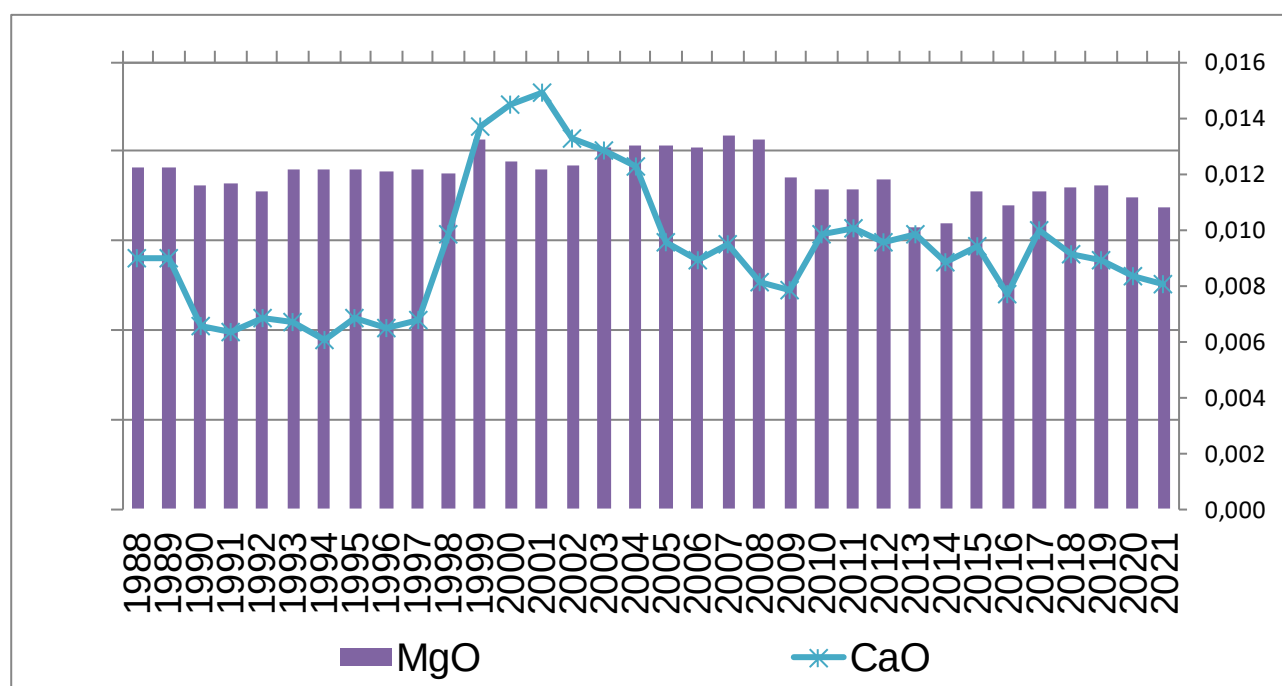


Figure 57 Average CaO and MgO for the country, based on plant specific activity data in logarithmic scale.

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

is taken from the annual reports under the IPPC permits. In addition, information for the content of calcium and magnesium oxide in the clinker is required from the plants.

The emissions calculations and the applied emission factor are according to equation 2.2 on pages 2.9 from item 2.2.1.1 (2006 IPCC GL):

$$\text{Emissions} = \text{EF}_{\text{clinker}} \cdot \text{CP} \cdot \text{CKD Correction Factor}$$

$$\text{EF}_{\text{clinker}} = \sum \text{M} \cdot \text{C}_{(\text{MeO})}$$

$$\text{C}_{(\text{MeO})} = ((\sum \text{Cn}_{(\text{MeO})} \cdot \text{CPn}) / \text{CP}) / 100$$

Where:

CKD Correction Factor = 1.00 for the period 2009-2018, and 1.02 for the period 1988-2008

M - Molecular Weight CO₂/ 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 period 2009-2018) 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/MeCO₃) 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:

$$\text{Emissions} = 0.533 \cdot \text{CP} \quad (\text{for 2021})$$

The CO₂ emissions for 2020 are taken from the operators EU ETS reports. In their reports CaCO₃, MgCO₃ 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 2021. They are presented in the table below together with the relevant coefficients and the calculated CO₂ emissions:

Table 118 Clinker production, weight fraction and CO₂ emission

Clinker Production Data		IEF [kt CO ₂ / kt production]	CO ₂ Emissions [kt]
Year	[kt/y]		
1988	4535,24	0,541	2454,46
1989	4232,71	0,541	2290,73
1990	3986,62	0,537	2142,42
1991	2354,10	0,537	1264,77
1992	2041,10	0,538	1097,10
1993	2143,81	0,538	1153,80
1994	2680,61	0,537	1440,69
1995	3700,60	0,538	1992,66
1996	3645,10	0,538	1960,52
1997	2921,99	0,538	1573,01
1998	2063,45	0,542	1118,43
1999	2018,72	0,548	1106,45
2000	2211,23	0,548	1211,57

Clinker Production Data		IEF [kt CO ₂ / kt production]	CO ₂ Emissions [kt]
Year	[kt/y]		
2001	2239,65	0,548	1228,41
2002	2222,32	0,547	1214,71
2003	2327,30	0,547	1272,52
2004	2644,37	0,546	1444,25
2005	2981,62	0,543	1618,09
2006	2859,79	0,542	1549,68
2007	3644,85	0,543	1979,36
2008	3509,82	0,541	1899,69
2009	1858,85	0,529	982,97
2010	1514,55	0,533	807,29
2011	1475,70	0,534	787,30
2012	1839,27	0,534	981,29
2013	1676,00	0,532	891,63
2014	1716,92	0,531	911,12
2015	2073,69	0,533	1105,43
2016	2257,05	0,529	1194,11
2017	2326,86	0,533	1239,30
2018	2297,48	0,533	1223,50
2019	2127,51	0,535	1137,77
2020	1999,88	0,533	1065,91
2021	1989,26	0,533	1060,36

Uncertainties and time series consistency

Taking into account the economic crises of 1989/1990 1997/1998 and 2008/2010 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%

4.2.1.4 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 (EPTR data), as well as in their verified EU ETS emission reports.

All verification EU ETS reports are publically available at: <http://eea.government.bg/bg/r-r/r-te/verifitsirani-dokladi-19>

4.2.1.5 Source specific recalculations

No recalculations were made in the sector for the inventory year.

4.2.1.6 Source specific planned improvements

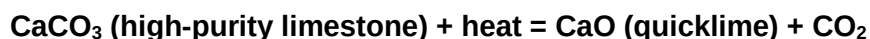
Major improvements in this category are not planned.

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 similar to those 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 CO₂. 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):



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.

The reduction in 2020 is because of the Covid – 19 pandemic many bussines have remained closed and reduced their production.

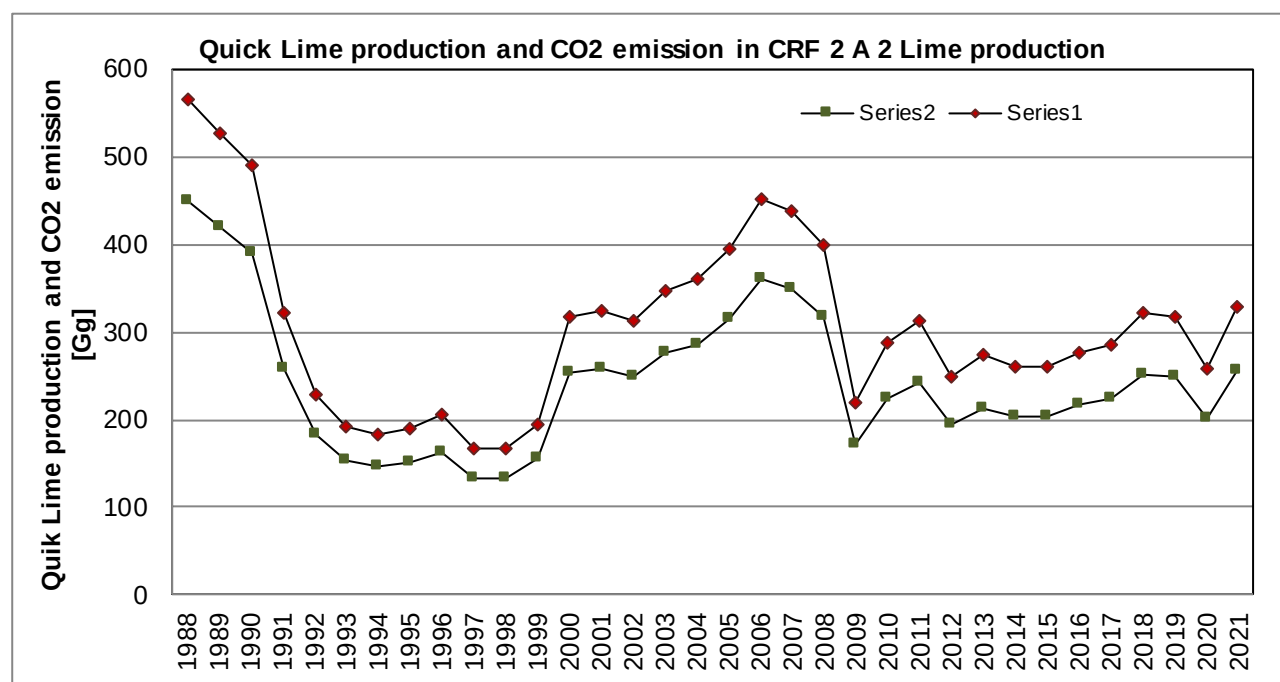


Figure 58 Lime Production and CO₂ emission in CRF 2.A.2 Lime production

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):

$$\text{CO}_2 \text{ Emissions} = \sum (\text{EF}_{\text{Lime},i} \cdot \text{M}_{\text{Lime},i} \cdot \text{CF}_{\text{LKD},i})$$

Where:

CO₂ Emissions = emissions of CO₂ from lime production, tonnes

EF_{Lime,i} = emission factor for lime of type i, tonnes CO₂/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 CO₂/tonne quicklime produced and 0.913 tonnes CO₂/tonne dolomitic lime produced.

It is assumed that the whole quantity of CaCO₃, MgCO₃, и CaMg(CO₃)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.

$$\text{M}_{\text{Lime}} = 0.85 \cdot \text{M}_{\text{high calciumlime}} + 0.15 \cdot \text{M}_{\text{dolomitic lime}}$$

Thus an approach in line with Tier 2 method (2006 IPCC Guidelines, p.2.21) is used to estimate CO₂ emissions from lime production.

The reduction in 2008 – 2009 reduction in the construction works and other quicklime consuming production processes and world economic crises lead to reduction in the Implied emissionfactor in 2008.

4.2.2.3.2 Emission factor

To estimate the emission factors are used the following equations:

EQUATION 3.5A

$$\text{EF}_{\text{high calciumlime}} = \text{Stoichiometric ratio (CO}_2 \text{ /CaO)} \cdot \text{CaO content} + \text{Stoichiometric ratio (CO}_2 \text{ /MgO)} \cdot \text{MgO content}$$

Where: EF_{high calciumlime} = emission factor for quicklime

EQUATION 3.5B

$$\text{EF}_{\text{dolomitic lime}} = \text{Stoichiometric ratio (CO}_2 \text{ / CaO} \cdot \text{MgO)} \cdot (\text{CaO} \cdot \text{MgO) content (Stoichiometric ratio (CO}_2 \text{ /CaO)} \cdot \text{CaO content} + \text{Stoichiometric ratio (CO}_2 \text{ /MgO)} \cdot \text{MgO content)}$$

Where: EF_{dolomitic lime} = emission factor for dolomitic quicklime

The above equations are used to estimate the emission factor.

$$\text{IEF} = \text{AD Lime Production [kt/y]} / \text{C2O Emissions [kt CO}_2\text{]}.$$

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 CO₂ from lime production.

Issues of double counting:

CO₂ emissions from Lime production are reported in this chapter and are not included in Limestone and dolomite use chapter.

Table 119 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	0,7963	450,07
1989	527,93	0,7963	420,38
1990	490,39	0,7963	390,49
1991	323,18	0,7963	257,34
1992	228,88	0,7963	182,26
1993	192,93	0,7963	153,62
1994	183,49	0,7963	146,11
1995	190,48	0,7963	151,67
1996	205,21	0,7963	163,40
1997	167,39	0,7963	133,29
1998	167,90	0,7963	133,70
1999	195,22	0,7963	155,45
2000	318,70	0,7963	253,78
2001	323,84	0,7963	257,87
2002	312,45	0,7963	248,80
2003	346,88	0,7963	276,21
2004	359,90	0,7963	286,59
2005	395,12	0,7963	314,63
2006	452,75	0,7963	360,52
2007	439,09	0,7963	349,64
2008	399,27	0,7963	317,93
2009	220,38	0,7801	171,91
2010	288,60	0,7801	225,13
2011	312,25	0,7801	243,58
2012	249,03	0,7801	194,26
2013	273,62	0,7801	213,45
2014	260,94	0,7801	203,55
2015	261,59	0,7801	204,06
2016	277,69	0,7801	216,61
2017	286,55	0,7801	223,53
2018	322,69	0,7801	251,72
2019	318,73	0,7801	248,63
2020	257,98	0,7801	201,24
2021	327,99	0,7801	255,85

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 production 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.

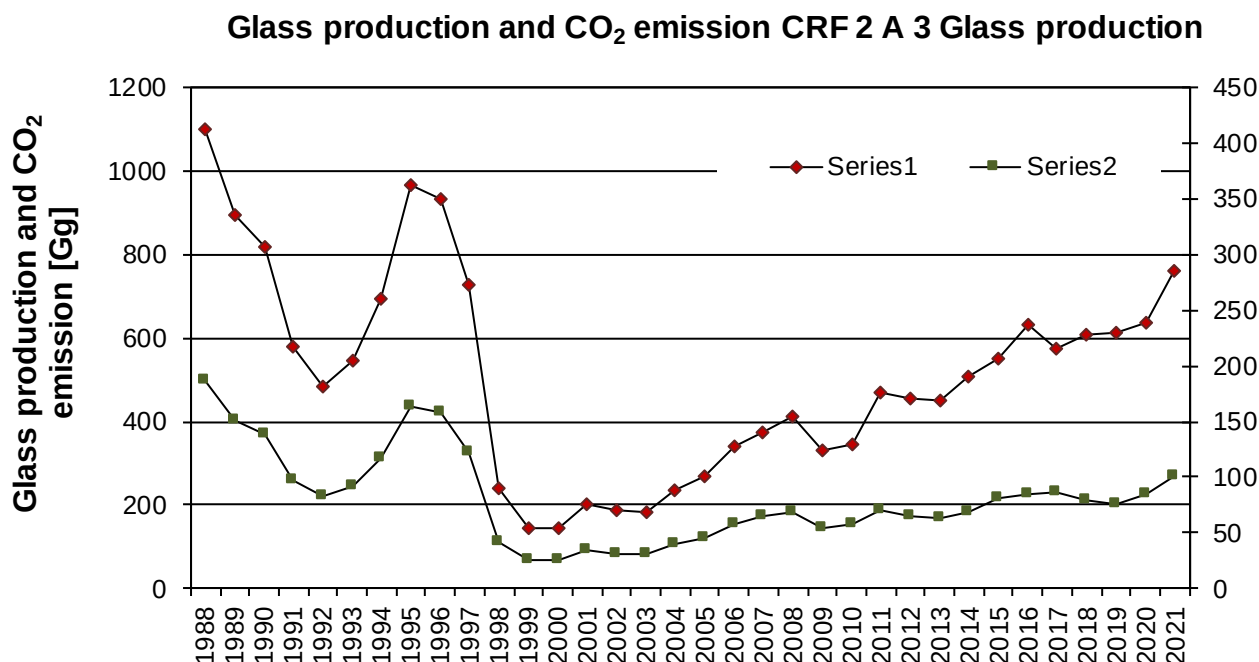


Figure 59 Glass Production and CO₂ emission in CRF 2.A.3 Glass production

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:

$$\text{Emissions CO}_2 = \text{Emission factor} \cdot \text{Glass production}$$

For the period 2007 - 2020 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 CO₂ 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 120). 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 - 2020. For the time series 1988 – 2020 statistical activity data was 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.

Table 120 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	186,245
1989	896,74	0,169	151,542
1990	818,04	0,169	138,243
1991	579,65	0,169	97,957
1992	485,66	0,169	82,073
1993	547,33	0,169	92,495
1994	694,82	0,169	117,421
1995	968,79	0,169	163,718
1996	935,62	0,169	158,114
1997	727,54	0,169	122,949
1998	242,41	0,169	40,965
1999	145,54	0,169	24,596
2000	146,66	0,169	24,784
2001	199,59	0,169	33,730
2002	186,58	0,169	31,531
2003	180,62	0,169	30,524
2004	237,31	0,169	40,104
2005	267,94	0,169	45,281
2006	340,01	0,169	57,459
2007	374,65	0,171	64,213
2008	410,19	0,167	68,334
2009	332,20	0,163	54,207
2010	344,16	0,166	57,115
2011	468,41	0,150	70,348
2012	454,32	0,142	64,619
2013	452,32	0,138	62,536
2014	508,00	0,135	68,642
2015	550,91	0,146	80,407
2016	631,60	0,133	84,010
2017	575,64	0,149	85,780
2018	607,46	0,131	79,401
2019	612,27	0,124	76,060
2020	635,40	0,134	84,831
2021	764,13	0,131	100,031

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 are no source specific recalculations for this category.

4.2.3.7 Source specific planned improvements

For the subsector it is planned to obtain more detailed activity data and to reallocate the emissions from 2A4b, on soda ash used in glass production. This improvement has not yet been implemented.

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.

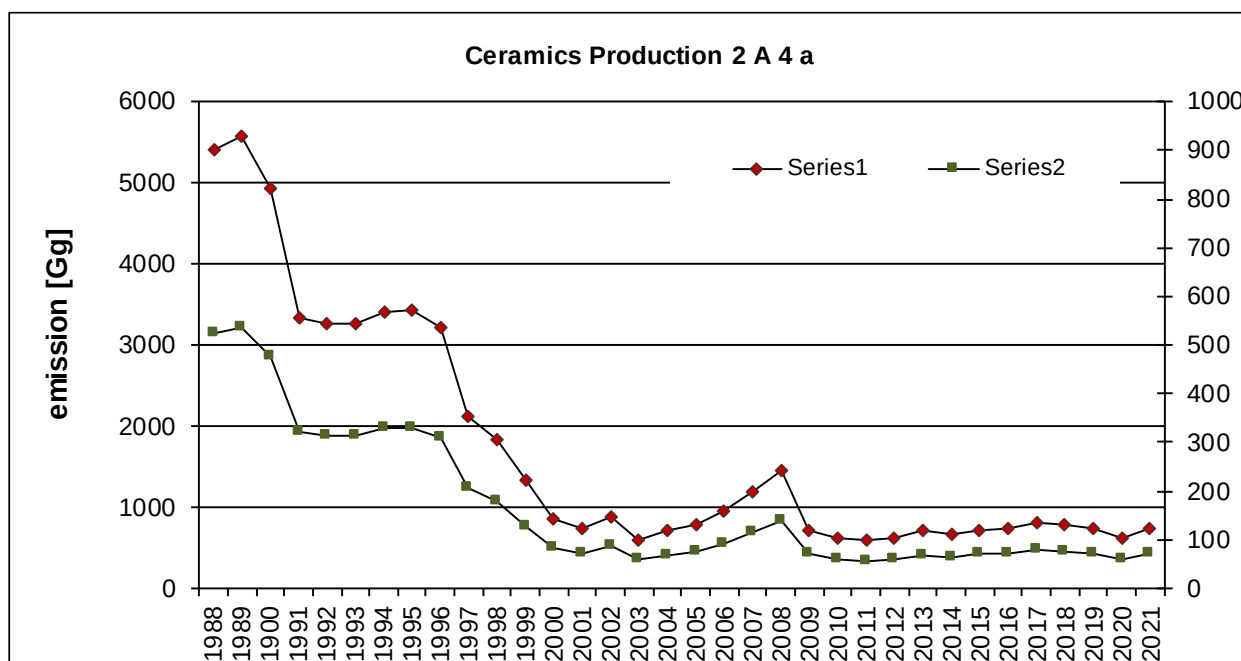


Figure 60 Ceramics Production and CO₂ emission in 2A4a "Other Process Uses of Carbonates"

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 for 2A4a Ceramic Production (Bricks and Tiles).

In emissions estimations the general approach described in the 2006 IPCC Guidelines is applied using the following equation:

$$\text{TOTAL CO}_2 = (\text{AD} \cdot \text{EF})$$

where:

TOTAL CO₂ = the process emission (tonnes) of CO₂

AD = production of ceramics production (tonnes/yr)

EF = the emission factor for CO₂ for ceramics produced.

4.2.4.3.2 CO₂ 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 CO₂)

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 m³ 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 2020 are estimated to 71.88 kt and the production is 745.44 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 121 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	5419,08	0,096	522,51
1989	5571,17	0,096	537,17
1990	4929,78	0,096	475,33
1991	3338,48	0,096	321,90
1992	3255,69	0,096	313,91
1993	3268,13	0,096	315,11
1994	3418,26	0,096	329,59
1995	3428,06	0,096	330,53
1996	3218,09	0,096	310,29
1997	2124,06	0,096	204,80
1998	1845,24	0,096	177,92
1999	1329,34	0,096	128,17
2000	859,69	0,096	82,89
2001	745,66	0,096	71,90
2002	892,53	0,096	86,06
2003	598,29	0,096	57,69
2004	716,09	0,096	69,05
2005	790,03	0,096	76,17
2006	947,76	0,096	91,38
2007	1188,96	0,096	114,64
2008	1450,24	0,096	139,83
2009	725,03	0,096	69,91
2010	621,63	0,096	59,94
2011	585,70	0,096	56,47
2012	615,71	0,096	59,37
2013	710,42	0,096	68,50
2014	660,14	0,096	63,65
2015	723,89	0,096	69,80
2016	728,17	0,096	70,21
2017	804,92	0,096	77,61
2018	785,91	0,096	75,78
2019	745,44	0,096	71,88
2020	629,79	0,096	60,72
2021	740,61	0,096	71,41

* 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 IPCC reports on the activity data used.

4.2.4.6 Source specific recalculations

There are no source specific recalculations for this category.

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 CO₂ 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 it is used about 80-90% of the total quantity used 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 caused by a new approach used to calculate the amounts of soda ash used in the country as = production + export – import, and not on the actual used 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 caused by fluctuation in export: approximately 100 000 t less quantity exported than previous years, approximately the same amount of output and about 2000 t more imported quantity compared to 2005.

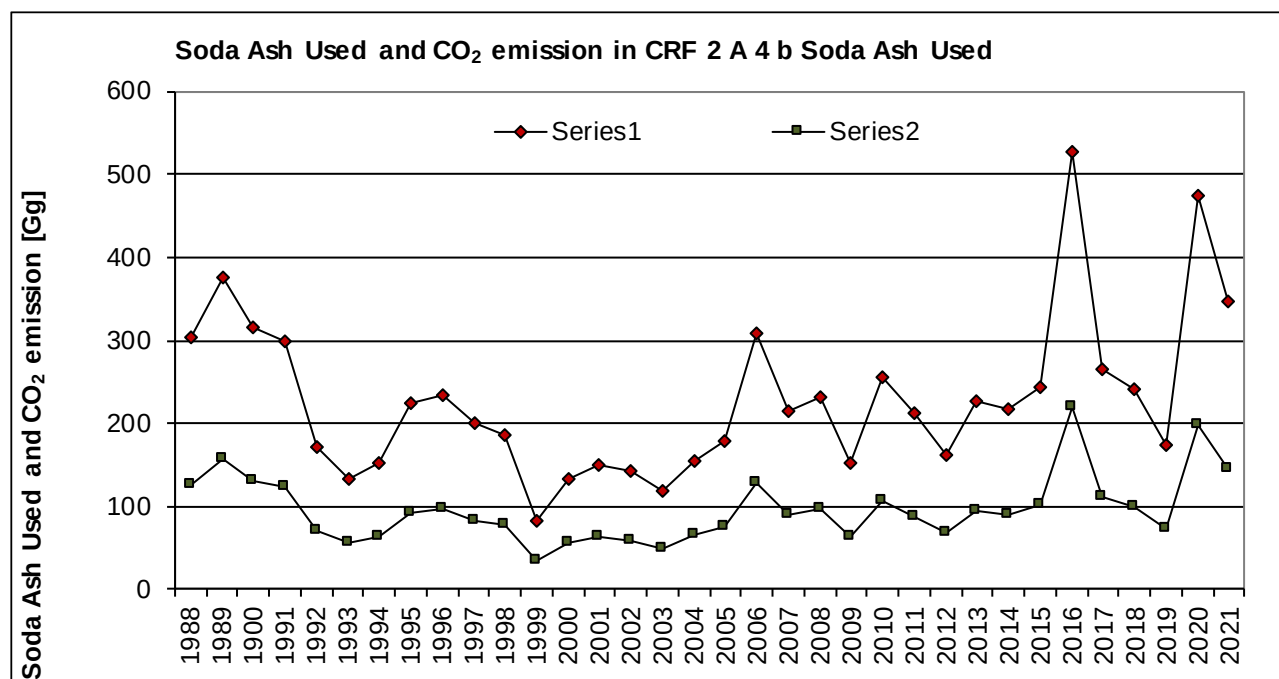


Figure 61 Soda ash used and CO₂ emission in CRF 2.A.4.b “Other Process Uses of Carbonates”

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 Na₂CO₃.

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 CO₂ 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 CO₂/t soda). Plant specific and country specific data were used to estimate CO₂ emissions from Soda ash use.

In emissions estimations the general approach is applied using the following equation:

$$\text{TOTAL CO}_2 = \text{AD} \cdot \text{EF}$$

where:

TOTAL = the process emission (tonnes) of CO₂

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 CO₂ (EF = 415.229 kg CO₂/t soda)

4.2.5.3.2 CO₂ Emission factor

Default emission factor (stoichiometry) of 415.229 kg CO₂/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 2020 are estimated to 197.26 kt and the soda ash used is 475.06 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 122 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
1989	376,79	415,229	156,45
1990	316,39	415,229	131,37
1991	297,79	415,229	123,65
1992	171,96	415,229	71,40
1993	131,96	415,229	54,79
1994	151,86	415,229	63,06
1995	223,34	415,229	92,74
1996	234,48	415,229	97,36
1997	199,95	415,229	83,03
1998	186,70	415,229	77,53
1999	81,41	415,229	33,80
2000	133,50	415,229	55,43
2001	150,73	415,229	62,59
2002	141,56	415,229	58,78
2003	119,17	415,229	49,48
2004	155,47	415,229	64,55
2005	179,07	415,229	74,35
2006	307,56	415,229	127,71
2007	214,85	415,229	89,21
2008	232,72	415,229	96,63
2009	150,95	415,229	62,68
2010	254,42	415,229	105,64
2011	211,72	415,229	87,91
2012	161,80	415,229	67,18
2013	227,35	415,229	94,40
2014	217,94	415,229	90,49
2015	242,46	415,229	100,68
2016	528,03	415,229	219,25
2017	264,95	415,229	110,01
2018	240,60	415,229	99,91
2019	174,34	415,229	72,39
2020	475,06	415,229	197,26
2021	347,20	415,229	144,17

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 CO₂ 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 $\pm 1\%$ - 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

For the subsector it is planned to obtain more detailed activity data and to reallocate the emissions from 2A4b, on soda ash used in glass production. This improvement has not yet been implemented.

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 (SO₂) from the exhaust flue gas of fossil fuel 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 SO₂ 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 CaCO₃. 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 coal-fired 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 SO₂ 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. CO₂ 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 installations 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.

The reduction in 2020 is because of the Covid – 19 pandemic many businesses have remained closed and reduced their production.

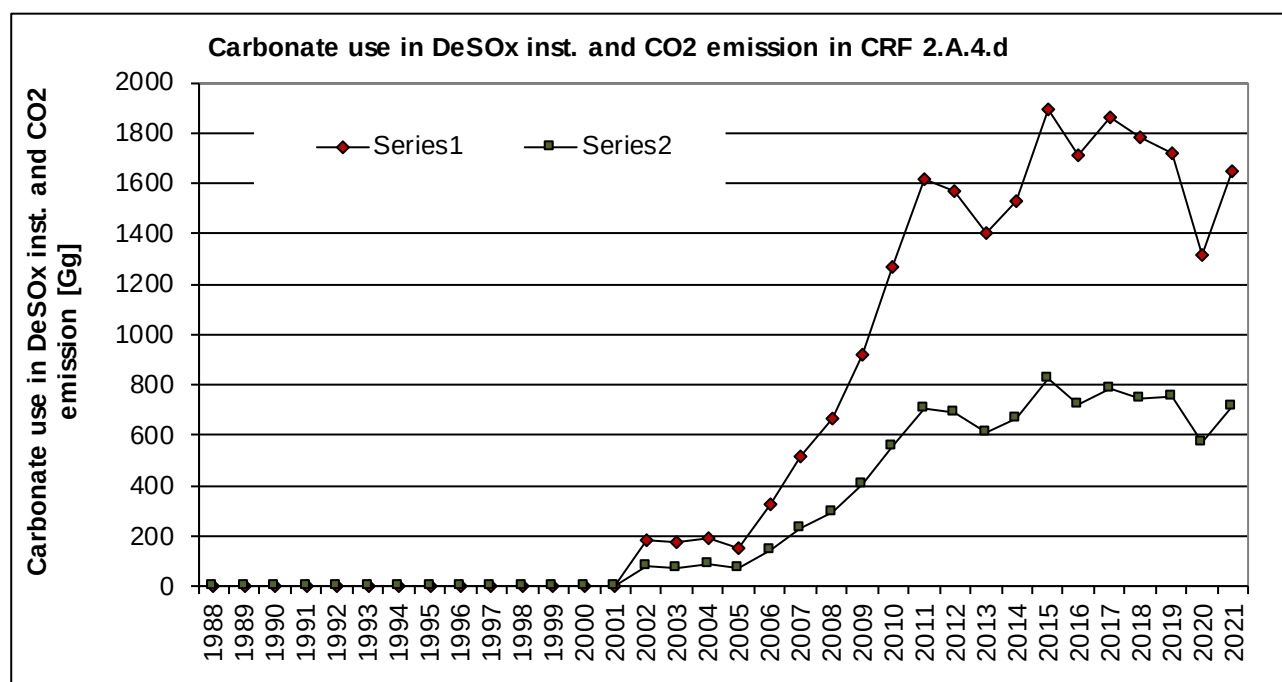


Figure 62 CaCO₃, MgCO₃ use and CO₂ emission in CRF 2.A.4.d "Other Process Uses of Carbonates"

4.2.6.3 Methodological issues

Tier 2 method for the CO₂ emissions estimation is used. The CO₂ emissions estimated using the above equation are taken from the LCP operators the EU ETS reports. The quantities of calcium carbonate

(CaCO₃) and magnesium carbonate (MgCO₃) used for the estimations are also taken from 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 CO₂ emissions estimation is used. Under Tier 2, the amount of CO₂ 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:

$$\text{CO}_2 \text{ Emissions} = (M_{\text{Ca}} \cdot \text{EF}_{\text{Ca}}) + (M_{\text{Mg}} \cdot \text{EF}_{\text{Mg}})$$

Where:

CO₂ Emissions = emissions of CO₂ 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 CO₂/tonne carbonate

The CO₂ emissions estimated using the above equation are taken from the operators EU ETS reports.

4.2.6.3.2 CO₂ Emission factor

The emission factor is based on the mass of CO₂ released per mass of carbonate consumed (2006 IPCC GL, p. 2.7).

The EFs used to estimate CO₂ emissions from desulphurization processes are the following:

$$\text{EF}_{\text{CaCO}_3} = 0.440,$$

$$\text{EF}_{\text{MgCO}_3} = 0.522.$$

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 2020 are estimated to 717.05 kt and the carbonate use is 1646.52 kt and the IEF is 0.435 kt/production, respectively data for the base year (1988) are estimated to 0,0 kt and the carbonate use is 0,0 kt.

Table 123 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]
1988-2001	0,0	-	0
2002	183,58	0,440	80,77
2003	173,28	0,416	72,10
2004	192,61	0,440	84,75
2005	154,26	0,440	67,87
2006	326,62	0,440	143,71
2007	518,91	0,440	228,32
2008	663,61	0,440	292,19
2009	919,70	0,440	404,66
2010	1271,65	0,438	556,68
2011	1618,22	0,438	708,16
2012	1572,51	0,439	690,11
2013	1400,64	0,436	610,83
2014	1532,72	0,436	667,83
2015	1892,29	0,436	825,29
2016	1711,54	0,423	724,01

2017	1865,33	0,421	785,25
2018	1780,88	0,420	748,22
2019	1721,55	0,436	750,95
2020	1313,87	0,435	572,19
2021	1646,52	0,435	717,05

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 CO₂ 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

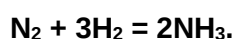
No source specific improvements are planned.

4.3 CHEMICAL INDUSTRY (CRF 2.B)

4.3.1 AMMONIA PRODUCTION (CRF 2.B.1)

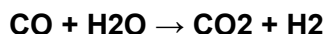
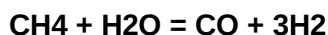
4.3.1.1 Source category description

Ammonia is synthesised from nitrogen and hydrogen by the following reaction:



The technological process for Ammonia production in both of the currently operating plants is similar. Ammonia (NH₃) 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:



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.

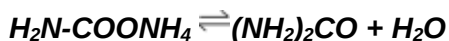
Currently ammonia is produced in two plants in Bulgaria. Both plants are falling under the IPPC Directive and EU ETS. Until the year of 2002 there were four plants operating.

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 (CO_2) at high temperature and pressure to form ammonium carbamate ($\text{H}_2\text{N-COONH}_4$):



The second is urea conversion: the slower endothermic decomposition of ammonium carbamate into urea and water:



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 has been stopped since 2003 with enclosure of operations of two of the four factories for the production of fertilizers in Bulgaria. The two remaining plants do not produce urea.

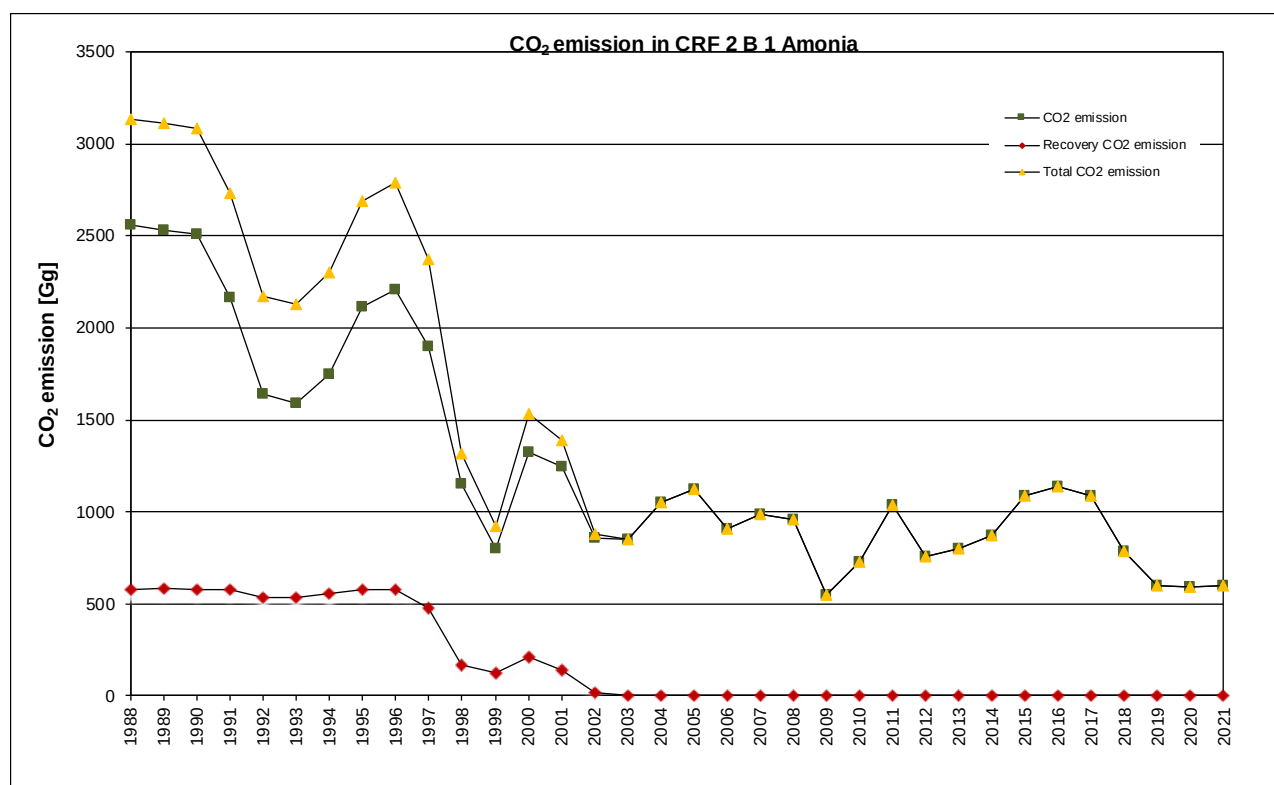


Figure 63 CO2 emissions, recovery CO2 emissions and total CO2 emissions in CRF 2 B 1 Ammonia production

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

CO₂ 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_{CO_2} = 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_{CO_2} = 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 124 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. For more information refer to the relevant part of the BG NIR.

Table 125 Ammonia production and CO_2 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 (without urea) [Gg CO_2]	Recovery CO_2 Emissions (urea) [Gg CO_2]
1988	PS data / NSI	C	C	3135,822	2557,471	578,3507
1989	PS data / NSI	C	C	3117,493	2534,982	582,5107
1990	PS data / NSI	C	C	3086,747	2507,854	578,8927
1991	PS data / NSI	C	C	2735,177	2161,492	573,6848
1992	PS data / NSI	C	C	2172,804	1642,493	530,3106
1993	PS data / NSI	C	C	2126,912	1590,623	536,2883
1994	PS data / NSI	C	C	2302,309	1747,503	554,8059
1995	PS data / NSI	C	C	2690,861	2113,673	577,1881
1996	PS data / NSI	C	C	2787,387	2210,785	576,6022
1997	PS data / NSI	C	C	2375,817	1902,379	473,4382
1998	PS data / NSI	C	C	1318,421	1149,268	169,1529
1999	PS data / NSI	C	C	923,6601	797,0928	126,5673
2000	PS data / NSI	C	C	1530,179	1320,592	209,5861
2001	PS data / NSI	C	C	1385,587	1246,052	139,5345
2002	PS data / NSI	C	C	876,672	859,8794	16,79259

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 (without urea) [Gg CO ₂]	Recovery CO ₂ Emissions (urea)[Gg CO ₂]
2003	PS data	C	C	852,0498	852,0498	0
2004	PS data	C	C	1049,308	1049,308	0
2005	PS data	C	C	1119,731	1119,731	0
2006	PS data	C	C	907,3814	907,3814	0
2007	PS data	C	C	983,3475	983,3475	0
2008	PS data	C	C	957,3828	957,3828	0
2009	PS data	C	C	549,6312	549,6312	0
2010	PS data	C	C	726,1123	726,1123	0
2011	PS data	C	C	1035,753	1035,753	0
2012	PS data	C	C	757,5126	757,5126	0
2013	PS data	C	C	802,1836	802,1836	0
2014	PS data	C	C	872,5179	872,5179	0
2015	PS data	C	C	1084,788	1084,788	0
2016	PS data	C	C	1137,619	1137,619	0
2017	PS data	C	C	1086,476	1086,476	0
2018	PS data	C	C	784,0016	784,0016	0
2019	PS data	C	C	600,7913	600,7913	0
2020	PS data	C	C	592,918	592,918	0
2021	PS data	C	C	595,1264	595,1264	0

*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 value 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 CO₂ 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)

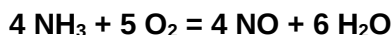
4.3.2.1 Source category description

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.

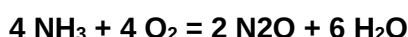
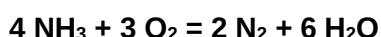
The nitric acid is produced by following general technological steps:

Oxidation of NH₃

NH₃ 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:



Nitrous oxide, nitrogen and water are formed simultaneously in accordance with the following equations:



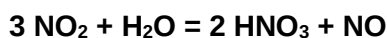
The reaction is carried out in the presence of a catalyst.

Oxidation of NO and absorption in H₂O

Nitric oxide is oxidised to nitrogen dioxide as the combustion gases are cooled, according to the equation:



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 NO₂ in the absorption column is contacted counter currently with flowing H₂O, reacting to give HNO₃ and 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 HNO₃ 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 NO_x abatement)

NSCR (Selective Non-Catalytic Reduction, for NO_x and N₂O 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. In the period 2008/2009 the world economic crisis gave its print on the rates of production in the country.

Emission reduction also is caused by implementin of new and efficient facilities:

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 N₂O emissions the following treatment facilities are utilised after 2005.

- Catalytic converter for N₂O reduction since September 2005 – average efficiency 75%
- Since November 2011 catalyst DN₂O(BASF) – 85% efficiency for N₂O

This is connected with the decrease of the Ammonia production which is performed by the same plants.

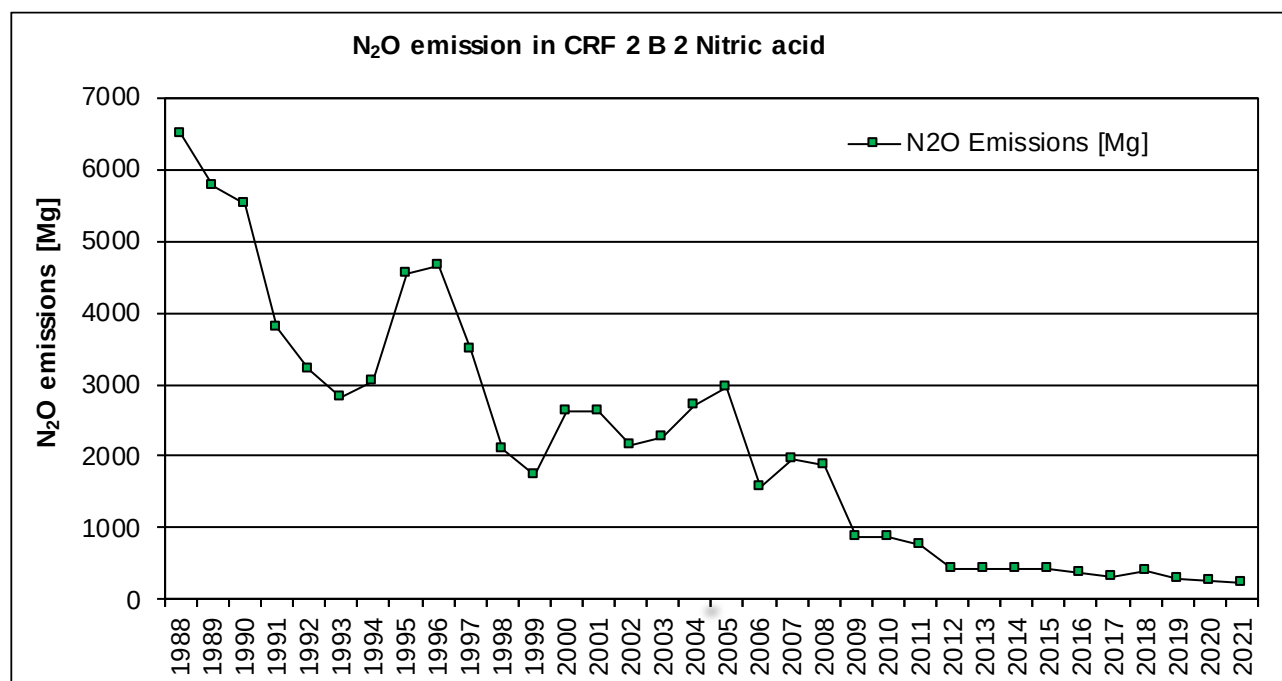


Figure 64 Nitric acid production and N2O emission in CRF 2 B 2 Nitric acid production

4.3.2.3 Methodological issues

4.3.2.3.1 Method

Taking into account the recommendations of the ERT for N₂O emissions from the nitric production, plant specific data are used and a country specific emission factor was developed. Following the Decision tree for N₂O emissions from nitric acid production (IPCC GPG 2000, p. 3.32) plant specific data on N₂O 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 N₂O 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:

$$\text{Emission N}_2\text{O} = \text{IEF} * \text{NAP}$$

Where:

IEF – Implied emission factor,

NAP – Nitric acid production.

4.3.2.3.2 N₂O 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 and unfortunately nowadays no information can be obtained.

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 % HNO₃.

For the third plant activity data from the NSI were used.

The following questionnaire is regularly sent to the plant operators:

Table 126 Questionnaire to plant operator of Ammonia production

1	Nitric acid production (100%)	t
2	N ₂ O emissions	t/y

Table 127 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 ₂ O/kt HNO ₃]	N ₂ O Emissions [kt N ₂ O]
1988	PS data / NSI	C	C	6,48
1989	PS data / NSI	C	C	5,77
1990	PS data / NSI	C	C	5,53
1991	PS data / NSI	C	C	3,80
1992	PS data / NSI	C	C	3,20
1993	PS data / NSI	C	C	2,82
1994	PS data / NSI	C	C	3,04
1995	PS data / NSI	C	C	4,54
1996	PS data / NSI	C	C	4,67
1997	PS data / NSI	C	C	3,49
1998	PS data / NSI	C	C	2,09
1999	PS data / NSI	C	C	1,73
2000	PS data	C	C	2,63
2001	PS data	C	C	2,63
2002	PS data	C	C	2,16
2003	PS data	C	C	2,26
2004	PS data	C	C	2,72
2005	PS data	C	C	2,95
2006	PS data	C	C	1,58
2007	PS data	C	C	1,95
2008	PS data	C	C	1,87
2009	PS data	C	C	0,88
2010	PS data	C	C	0,86
2011	PS data	C	C	0,76
2012	PS data	C	C	0,42
2013	PS data	C	C	0,41
2014	PS data	C	C	0,42

Year	Nitric acid Production (HNO ₃) [kt/y]	Nitric acid Production (HNO ₃) [kt/y]	Emission Factor [kt N ₂ O/kt HNO ₃]	N ₂ O Emissions [kt N ₂ O]
2015	PS data	C	C	0,42
2016	PS data	C	C	0,38
2017	PS data	C	C	0,31
2018	PS data	C	C	0,39
2019	PS data	C	C	0,29
2020	PS data	C	C	0,27
2021	PS data	C	C	0,24

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 the 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 work in 1999 - 2000, statistical data had to be used. Therefore an uncertainty of 2 % 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.

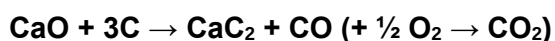
4.3.4 CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID PRODUCTION (2.B.4)

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:



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:

**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.

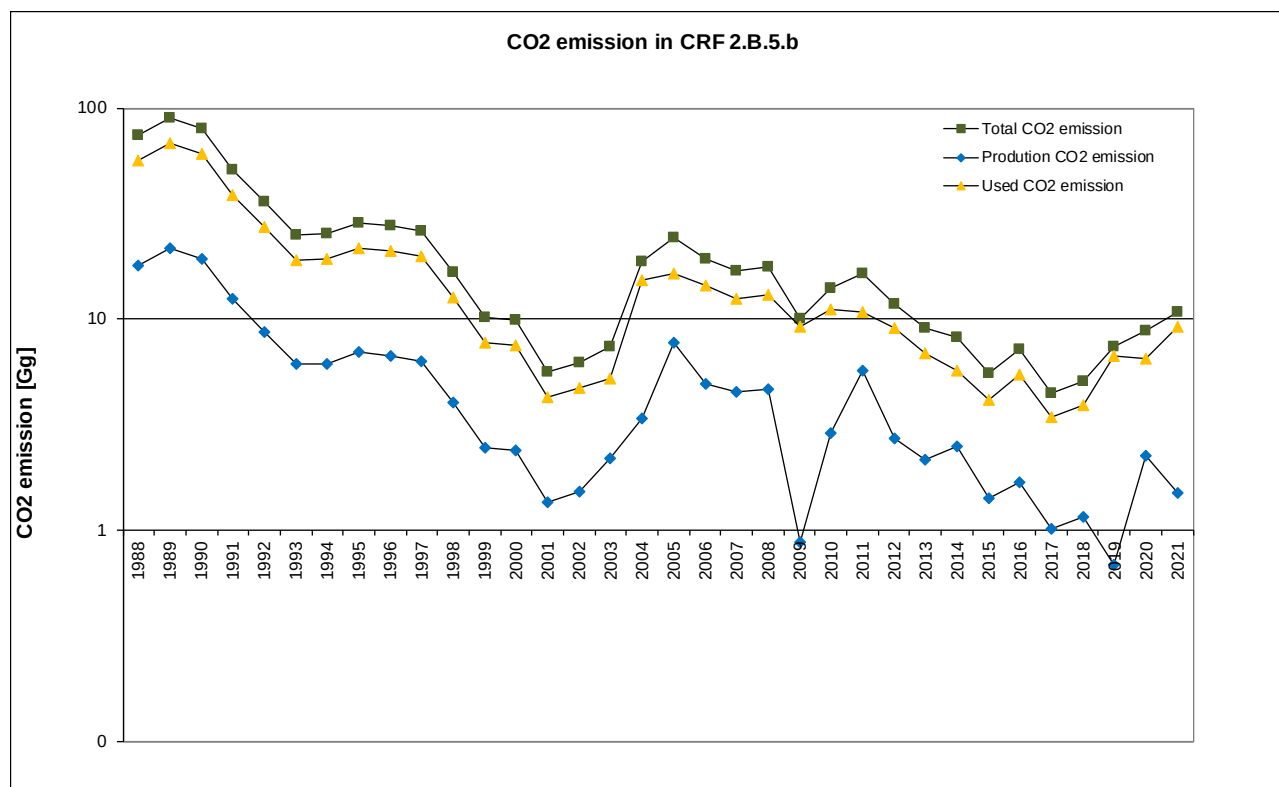


Figure 65 CO₂ emission of Carbide production and use in in logarithmic scale for CRF 2.B.5.b

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 CO₂ 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:

$$E_{CO_2} = (AD_c \cdot EF_c + AD_e \cdot EF_e - AD_p \cdot EF_p) \cdot 44/12$$

E_{CO_2} - emissions of CO₂, tonnes

AD_c - activity data on coal (antracit) consumption, tonnes

AD_e - activity data on graphite electrodes, tonnes

AD_p - activity data on calcium carbide, tonnes

EF_c - emission factor of carbon content in coals (based on data described in sector Energy - CCF, COF – 100%).

EF_e - emission factor of carbon content in graphite electrodes (100%)

EF_p - 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

$$E_{CO_2} = AD_p \cdot EF_p \cdot 44/12$$

The recovered carbon from calcium carbide production is reported as 100% used.

4.3.5.3.2 CO₂ Emission factor

For the consumed amount of fuels using the same emission factors as described in Chapter **Energy**.

For Graphite electrodes (100% "C" CO₂ / C - 44/12) and calcium carbide (2CO₂ / CaC₂ - 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 128 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	73,94	17,89	56,04
1989	C	C	89,94	21,77	68,18
1990	C	C	79,89	19,34	60,56
1991	C	C	51,16	12,38	38,78
1992	C	C	35,76	8,65	27,11
1993	C	C	25,12	6,08	19,04
1994	C	C	25,35	6,13	19,21
1995	C	C	28,65	6,93	21,72
1996	C	C	27,61	6,68	20,93
1997	C	C	26,01	6,30	19,72
1998	C	C	16,68	4,04	12,64
1999	C	C	10,17	2,46	7,71
2000	C	C	9,85	2,38	7,47
2001	C	C	5,63	1,36	4,27
2002	C	C	6,25	1,51	4,74
2003	C	C	7,37	2,18	5,19
2004	C	C	18,70	3,37	15,34
2005	C	C	24,20	7,67	16,53
2006	C	C	19,37	4,90	14,46
2007	C	C	16,97	4,54	12,43
2008	C	C	17,64	4,64	13,00
2009	C	C	10,09	0,87	9,22
2010	C	C	14,03	2,88	11,14
2011	C	C	16,51	5,72	10,80
2012	C	C	11,83	2,73	9,10
2013	C	C	9,02	2,14	6,88
2014	C	C	8,19	2,47	5,71
2015	C	C	5,53	1,42	4,11
2016	C	C	7,16	1,69	5,48
2017	C	C	4,43	1,01	3,42
2018	C	C	5,07	1,15	3,92

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]
2019	C	C	7,34	0,69	6,65
2020	C	C	8,74	2,25	6,49
2021	C	C	10,70	1,50	9,20

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:

Two aspects are relevant (2006 IPCC GL, p. 3.45)

Where activity data are obtained directly from plants, uncertainty estimates can be obtained from operators. This will include uncertainty estimates for petroleum coke and limestone used and for carbide production data. Data obtained from national statistical agencies or from industrial and trade organizations usually does not include uncertainty estimates. It is good practice to consult the national statistical agencies in order 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:

In general, the default CO₂ emission factors are relatively uncertain because industrial-scale carbide production differ from the stoichiometry of theoretical chemical reactions. The uncertainty in the emission factors for CH₄ 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 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 is 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 CO₂-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 plant and 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. A revitalization period followed and the production rates were restored to some degree.

The reason for the declining from 2018 to 2019 is market fluctuation and is not a stable rate decrease. The reduction in 2020 is because of the Covid – 19 pandemic many bussines have remained closed and reduced their production.

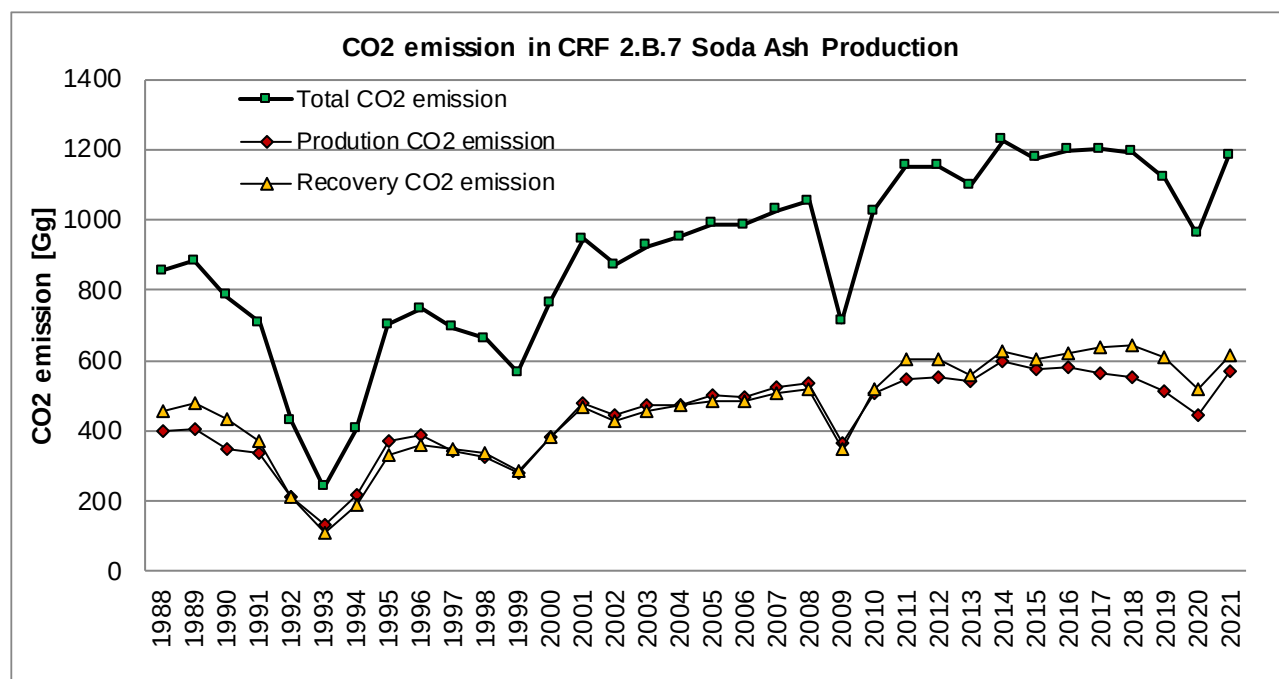


Figure 66 Soda ash production and CO₂ emission in CRF 2.B.7

4.3.7.2 Methodological issues

4.3.7.2.1 Method

Emissions of CO₂ 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 CO₂ 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:

$$E_{CO_2} = E_{CO_2} (\text{used coal}) + E_{CO_2} (\text{production quick lime}) - \text{Recovery } E_{CO_2}$$

E_{CO_2} (used coal) - Emissions from fuel used are calculated in the manner described in chapter Energy.

E_{CO_2} (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_{CO_2} - Recovery CO₂ emissions are calculated using the formula specified in Sector 2.A.4.b Soda ash use.

4.3.7.2.2 CO₂ 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 129 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 CO ₂ Emissions [Gg CO ₂]
1988	C	C	854,42	397,64	456,78
1989	C	C	883,38	404,63	478,75
1990	C	C	783,55	349,14	434,41
1991	C	C	707,83	336,92	370,91
1992	C	C	426,55	212,02	214,53
1993	C	C	239,17	131,44	107,73
1994	C	C	404,91	217,66	187,25
1995	C	C	701,22	370,68	330,54
1996	C	C	747,22	387,60	359,62
1997	C	C	691,89	342,79	349,10
1998	C	C	660,79	322,85	337,94
1999	C	C	565,83	279,08	286,75
2000	C	C	763,55	379,54	384,01
2001	C	C	946,05	479,71	466,34
2002	C	C	871,68	442,62	429,05
2003	C	C	926,11	471,25	454,85
2004	C	C	950,16	475,94	474,22
2005	C	C	988,47	503,30	485,17
2006	C	C	985,37	498,51	486,87
2007	C	C	1028,13	521,43	506,69
2008	C	C	1054,84	533,90	520,94
2009	C	C	709,69	362,61	347,08
2010	C	C	1024,44	504,88	519,55
2011	C	C	1151,87	548,82	603,05
2012	C	C	1151,67	550,17	601,50
2013	C	C	1099,71	538,76	560,95
2014	C	C	1227,85	599,18	628,67
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
2018	C	C	1192,26	550,78	641,48
2019	C	C	1119,63	512,15	607,48
2020	C	C	959,50	442,62	516,88
2021	C	C	1184,93	569,43	615,50

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 proportional to 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 was used the uncertainty of 2 % for activity data can be 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 CO₂ 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 $\pm 1\%$ - 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 - $\text{C}_2\text{H}_4 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_4\text{Cl}_2$

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. In the official information from the National statistical institute there is no information about vinyl chloride production in the country.

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.

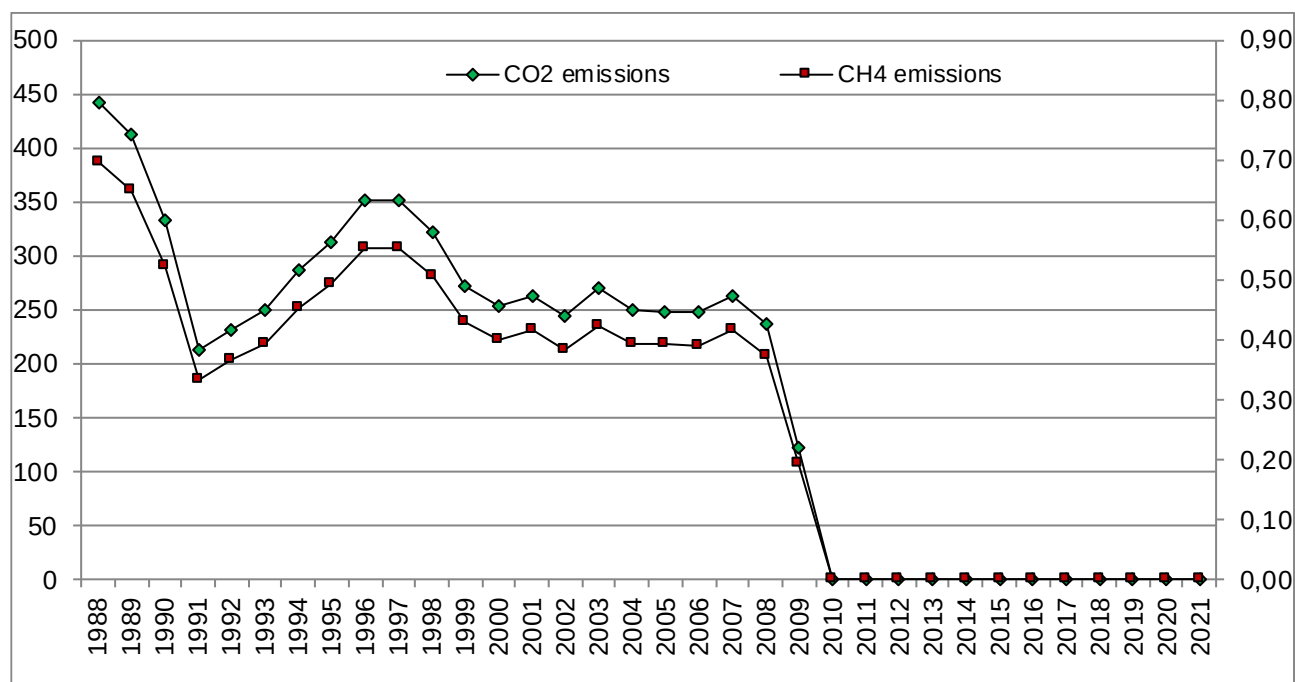


Figure 67 CO2 and CH4 emissions in CRF 2.B.2.b Ethylene production

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.

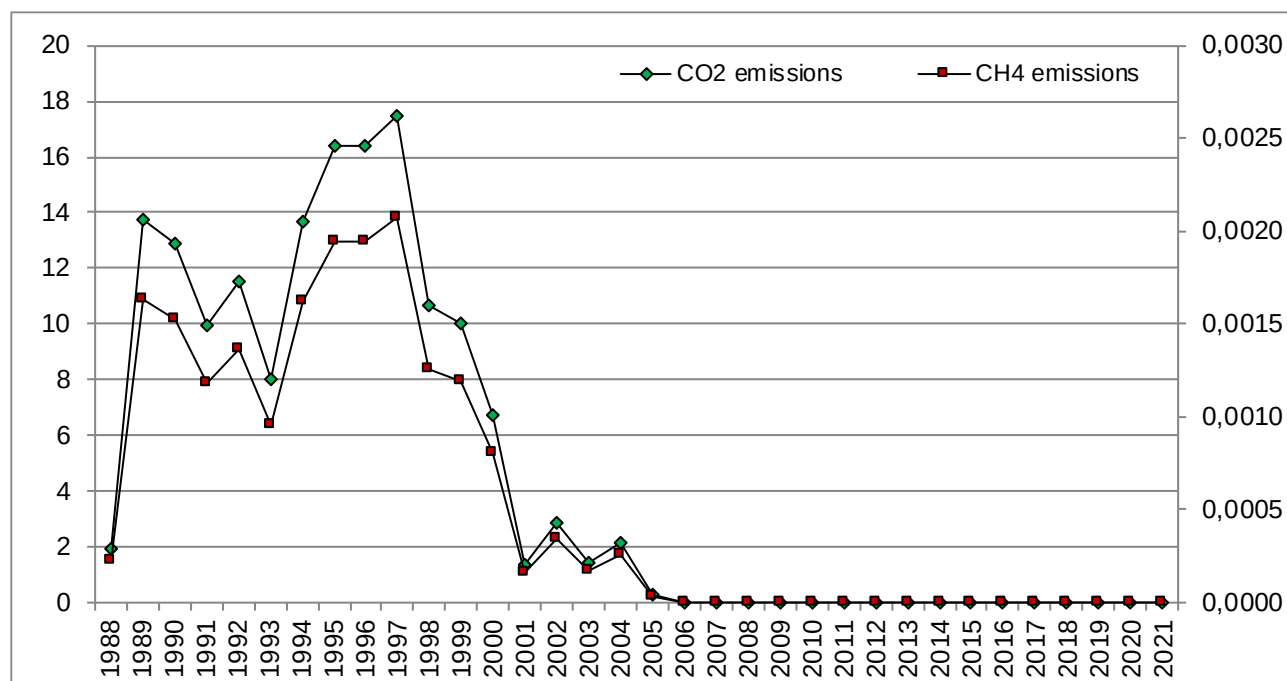


Figure 68 CO2 emissions in CRF 2.B.2.c Ethylene Dichloride production

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 CO₂ and CH₄ 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 CO₂ 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:

$$\text{TOTAL CO}_2/\text{CH}_4 = \sum(\text{AD} \cdot \text{EF} \cdot \text{DGAF})$$

where:

TOTAL CO₂ / CH₄ = the process emission (tonnes) of CO₂ / CH₄

AD = production of ethylene (tonnes/yr)

EF = the emission factor for CO₂ and CH₄ for ethylene produced.

DGAF = default geographic adjustment factor for Eastern Europe

Ethylene Dichloride (2.B.8.c)

Emissions of CO₂ 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:

$$\text{TOTAL CO}_2/\text{CH}_4 = \sum(\text{AD} \cdot \text{EF})$$

where:

TOTAL CO₂ = the process emission (tonnes) of CO₂

AD = production of ethylene dichloride (tonnes/yr)

EF = the emission factor for CO₂ for ethylene dichloride produced.

4.3.8.4.1 CO₂ and CH₄ 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 CO₂/t Ethylene and 3 kg CH₄/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 CO₂ 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 CO₂ Emission Factor) of 0.191 t CO₂/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 CO₂ and 0,70 kt CH₄ (summary 459.5 CO₂ eq) and for the last year of plant exploitation (2009) 121,9 kt CO₂ and 0,20 kt CH₄ (summary 126,9 CO₂ eq.).

Ethylene Dichloride (2.B.8.c)

The quantity of emissions from this activity for the base year (1988) is 1.9 kt CO₂ and 0,0002 kt CH₄ (summary 1.9 CO₂ eq.) and for the last year of plant exploitation (2005) 0.26 kt CO₂ and 0,000003 kt CH₄ (summary 0.26 CO₂ eq.).

4.3.8.5 Uncertainties and time series consistency

Ethylene (2.B.8.b)

	CO ₂	CH ₄
Combined uncertainty	30.41 %	11.18 %
AD	± 5 %	± 5 %
EF	± 30 %	± 10 %

Ethylene Dichloride (2.B.8.c)

	CO ₂
Combined uncertainty	20.62 %
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, because of lack of activity in the moment.

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. In Bulgaria in the beginning of the assessment period (1998), EU (15) steel production was based on the blast furnace/ basic-oxygen route (approximately 65%) and the electric arc furnace (EAF) route (approximately 35%).¹⁹

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, is:

- to reduce the carbon content to a specified level (from approximately 4% to less than 1%, and often lower percent);
- 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).

¹⁹ (ftp://ftp.jrc.es/pub/eippcb/doc/isp_bref_1201.pdf)

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.

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-Decarburisation).

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%).

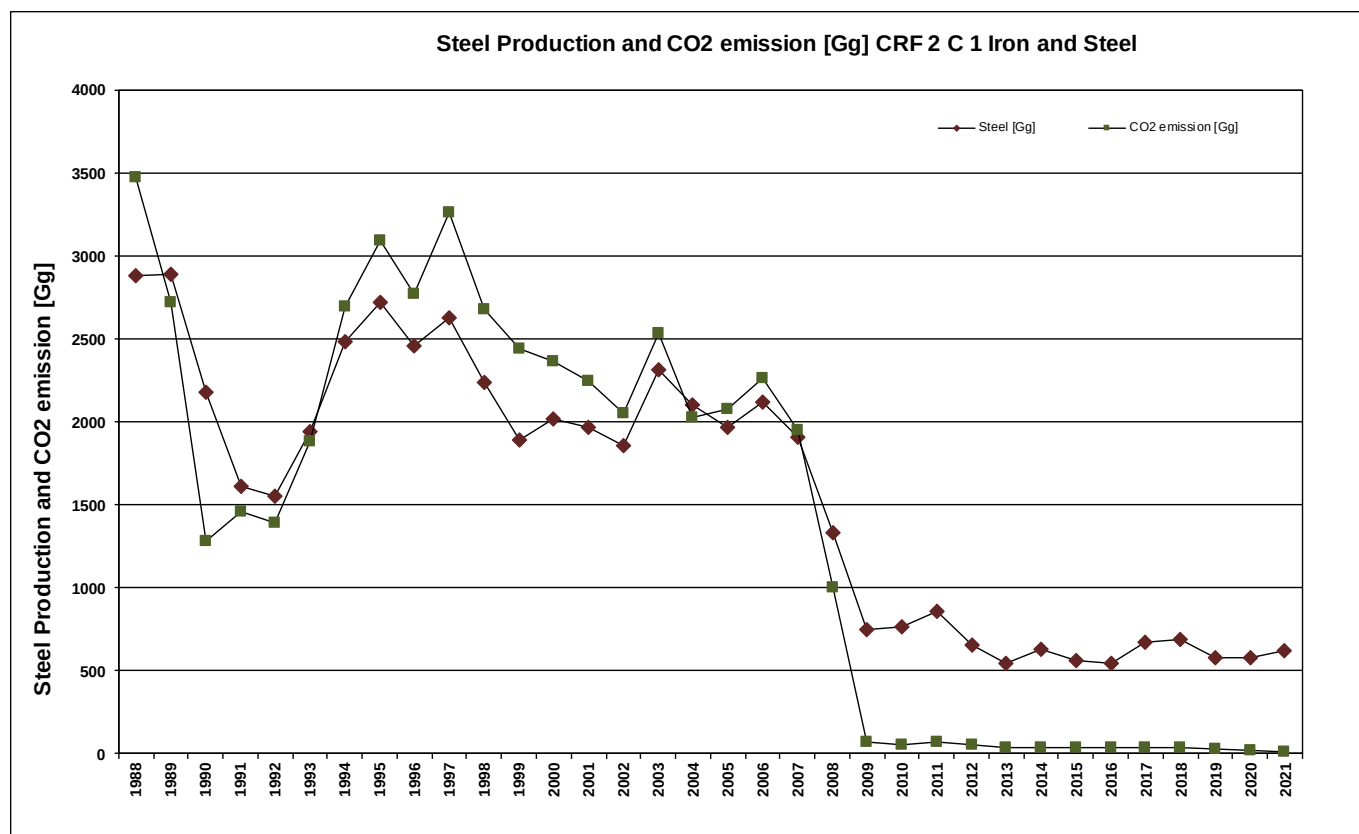


Figure 69 Iron and Steel Production and CO2 emission in CRF 2.C.1.a Iron and Steel production

4.4.1.3 Methodological issues

4.4.1.3.1 Method

Open hearth furnace

To estimate the CO₂ 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 CO₂ 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 CO₂ 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:

$$\text{Iron \& Steel: ECO}_2, \text{ non-energy} = \text{BOF} \cdot \text{EF}_{\text{BOF}} + \text{EAF} \cdot \text{EF}_{\text{EAF}} + \text{OHF} \cdot \text{EF}_{\text{OHF}}$$

4.4.1.3.2 Emission factor

Open hearth furnace – default emission factor is used – 1.72 t CO₂/t Steel (TABLE 4.1)

TIER 1 DEFAULT CO₂ 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 CO₂ 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 Factor_{EAF} • 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 BAM I 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 130 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	1,21	3481,44
1989	BAMI / WSA	2890,00	0,94	2724,87
1990	BAMI / WSA	2180,00	0,59	1283,24
1991	BAMI / WSA	1616,00	0,90	1460,58
1992	BAMI / WSA	1552,00	0,90	1392,13
1993	BAMI / WSA	1942,00	0,97	1883,71
1994	BAMI / WSA	2490,00	1,08	2697,12
1995	BAMI / WSA	2724,00	1,14	3095,68
1996	BAMI / WSA	2457,00	1,13	2771,76
1997	BAMI / WSA	2628,00	1,24	3268,68
1998	BAMI / WSA	2242,00	1,19	2676,82
1999	BAMI / WSA	1889,00	1,29	2444,83
2000	BAMI / WSA	2022,00	1,17	2368,01
2001	BAMI / WSA	1972,00	1,14	2247,66
2002	BAMI / WSA	1860,00	1,10	2055,21
2003	BAMI / WSA	2316,00	1,10	2537,47
2004	BAMI / WSA	2106,00	0,96	2031,37
2005	BAMI / WSA / ETS	1969,00	1,06	2078,16
2006	BAMI / WSA / ETS	2124,00	1,06	2261,72
2007	BAMI / WSA / ETS	1909,00	1,02	1953,25
2008	BAMI / WSA / ETS	1330,00	0,75	1003,16
2009	BAMI / WSA / ETS	744,53	0,100	74,17
2010	BAMI / WSA / ETS	761,41	0,070	53,47
2011	BAMI / WSA / ETS	858,92	0,079	67,96
2012	BAMI / WSA / ETS	653,88	0,077	50,33
2013	BAMI / WSA / ETS	541,23	0,060	32,65
2014	BAMI / WSA / ETS	634,03	0,063	40,22
2015	BAMI / WSA / ETS	563,76	0,066	37,22

Year	Steel Production	Steel Production [kt/y]	Emission Factor [kt CO ₂ /kt Steel]	CO ₂ Emissions [kt CO ₂]
2016	BAMI / WSA / ETS	549,04	0,065	35,86
2017	BAMI / WSA / ETS	673,47	0,052	35,17
2018	BAMI / WSA / ETS	686,91	0,052	35,38
2019	BAMI / WSA / ETS	579,17	0,055	31,58
2020	BAMI / WSA / ETS	579,43	0,038	21,98
2021	BAMI / WSA / ETS	617,57	0,017	10,76

As can be seen in Table 130 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 CO₂ emissions.

For the period 2009-2020, there is no BOF steel production in Bulgaria ceased since the above mentioned 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, CO₂ 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.

CO₂ emissions were taken from ETS reports.

Aggregated national steel production data provided by BAMl and reported by World Steel Association are used for crosscheck.

4.4.1.6 Source specific recalculations

No recalculations were made.

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 was 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).

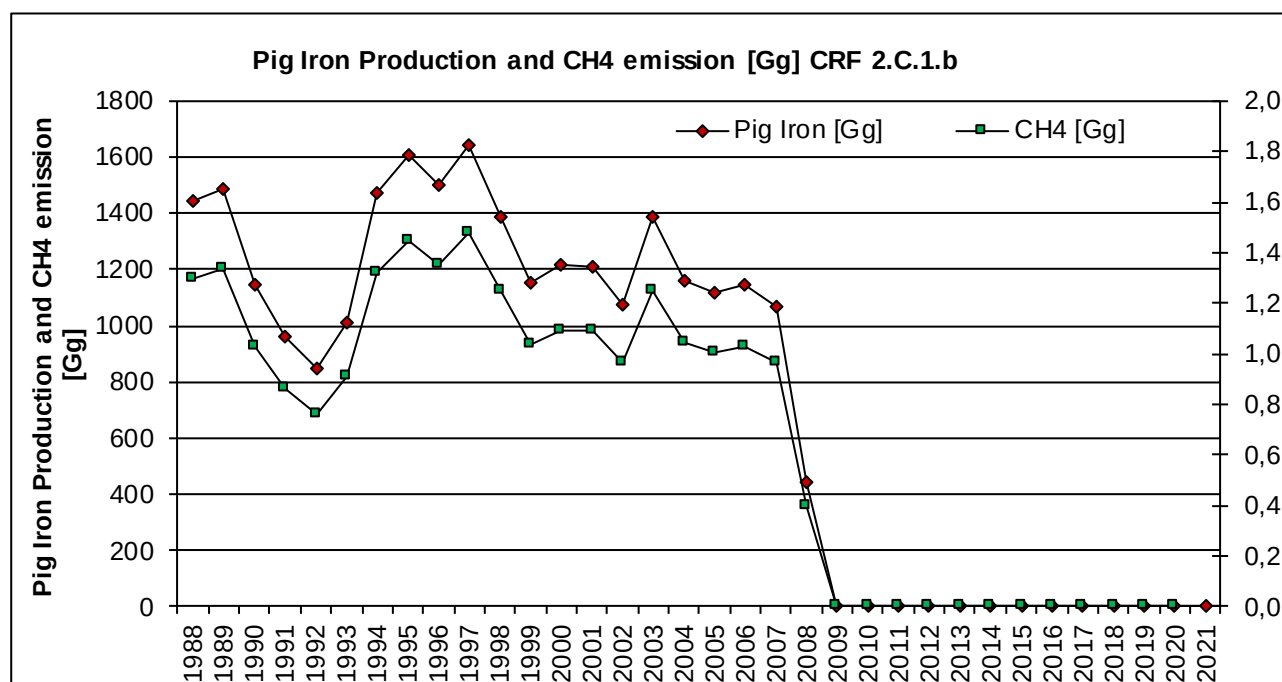


Figure 70 Pig iron Production and CH4 emission in CRF 2.C.1.b Pig iron production

4.4.2.3 Methodological issues

4.4.2.3.1 Method

Tier 1 methodology for CH₄ 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

CH₄ EMISSIONS FROM BLAST FURNACE PRODUCTION OF PIG IRON (TIER 1)

$$E_{CH_4, \text{non-energy}} = PI \cdot EF_{PI}$$

Where

$E_{CH_4, \text{non-energy}}$ – non-energy CH₄ 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 CH₄/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 CO₂ emissions from pig iron production are reported under BOF steel production (see *Basic oxygen steelmaking*).

Table 131 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	0,9	1,30
1989	1487	0,9	1,34
1990	1143	0,9	1,03
1991	960	0,9	0,86
1992	848	0,9	0,76
1993	1013	0,9	0,91
1994	1470	0,9	1,32
1995	1607	0,9	1,45
1996	1504	0,9	1,35
1997	1643	0,9	1,48
1998	1390	0,9	1,25
1999	1152	0,9	1,04
2000	1216	0,9	1,09
2001	1211	0,9	1,09
2002	1072	0,9	0,96
2003	1386	0,9	1,25
2004	1158	0,9	1,04
2005	1115	0,9	1,00
2006	1147	0,9	1,03

Year	Pig Iron Production [kt/y]	Emission Factor [t CH ₄ / kt production]	CH ₄ Emissions [kt CH ₄]
2007	1069	0,9	0,96
2008	440	0,9	0,40
2009 – 2021	0	0,9	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 BAM I 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 CO₂ emissions.

This is only a minor source of CO₂ and CH₄ 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 CO₂ emissions in ferroalloys production are not included. There is not ferroalloys production in Bulgaria for 2020.

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 after 2008. This is due to the fact that a steel making plant which produced sinter, pig iron and steel ceased operation in November 2008.

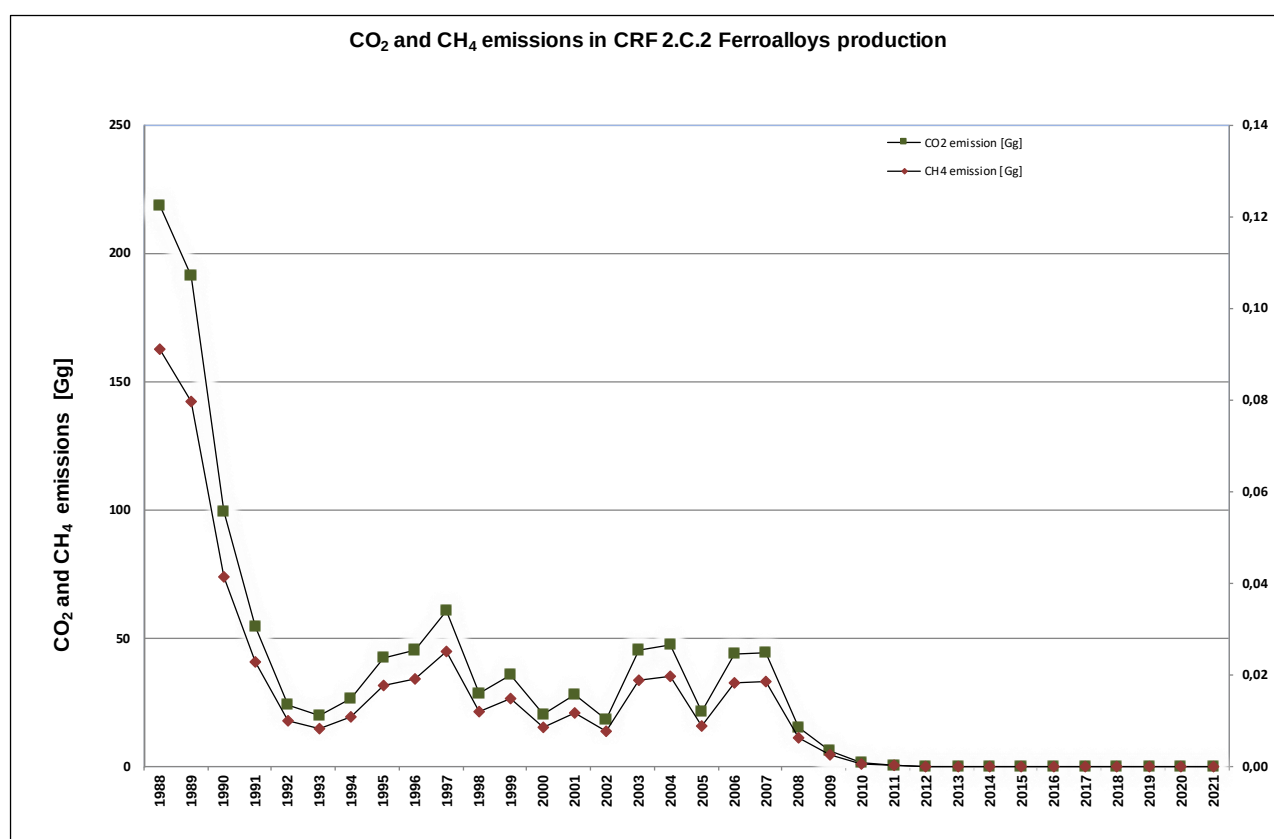


Figure 71 CO₂ and CH₄ emission in CRF 2.C.2 Ferroalloys production

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 CO₂ and CH₄ 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:

$$\text{TOTAL CO}_2/\text{CH}_4 = \sum(\text{AD}_i \cdot \text{EF}_i)$$

where:

TOTAL CO₂ / CH₄ = the process emission (tonnes) of CO₂/ CH₄

AD_i = production of ferroalloy type „I“ (tonnes/yr)

EF_i = the emission factor for CO₂ and CH₄ for ferroalloys produced.

4.4.6.2.3 CO₂ 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 CO₂ emissions and they are presented in the table below by the types of available products and an average EF for CH₄ - 1kg /t.

Table 132 CO₂ emission factors used for different types of products

Ferroalloy types	IEF [kg CO₂/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 133 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
1989	C	0,07984	228,49
1990	C	0,04145	129,37
1991	C	0,02273	73,07
1992	C	0,00998	31,57
1993	C	0,00828	26,90
1994	C	0,01099	35,63
1995	C	0,01766	55,82
1996	C	0,01901	60,41
1997	C	0,02523	79,89
1998	C	0,01201	44,72
1999	C	0,01487	42,28
2000	C	0,00845	21,88
2001	C	0,01165	23,98
2002	C	0,00768	18,05
2003	C	0,01890	44,08
2004	C	0,01982	40,21
2005	C	0,00897	20,10
2006	C	0,01838	40,40
2007	C	0,01849	36,80
2008	C	0,00627	20,99
2009	C	0,00262	7,82
2010	C	0,00065	2,35
2011	C	0,00019	0,62
2012	C	0,00003	0,08
2013	C	0,00002	0,05
2014	C	0,00003	0,08
2015	C	0,00001	0,04
2016	C	0,00002	0,04
2017	C	0,00001	0,02
2018 – 2021	C	0,00000	0,00

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 was impossible to face the modern requirements in the environmental legislation.

The CO₂ 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 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 end.

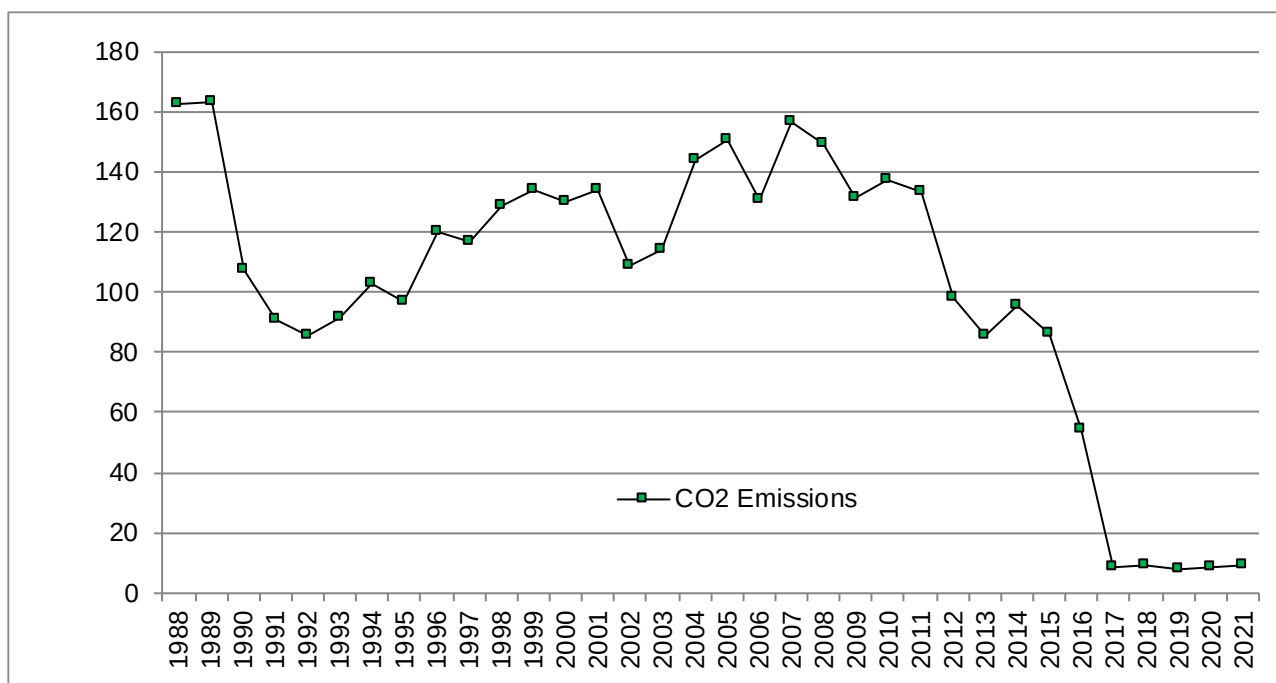


Figure 72 CO2 emissions in CRF 2.C.5 Lead production

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 verified reports and annual environmental reports.

The used methodology is analogous 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.

Activity 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 CO₂ 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 2005-2020 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 (2005-2020) from data, obtained by NSI and the enterprises.

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 CO₂ 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.

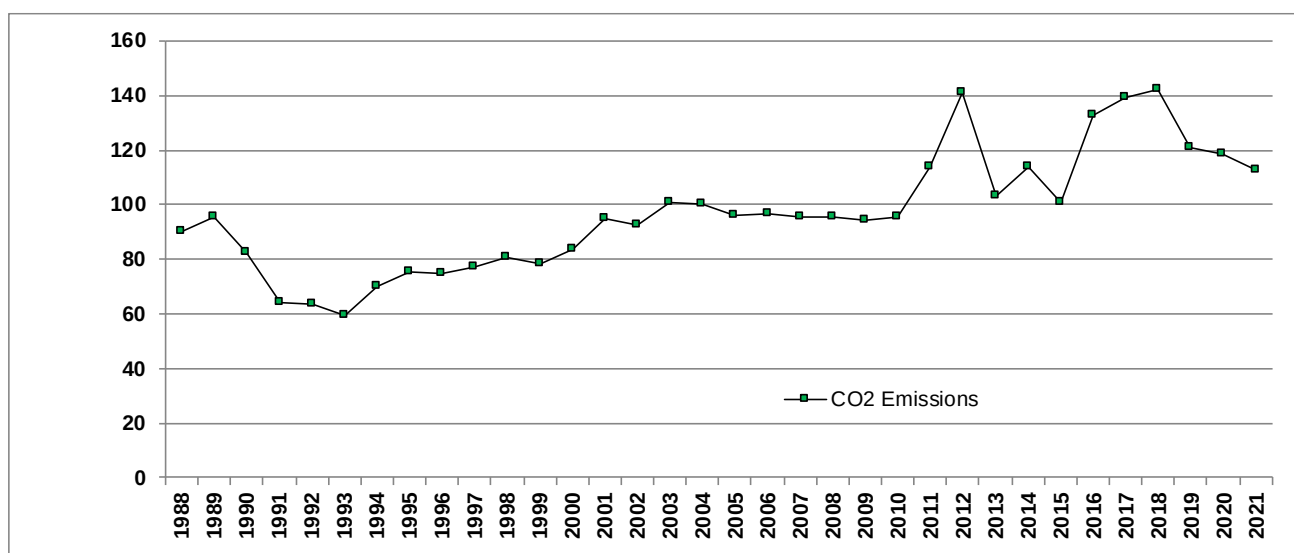


Figure 73 CO2 emissions in CRF 2.C. Zinc production

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 verified EU ETS reports and annual environmental reports.

The used methodology is analogous 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 CO₂ 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 2005-2020 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 (2005-2020) from data, obtained by NSI and the enterprises.

4.4.10.4 Uncertainties and time series consistency

Combined uncertainty	15.81 %
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

This section is established for estimating the emissions from the first use of fossil fuels as a product for primary purposes other than i) combustion for energy purposes and ii) use as feedstock or reducing agent.

The products covered here comprise lubricants, paraffin waxes, bitumen/asphalt, and solvents. Emissions from further uses or disposal of the products after first use (i.e., the combustion of waste oils such as used lubricants) are to be estimated and reported in the Waste Sector when incinerated or in the Energy Sector when energy recovery takes place.

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. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. 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 CO₂ emissions is presented in the following figure. In 2020 emissions have been decreased due to the Covid – 19 pandemic. Many bussines have remained closed and reduced their production.

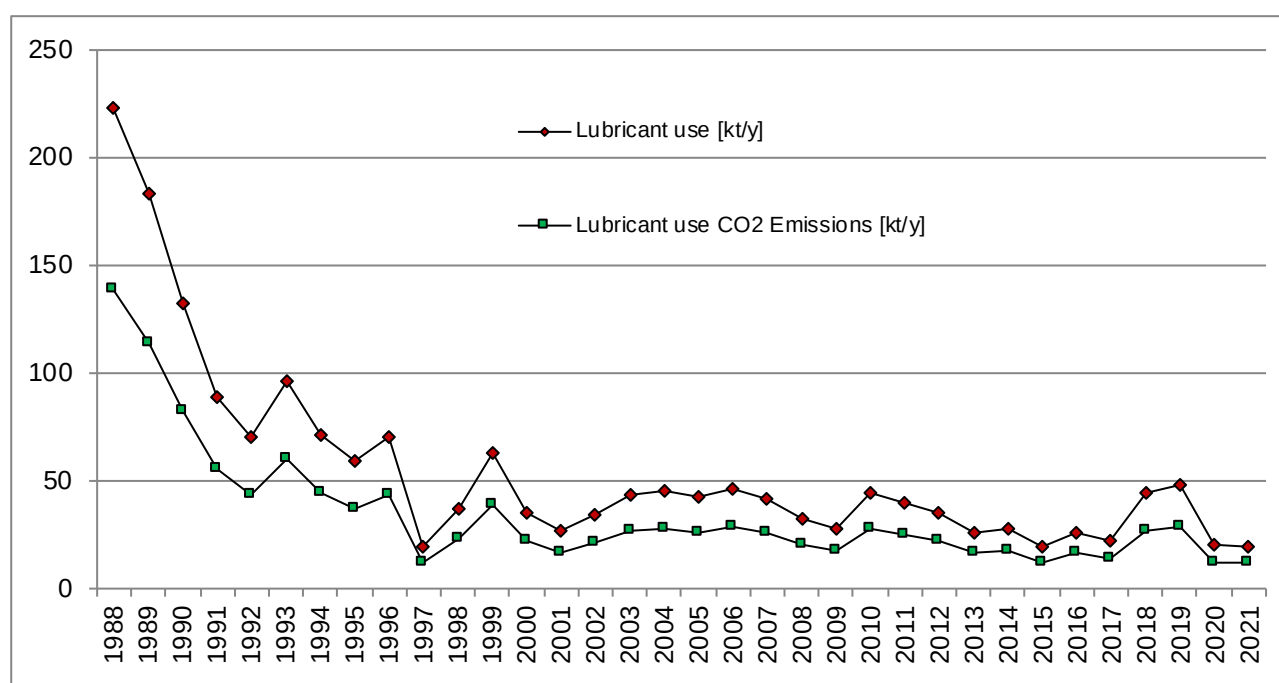


Figure 74 Lubricant use and CO₂ emissions in CRF 2.D.1

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 CO₂ emissions are therefore considered as non-combustion emissions reported in 2D1 Lubricant use. In 2022 submission a recommendation from TERT was fulfilled and the lubricants used in four stroke engines only are included in this category. The emissions from two stroke engines are reported in the Energy sector.

For the calculation of CO₂ 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:

$$\text{CO}_2, \text{Emissions} = \text{AD} \cdot \text{EFlubricant}, \text{CO}_2$$

$$\text{EFlubricant}, \text{CO}_2 = \text{NCVlubricant} \cdot \text{CClubricant} \cdot \text{ODUlubricant} \cdot 44/12$$

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 CO₂/C) yields the emission factor (expressed as tonne CO₂/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 134 Lubricant use and CO₂ emissions in CRF 2.D.1.

CRF 2.D.1 - Lubricant use		
Year	Lubricant use [kt/y]	CO ₂ Emissions [kt]
1988	223,0	138,35
1989	183,0	113,53
1990	132,0	81,89
1991	89,0	55,22
1992	70,0	43,43
1993	96,0	59,56
1994	71,0	44,05
1995	59,0	36,60
1996	70,0	43,43
1997	19,0	11,79
1998	37,0	22,95
1999	63,0	39,09
2000	35,0	21,71
2001	27,0	16,75
2002	34,0	21,09
2003	43,0	26,68
2004	45,0	27,92
2005	42,0	26,06
2006	46,0	28,54
2007	41,0	25,44
2008	32,0	19,85
2009	28,0	17,37
2010	44,0	27,30
2011	40,0	24,82
2012	35,0	21,71
2013	26,0	16,13
2014	28,0	17,37
2015	19,0	11,79
2016	26,0	16,13

CRF 2.D.1 - Lubricant use		
Year	Lubricant use [kt/y]	CO2 Emissions [kt]
2017	22,2	13,77
2018	44,6	26,3
2019	47,6	28,1
2020	19,9	11,7
2021	19,6	11,6

4.5.1.5 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in the following table.

The default ODU factors developed are very uncertain, as they are based on limited knowledge of typical lubricant oxidation rates. The carbon content coefficients are based on two studies of the carbon content and heating value of lubricants, from which an uncertainty range of about ± 3 percent is estimated.

Table 135 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

In 2022 submission a recalculation provoked by recommendation from TERT was fulfilled and the lubricants used in four stroke engines only are included in this category. The emissions from two stroke engines are reported in the Energy sector.

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). 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. 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 CO₂ emissions is presented in the following figure.

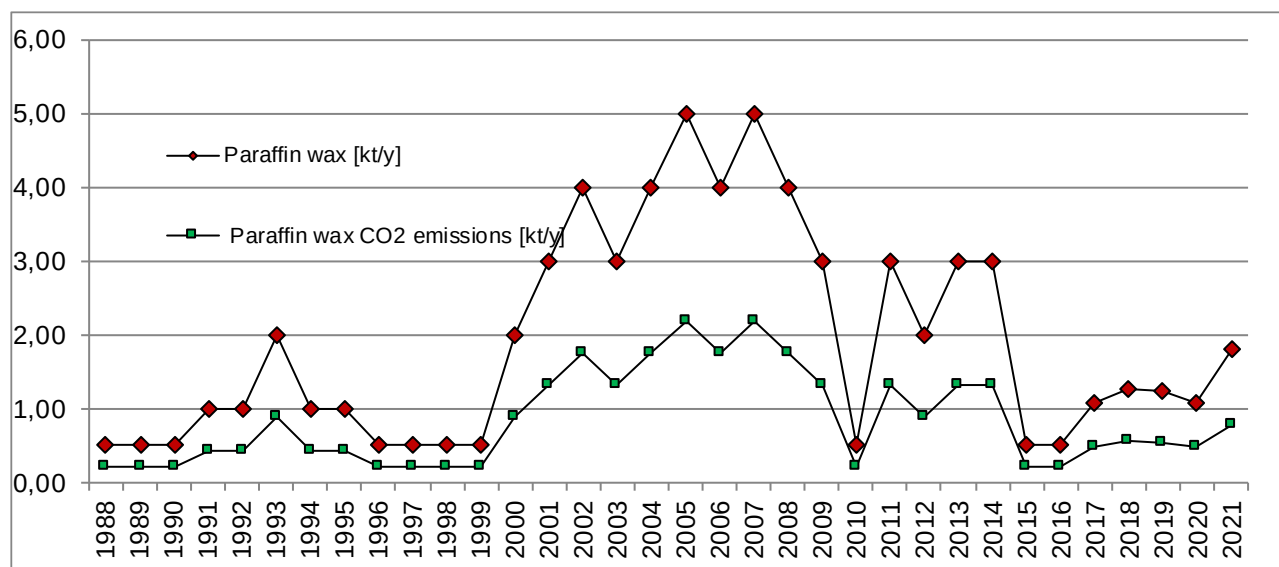


Figure 75 Paraffin wax use and CO2 emissions in CRF 2.D.2.

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 paraffins are combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or in wastewater treatment (for surfactants). In the cases of incineration and wastewater treatment the emissions should 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: CO₂ emissions are calculated according to Equation 5.4 with aggregated default data for the limited parameters available:

$$\text{CO}_2 \text{ Emissions} = \text{PW} \cdot \text{CCWax} \cdot \text{ODUWax} \cdot 44 / 12$$

Where:

CO₂ Emissions = CO₂ emissions from waxes, tonne CO₂

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 CO₂/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]	CO₂ Emissions [kt/year]
1988	0,50	0,22
1989	0,50	0,22
1990	0,50	0,22
1991	1,00	0,44
1992	1,00	0,44
1993	2,00	0,88
1994	1,00	0,44
1995	1,00	0,44
1996	0,50	0,22
1997	0,50	0,22
1998	0,50	0,22
1999	0,50	0,22
2000	2,00	0,88
2001	3,00	1,32
2002	4,00	1,76
2003	3,00	1,32
2004	4,00	1,76
2005	5,00	2,2
2006	4,00	1,76
2007	5,00	2,2
2008	4,00	1,76
2009	3,00	1,32
2010	0,50	0,22
2011	3,00	1,32
2012	2,00	0,88
2013	3,00	1,32
2014	3,00	1,32
2015	0,50	0,22
2016	0,50	0,22
2017	1,09	0,48
2018	1,26	0,56
2019	1,24	0,55
2020	1,09	0,48
2021	1,80	0,79

4.5.2.5 Uncertainties and time series consistency

Much of the uncertainty in emission estimates is related to the difficulty in determining the quantity of nonenergy products used and discarded in individual countries, for which a default of 5 percent may be used in countries with well developed energy statistics and 10-20 percent in other countries, based on expert judgement of the accuracy of energy statistics.

The uncertainty of the GHG emissions is presented in the following table.

Table 136 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;

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 CO₂ 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.

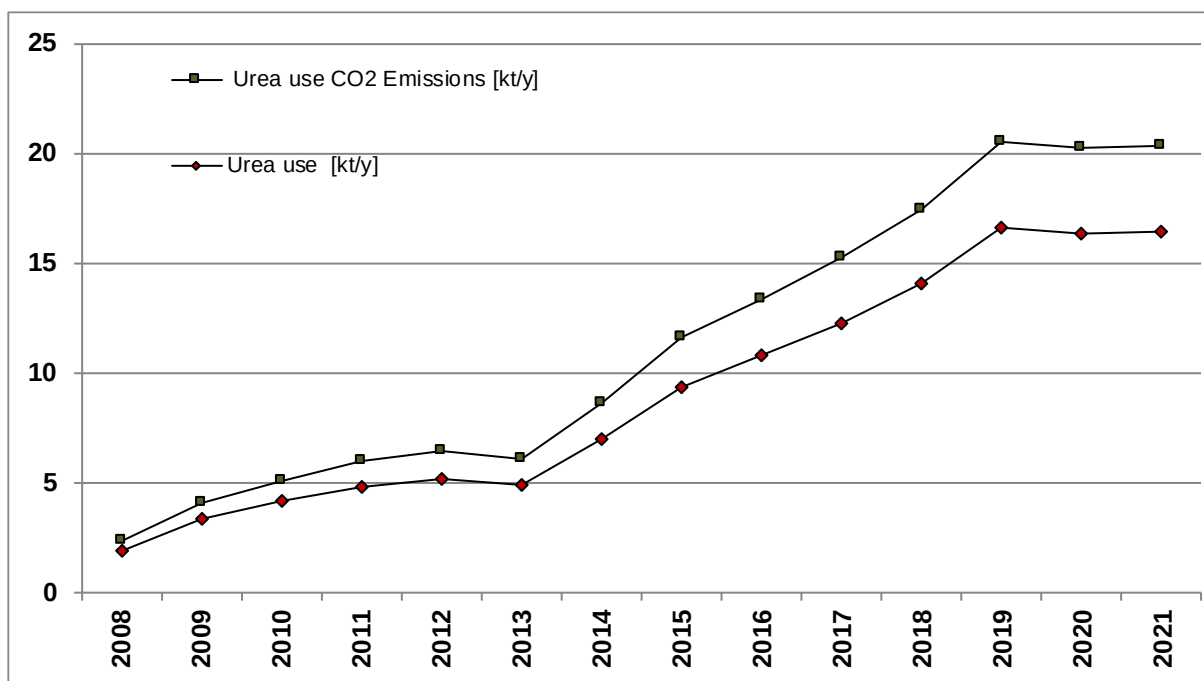


Figure 76 Urea use and CO2 emissions in CRF 2.D.3.d.

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:

$$\text{CO}_2 \text{ Emissions} = \text{EF} \cdot \text{FC} \cdot \text{Share of SCR vehicles mileage} \cdot \text{Specific urea share}$$

“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 CO₂ emissions from urea use in SCR-catalysts in vehicles is a default value (EMEP/EEA 2013) considering the molecular mass conversion of urea into CO₂ 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 137 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]
1988-2007	NO	NO
2008	1,913	0,455
2009	3,305	0,787
2010	4,121	0,981
2011	4,794	1,141
2012	5,203	1,238

2D3D - UREA USE IN SCR CATALYSTS OF DIESEL ENGINES		
Year	Urea use [kt]	CO₂ Emissions [kt/year]
1988-2007	NO	NO
2013	4,923	1,172
2014	6,975	1,660
2015	9,384	2,233
2016	10,805	2,572
2017	12,301	2,928
2018	14,098	3,355
2019	16,614	3,954
2020	16,344	3,890
2021	16,421	3,908

1.1.1.2 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in the following table.

Table 138 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 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 CO₂.

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.

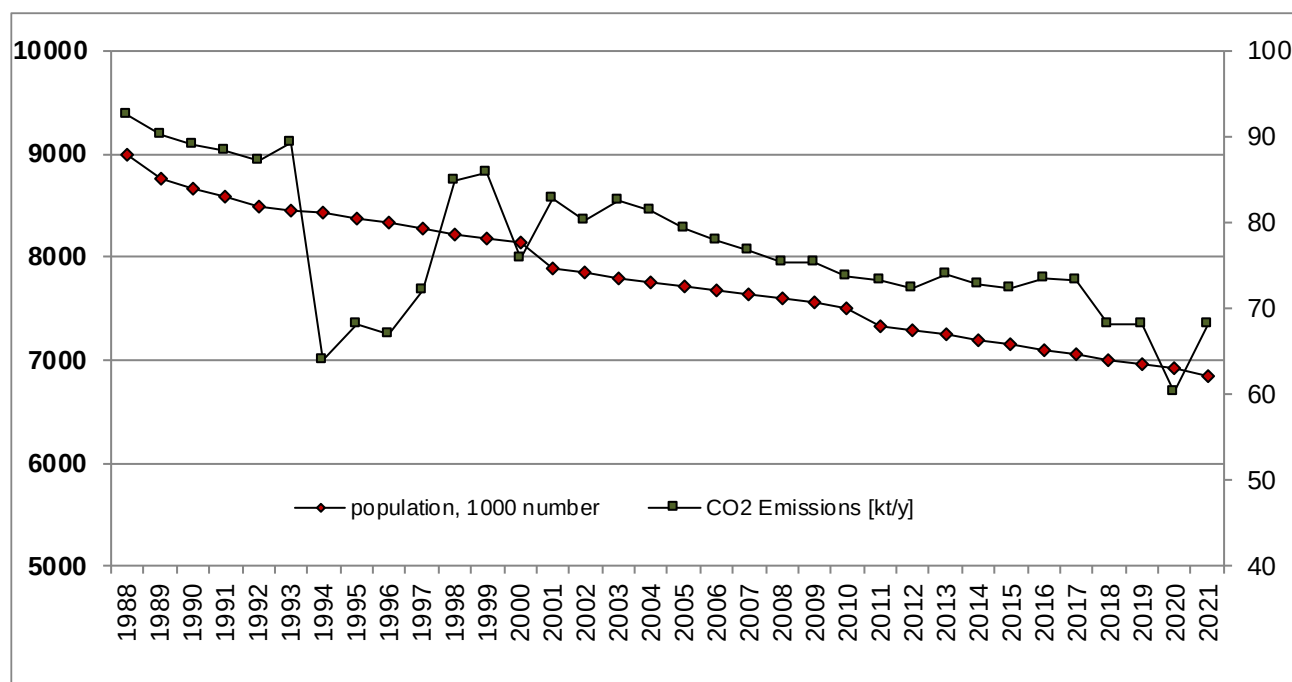


Figure 77 Population and CO2 emissions.

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 factor specified below. Thus obtained CO₂ emissions are subtracted emission category 2G4.

CO₂ emissions:

$$All\ Emission_{CO_2} = AR_{population} \times IEF_{Average}$$

Where:

All EmissionCO₂ = the emission of CO₂

AR population = population of the country)

IEF CO₂ = average CO₂ emission from solvent use per capita value (0.013286 ktCO₂/ population-1000 number).

This equation is applied at national level, using annual national total figures for the activity data.

$$2D3b\ Emission_{CO_2} = All\ Emission_{CO_2} - 2G4\ Emission_{CO_2}$$

NMVOC emissions:

Emissions calculation NMVOC is back interlocking system of proportions of calculating CO₂ emissions as described in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO₂ from NMVOC:

$$2D3b\ Emissions_{NMVOC} = \left(2D3b\ Emission_{CO_2} \times \frac{12}{44} \right) / C$$

Where C is the fraction carbon in NMVOC by mass (default = 0.6)

Reference for default: conversion- factor NMVOC – CO₂, 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 CO₂ 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 ktCO₂/ population-1000 number (average CO₂ 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 139 Solvent use and CO₂ emissions in CRF 2.D.3.b

2D3b – Other solvent used			
Year	Population [1000 number]	CO₂ Emissions [kt CO₂]	CO₂ Indirect Emissions [kt CO₂]
1988	8986,6	92,672	26,726
1989	8767,3	90,286	26,198
1990	8669,3	89,220	25,962
1991	8595,5	88,417	25,784
1992	8484,9	87,214	25,517
1993	8459,8	89,440	22,958
1994	8427,4	63,932	48,036
1995	8384,7	68,077	43,324
1996	8340,9	67,131	43,688
1997	8283,2	72,163	37,889
1998	8230,4	84,952	24,398
1999	8190,9	85,904	22,921
2000	8149,5	75,895	32,381
2001	7891,1	82,917	21,925
2002	7845,8	80,250	23,991
2003	7801,3	82,621	21,028
2004	7761,0	81,503	21,611
2005	7718,8	79,259	23,294
2006	7679,3	78,013	24,015
2007	7640,2	76,715	24,795
2008	7606,6	75,317	25,745
2009	7563,7	75,353	25,140
2010	7504,9	73,687	26,024
2011	7327,2	73,248	24,103
2012	7284,6	72,444	24,340
2013	7245,7	74,046	22,221
2014	7202,2	72,753	22,937
2015	7153,8	72,365	22,681
2016	7101,9	73,573	20,783
2017	7050,0	73,317	20,351
2018	7000,0	68,198	24,806
2019	6951,5	68,140	24,219
2020	6916,5	60,284	31,610
2021	6838,9	68,073	22,790

4.5.4.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in the following table.

Table 140 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

A recalculation was made for the whole time series concerning the indirect CO₂ emissions. The Indirect emissions are calculated according to EMEP CORINAIR 2019 Guidebook.

4.5.4.7 Source specific planned improvements

No source specific improvements are planned.

4.6 ELECTRONICS INDUSTRY (CRF 2.E)

A research showed that this activity is not applicable for Bulgaria and therefore no emissions are present and reported. Although a further research will be made.

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 :

Table 141 Summary of the results for 2021.

Sector	Actual emission	Actual share
	Gg CO ₂ -eq.	%
Solvents	0,00	0,00%
Aerosols	10,18	0,56%
Foams	0,00	0,00%
Domestic refrigeration	4,06	0,22%
Commercial and industrial refrigeration	205,73	11,33%
Transport refrigeration	2,65	0,15%
Domestic AC	1010,60	55,67%
Commercial and industrial AC	111,54	6,14%
Mobile AC	457,75	25,21%
Fire protection	12,96	0,71%
Total	1815,46	100,00%

The following figure shows the emissions for CRF Sector 2.F during 2020 in logarithmic scale so that the small emissions could be visible.

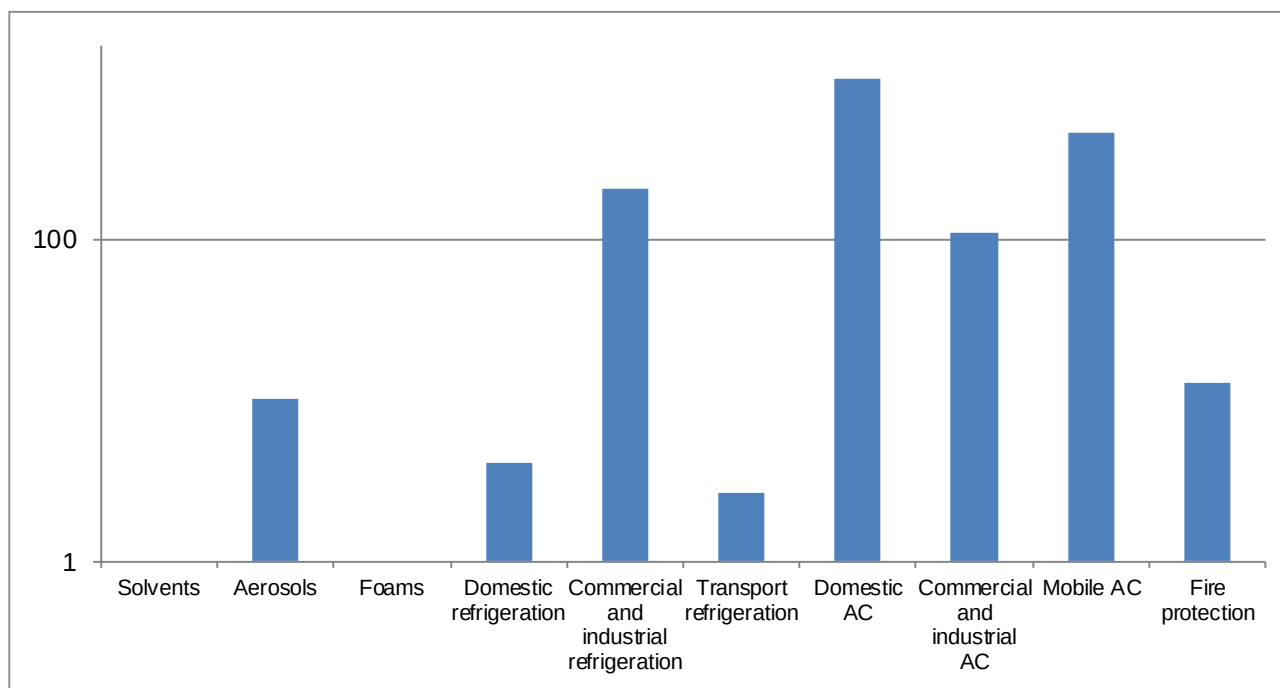


Figure 78 Actual emissions for 2021 [Gg CO₂-eq.]

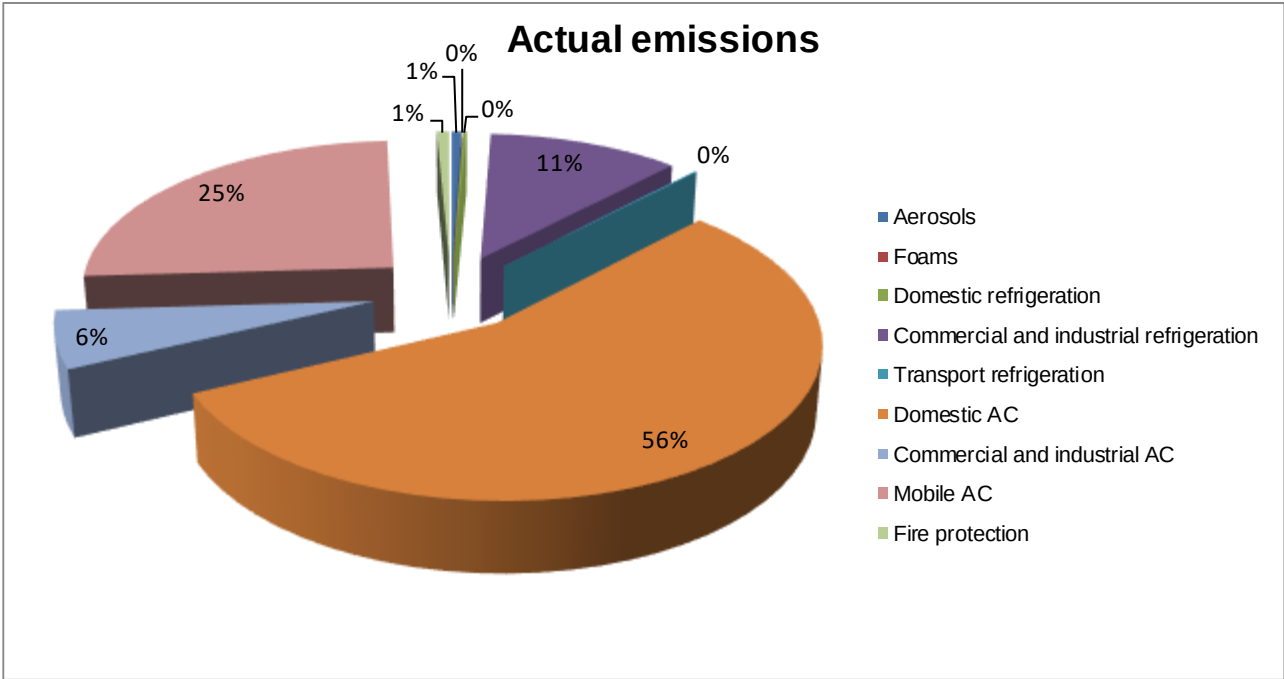


Figure 79 Actual emissions for 2021 [Gg CO₂-eq.]

The following table and figures represent the actual emissions for the whole time series:

Table 142 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 protection	Electrical equipment
1988	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3,40
1989	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3,60
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3,81
1991	NO	NO	NO	0,003	NO	NO	NO	NO	NO	NO	4,03
1992	NO	NO	NO	0,01	NO	NO	NO	NO	NO	NO	4,26
1993	NO	NO	NO	0,02	NO	NO	NO	NO	NO	NO	4,51
1994	NO	NO	NO	0,03	NO	NO	NO	NO	0,96	NO	4,77
1995	NO	NO	NO	0,05	NO	NO	NO	NO	2,96	NO	5,05
1996	NO	NO	NO	0,08	NO	0,04	NO	NO	5,19	NO	5,34
1997	NO	NO	NO	0,10	NO	0,09	NO	NO	8,25	NO	5,65
1998	NO	1,03	NO	0,15	NO	0,13	NO	NO	12,41	NO	5,98
1999	NO	1,63	NO	0,21	NO	0,19	NO	NO	17,63	NO	6,32
2000	NO	0,70	NO	0,24	13,83	0,31	NO	1,42	22,45	NO	6,69
2001	NO	0,31	NO	0,27	14,33	0,48	0,85	2,71	27,58	0,54	7,08
2002	NO	0,76	NO	0,30	21,10	0,69	3,03	3,99	33,47	0,67	7,49
2003	NO	1,20	NO	0,32	27,86	0,99	9,25	5,28	41,45	0,83	7,92
2004	NO	1,74	NO	0,34	34,62	1,34	18,20	6,57	59,05	1,04	8,38
2005	NO	2,39	10,63	0,35	41,39	2,21	29,84	7,86	100,17	1,30	8,42
2006	NO	6,55	30,99	1,27	48,15	2,69	50,17	9,14	144,94	1,62	8,74
2007	NO	9,02	41,96	2,56	54,92	2,95	99,17	10,43	158,46	2,02	9,08
2008	NO	9,40	116,80	3,96	61,68	3,13	177,12	11,72	216,53	2,51	9,44
2009	NO	10,87	58,18	4,53	68,45	2,73	201,99	13,01	256,92	3,47	9,81
2010	NO	9,94	37,88	6,88	75,21	2,40	228,04	14,30	264,13	3,47	19,34
2011	NO	9,44	31,92	7,62	105,85	2,25	266,71	18,39	287,58	4,75	17,49
2012	NO	9,11	26,07	9,29	114,62	2,21	318,87	23,30	293,64	4,77	16,59
2013	NO	9,62	21,40	15,52	131,30	2,23	401,22	28,83	324,98	5,47	21,05
2014	NO	8,68	21,96	18,37	143,60	2,44	464,49	33,71	374,61	5,69	17,40
2015	NO	10,31	24,91	11,65	176,66	2,34	525,47	53,03	424,45	6,38	18,62
2016	NO	13,33	24,29	9,90	176,29	2,27	667,57	53,06	455,19	6,75	19,32
2017	NO	12,07	25,43	8,29	181,52	2,34	1055,15	57,72	447,05	7,14	18,05
2018	NO	12,26	14,54	8,31	190,12	2,11	1452,48	64,77	446,89	7,75	18,54
2019	NO	12,73	35,90	6,59	199,23	2,17	866,71	113,09	455,93	8,41	18,82
2020	NO	12,64	NO	3,78	198,16	2,58	900,26	113,36	457,28	12,18	20,45
2021	NO	10,18	NO	4,06	205,73	2,65	1010,60	111,54	457,75	12,96	23,27

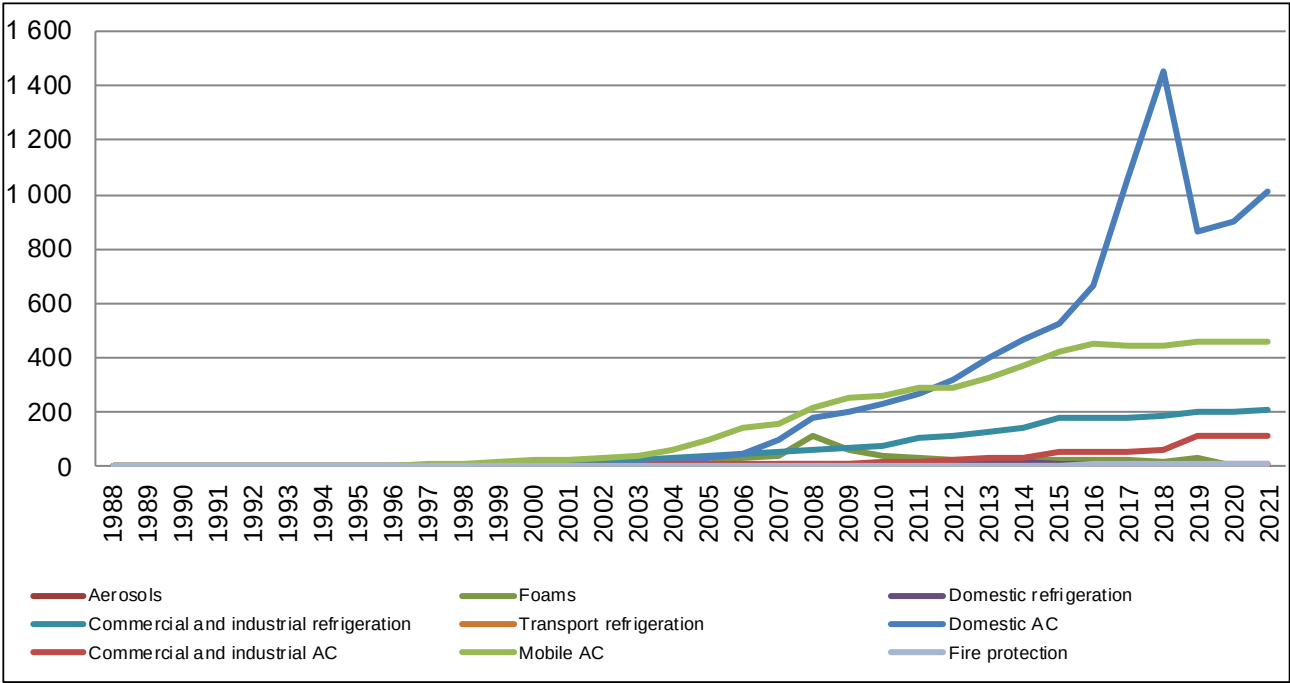


Figure 80 Actual emissions [Gg CO₂-eq.]

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.

In 2024 the ExEA is starting an Informational system (IS) for collecting activity data concerning the air conditioning, refrigeration, fire protection agents. This will have major impact on the transparency of the activity data collection and on the accuracy of the emission estimates. The IS is already under testing procedures and very soon it will be introduced for the people who are obliged to declare controlled substances under this category.

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, the use of CFCs and HCFCs (which were subsequently implemented in the European and national legislation) has been banned, 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 its heterogeneity.

In 2020/2021 some preliminary data were used because of lack of validated statistical information (the NSI is upgrading an Information System) for some subsectors. That is the main reason for the fluctuation in the emissions series in some sub sectors.

The following figure shows the total emissions of HFC (by type) from the sub-sector in logarithmic scale:

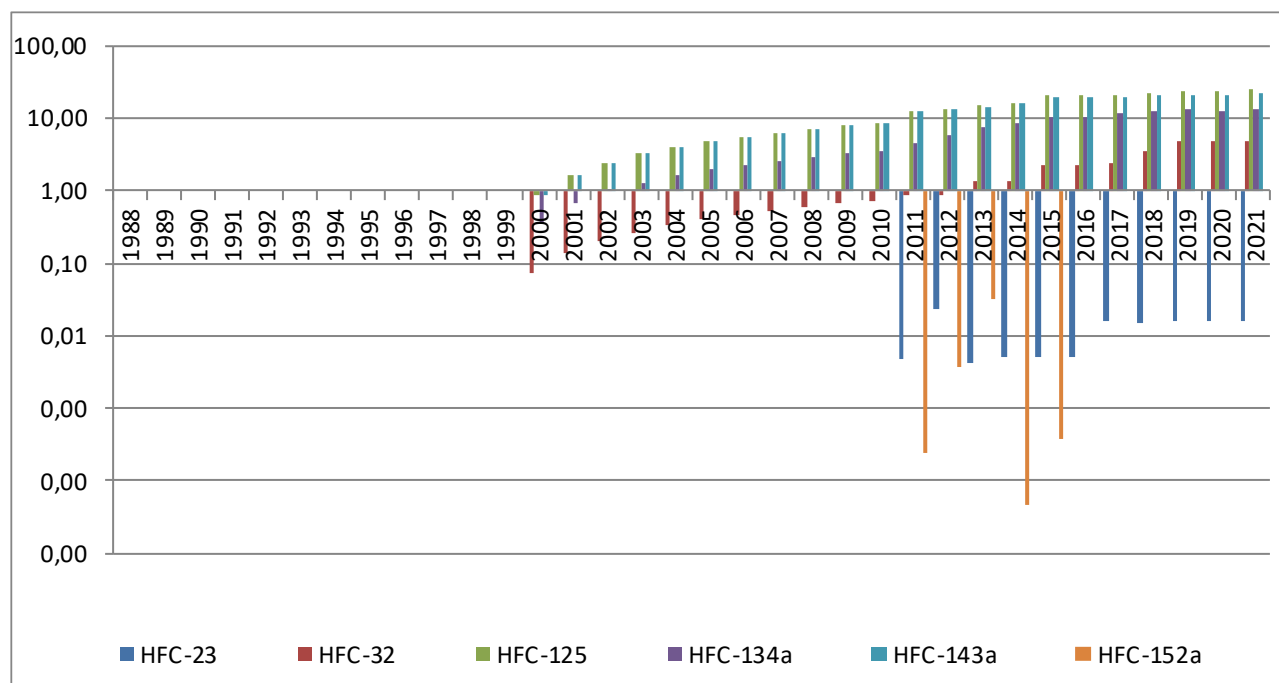


Figure 81 Total emissions by gasses of Commercial and industrial refrigeration in CRF 2.F.1.a and 2.F.1.c

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.

In 2020/2021 some preliminary data were used because of lack of validated statistical information (the NSI is upgrading an Information System) for some subsectors. That is the main reason for the fluctuation in the emissions. The following figure shows the total emissions of HFC (by type) from the sub-sector:

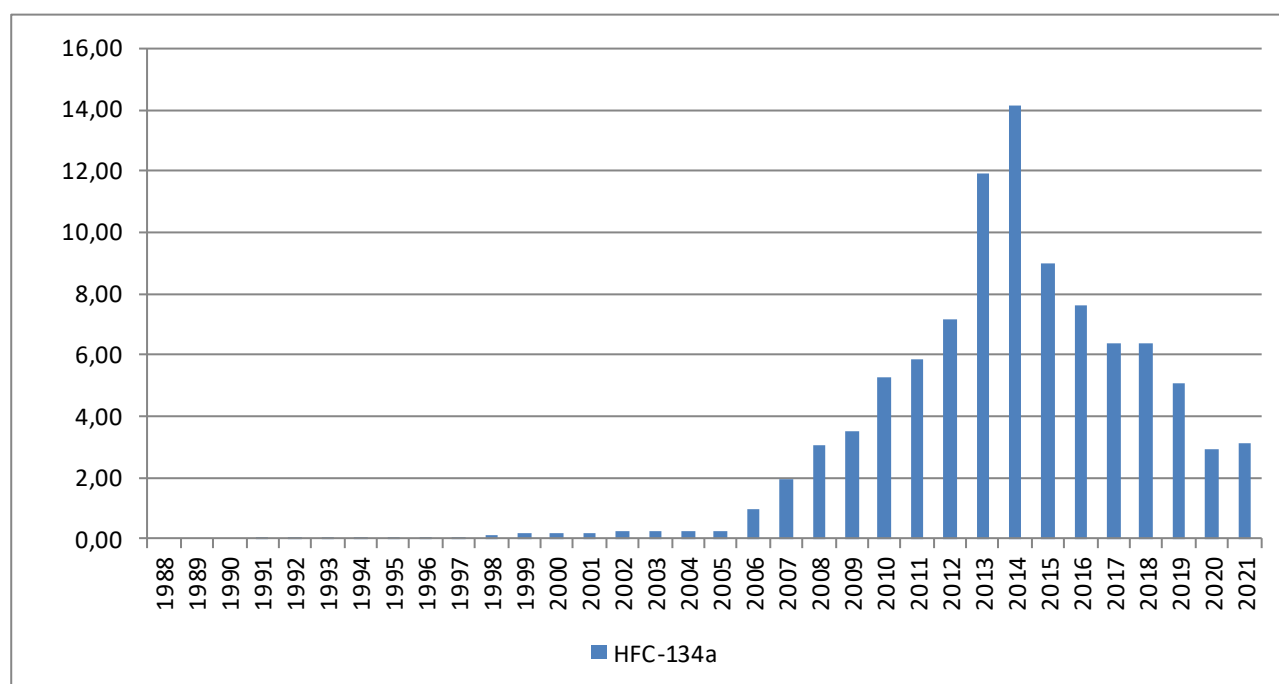


Figure 82 Total emissions of HFC – 134a in Domestic refrigeration in CRF 2.F.1.b

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 submitted 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, an attempted to contact and obtain information directly from some large transport companies, including ones operating outside Bulgaria was made. The 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 were 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 in logarithmic scale:

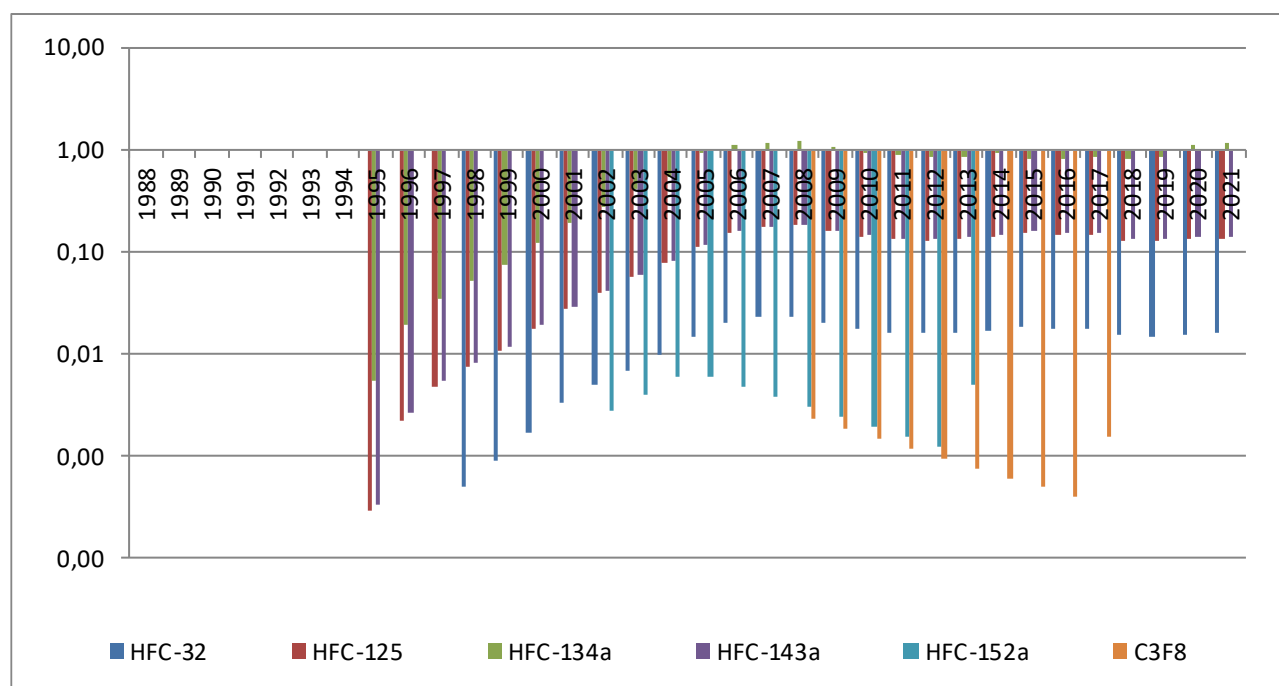


Figure 83 Total emissions by gasses of Transport refrigeration in CRF 2.F.1.d

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 in logarithmic scale:

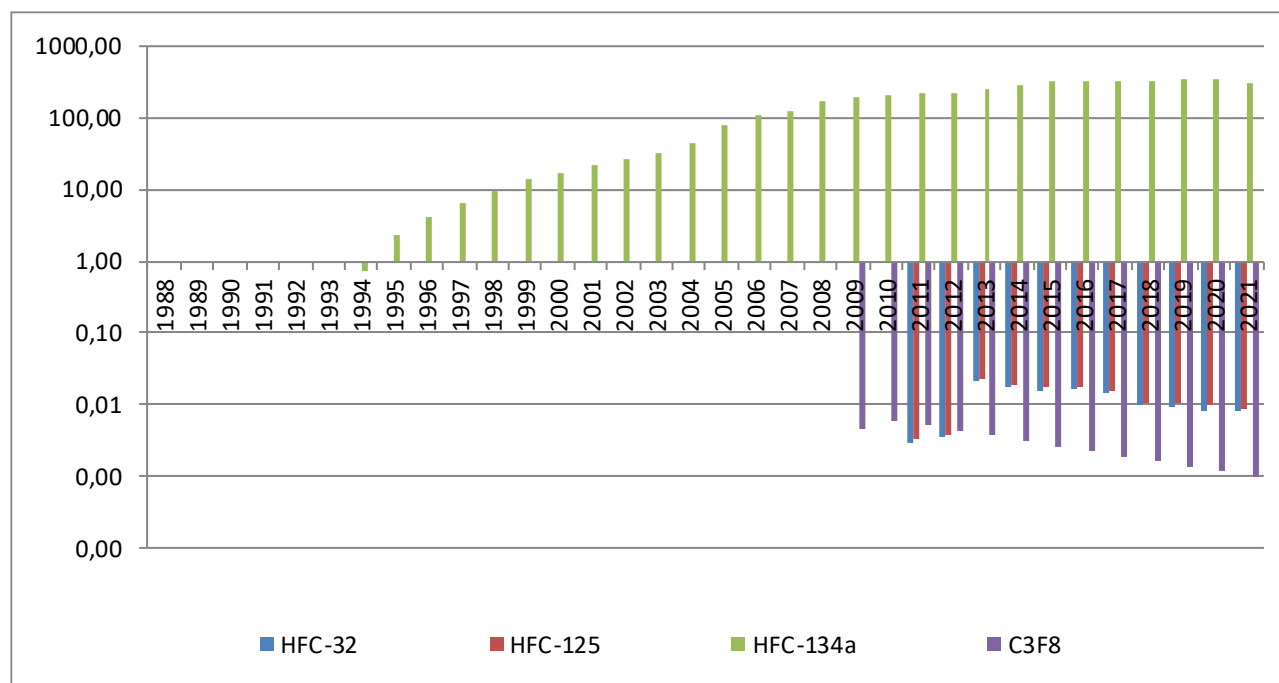


Figure 84 Total emissions by gasses of Mobile air conditioning in CRF 2.F.1.e

4.7.1.1.5 Stationary air conditioning (2.F.1.f)

Stationary air conditioning is divided in 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 in logarithmic scale:

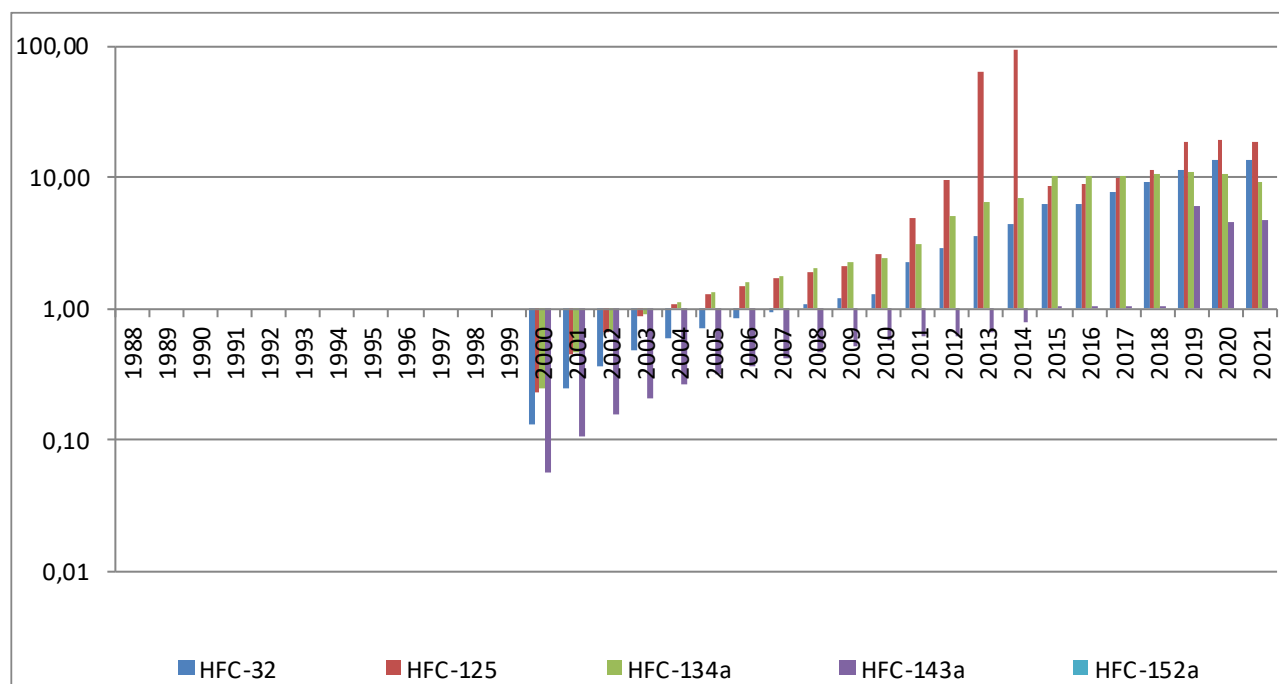


Figure 85 Total emissions by gasses of Stationary air conditioning in CRF 2.F.1.f

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 15 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 2020. 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, 2018), 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 under 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. Regarding the fact that in Bulgaria there has 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 up to nowadays 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 the year of import in Bulgaria was obtained. From 2011 to 2014, 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 the 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 ordinary 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% to 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 refrigeration 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 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 the 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. The equipment lifetime is set to 15 years (as average value) after the emission inventory review in 2020. 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 range 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 – 2020. 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- and therefore it was necessary here on the basis of imports of goods and services (World Bank, 2011) to extrapolate the import 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 . 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 approximately 80% of 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 steady 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 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 implemented.

4.7.1.5 Source-Specific recalculations

- There was a TC from TERT in 2020. Due to technical mistake in applying it, the ERT in 2022 gave us additional recommendations.
- For the subcategory Stationary air conditioning (2.F.1.f) a recalculation was made after the emission inventory review in 2020. The equipment lifetime factor was changed to 15 years.

4.7.1.6 Source-specific planned improvements

In 2024 the ExEA is starting an Informational system for collecting activity data concerning the air conditioning, refrigeration, fire protection agents. This will have major impact on the transparency of the activity data collection and on the accuracy of the emission estimates. The IS is now in the phase of testing and will soon be introduced. There will be no transitional period to evaluate the work of the new IS in accordance to the nowadays approach in activity data collection. There is some possibility of uneven fluctuation in the first year of the IS.

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 CO₂ 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.

There is a significant change in the foam blowing – HFC – 152a amount for due to technological change in one operator's manufacturing in the country. In 2018 the operator with major share started using izobutane instead of HFC – 152a. This lead to a dramatical drop in the emissions series. The remaining quantities were reported in 2019 and 0 emissions from this subcategory in 2020/2021.

The following figures show the activity data for the subsector in CO₂ equivalent:

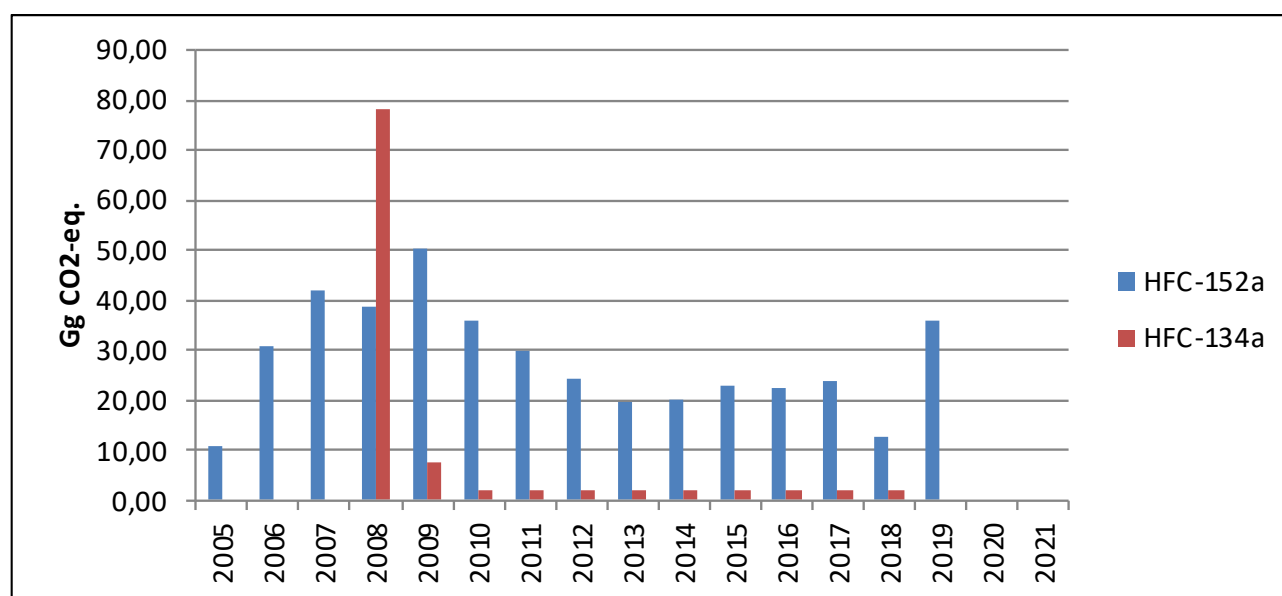


Figure 86 Total emissions Foam blowing CRF 2F2 – HFC 134a and HFC 152a

The following two tables represent the activity data for the subsector:

Table 143 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
1988-2007	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

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
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
2018	NO	C	NO	NO	1.36	NO
2019 – 2021	NO	C	NO	NO	NO	NO

Table 144 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 – 2004	NO	NO	NO	NO	NO	NO
2005	C	C	NO	77,01	NO	NO
2006	C	C	NO	205,28	19,25	NO
2007	C	C	NO	238,30	65,76	NO
2008	C	C	NO	170,61	108,89	NO
2009	C	C	NO	241,65	124,32	NO
2010	C	C	NO	107,20	153,65	NO
2011	C	C	NO	75,77	142,04	NO
2012	C	C	NO	50,04	125,47	NO
2013	C	C	NO	35,15	106,61	NO
2014	C	C	NO	57,13	88,75	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
2018	C	C	NO	8,76	83,78	NO
2019	C	C	NO	NO	260,11	NO
2020	C	C	NO	NO	NO	NO
2021	C	C	NO	NO	NO	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 the import and the 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 performed.

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, because the use of ODS is declining.

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 consulted to, 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. There is fluctuation in the time series because of restricting the Fireprotection regulations in the country for the past several years and more strict requirements are applied in the sector, as long as some fire equipment need a renovation.

The following figure shows the summed activity data for the subsector.

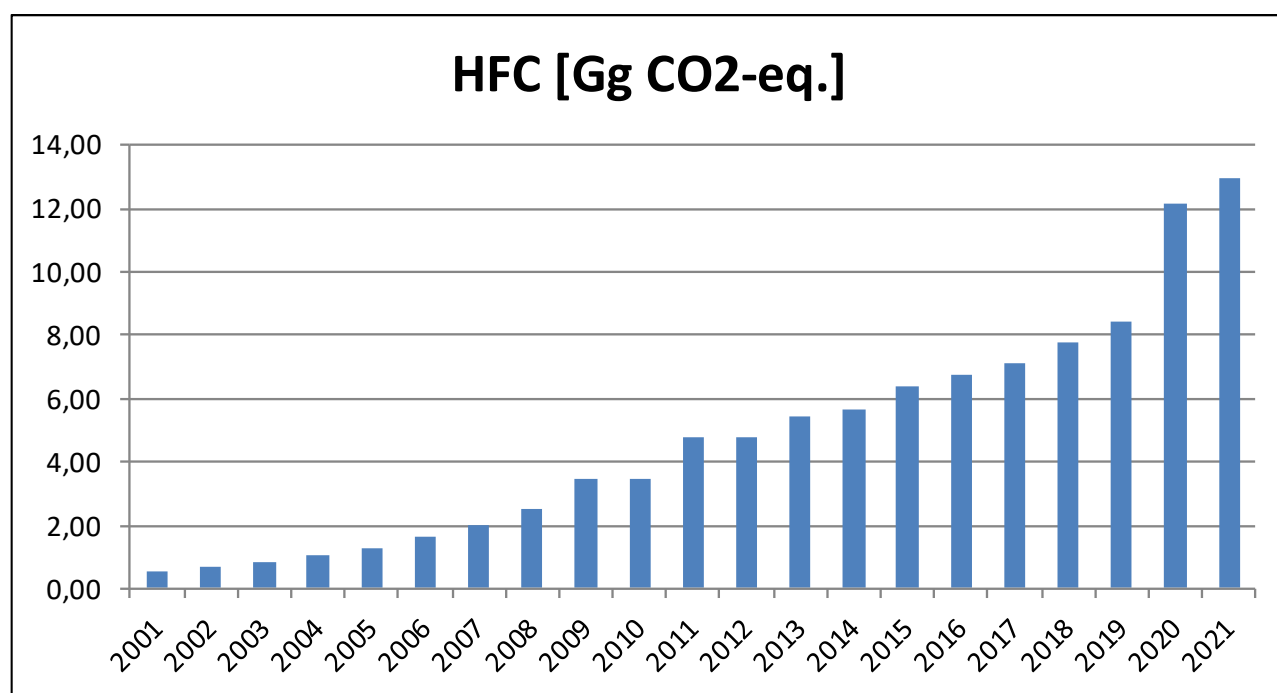


Figure 87 Fire protection CRF 2F3 – Sum of HFC 125 and HFC 227a

The following two tables represent the activity data for the subsector:

Table 145 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 – 2000	NO	NO	NO	NO	NO	NO

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
2001	0,148	0,148	NO	NO	0,007	NO
2002	0,037	0,185	NO	NO	0,009	NO
2003	0,046	0,231	NO	NO	0,012	NO
2004	0,057	0,288	NO	NO	0,014	NO
2005	0,071	0,359	NO	NO	0,018	NO
2006	0,088	0,447	NO	NO	0,022	NO
2007	0,110	0,557	NO	NO	0,028	NO
2008	0,138	0,695	NO	NO	0,035	NO
2009	2,712	3,407	NO	NO	0,170	NO
2010	0,000	3,407	NO	NO	0,170	NO
2011	0,000	3,407	NO	NO	0,170	NO
2012	0,000	3,407	NO	NO	0,170	NO
2013	3,409	6,816	NO	NO	0,341	NO
2014	0,346	7,161	NO	NO	0,358	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
2018	1,789	16,924	NO	NO	0,846	NO
2019	3,302	20,226	NO	NO	1,011	NO
2020	13,536	33,761	NO	NO	1,688	NO
2021	0,729	34,490	NO	NO	1,725	NO

Table 146 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 – 2000	NO	NO	NO	NO	NO	NO
2001	3,065	3,065	NO	NO	0,153	NO
2002	0,756	3,821	NO	NO	0,191	NO
2003	0,943	4,764	NO	NO	0,238	NO
2004	1,176	5,940	NO	NO	0,297	NO
2005	1,466	7,406	NO	NO	0,370	NO
2006	1,827	9,233	NO	NO	0,462	NO
2007	2,278	11,511	NO	NO	0,576	NO
2008	2,841	14,352	NO	NO	0,718	NO
2009	3,162	17,514	NO	NO	0,876	NO
2010	0,000	17,514	NO	NO	0,876	NO
2011	7,649	25,163	NO	NO	1,258	NO
2012	0,114	25,276	NO	NO	1,264	NO
2013	0,953	26,229	NO	NO	1,311	NO
2014	0,977	27,206	NO	NO	1,360	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
2018	1,989	30,273	NO	NO	1,514	NO
2019	0,775	31,047	NO	NO	1,552	NO
2020	9,731	40,778	NO	NO	2,039	NO

2021	3,961	44,739	NO	NO	2,237	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

In 2022 the ExEA is starting an Informational system for collecting activity data concerning the air conditioning, refrigeration, fire protection agents. This will have major impact on the transparency of the activity data collection and on the accuracy of the emission estimates.

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 concerning 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 research 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 in their work.

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 figure represents the activity data for the subsector in the period 1988 – 2021.

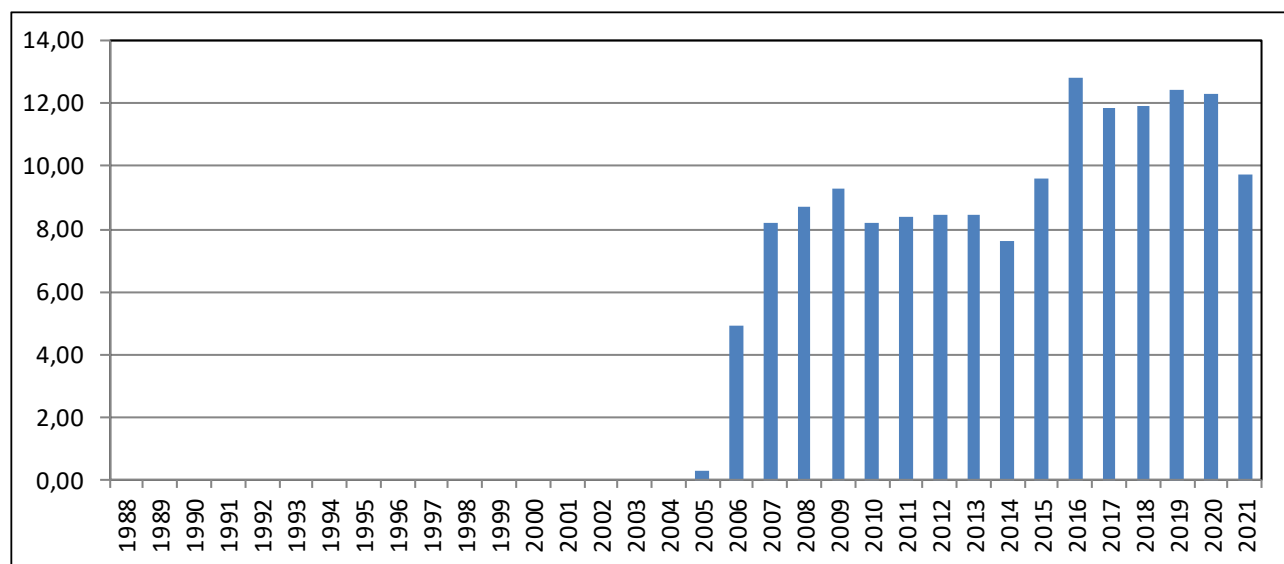


Figure 88 Aerosols CRF 2F4 – HFC 134a

The following table represents the activity data for the subsector:

Table 147 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 – 1997	NO	NO	NO	NO	NO	NO
1998	1,579	0,790	NO	0,021	0,790	NO
1999	0,935	0,467	NO	0,010	1,257	NO
2000	0,138	0,069	NO	0,004	0,536	NO
2001	0,333	0,167	NO	0,010	0,236	NO
2002	0,828	0,414	NO	0,012	0,581	NO
2003	1,017	0,508	NO	0,021	0,923	NO
2004	1,661	0,830	NO	0,021	1,339	NO
2005	2,015	1,007	NO	0,025	1,838	NO
2006	8,061	4,031	NO	0,022	5,038	NO
2007	5,809	2,905	NO	0,016	6,935	NO
2008	8,653	4,326	NO	0,023	7,231	NO
2009	8,064	4,032	NO	0,028	8,359	NO
2010	7,224	3,612	NO	0,027	7,644	NO
2011	7,306	3,653	NO	0,024	7,265	NO
2012	6,712	3,356	NO	0,030	7,009	NO
2013	8,092	4,046	NO	0,029	7,402	NO
2014	5,269	2,634	NO	0,024	6,681	NO
2015	10,586	5,293	NO	0,020	7,928	NO
2016	9,924	4,962	NO	0,010	10,255	NO
2017	8,641	4,320	NO	0,013	9,283	NO
2018	10,218	5,109	NO	0,024	9,429	NO
2019	9,363	4,682	NO	0,007	9,790	NO
2020	10,083	5,041	NO	0,010	9,723	NO
2021	5,583	2,792	NO	0,010	7,833	NO

4.7.4.2 Methodological Issues

According to the 2006 IPCC Guidelines, aerosol emissions are considered to be immediately, occurring during the first year of production. Using data on quantities of HFC-134a consumed by the company for the period 1988-2021, 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.

In the review in 2022 submission was suggested a different emission estimation approach for production.. The emissions from import of meter dose inhaler from import so far were estimated as from Manufacture emissions instead of in operation emissions which was corrected.

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

In the review in 2022 submission was suggested a different emission estimation approach for production.. The emissions from import of meter dose inhaler from import so far were estimated as from Manufacture emissions instead of in operation emissions which was corrected.

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 occurring.

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 occurring.

4.7.7 SEMICONDUCTOR MANUFACTURING (CRF SOURCE CATEGORY NUMBER)

Research showed that this activity is not applicable for Bulgaria and emissions are not occurring.

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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 SF₆ 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 SF₆ and equipment containing SF₆ 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 trend of the emissions in this sector can be seen in the following Figure:

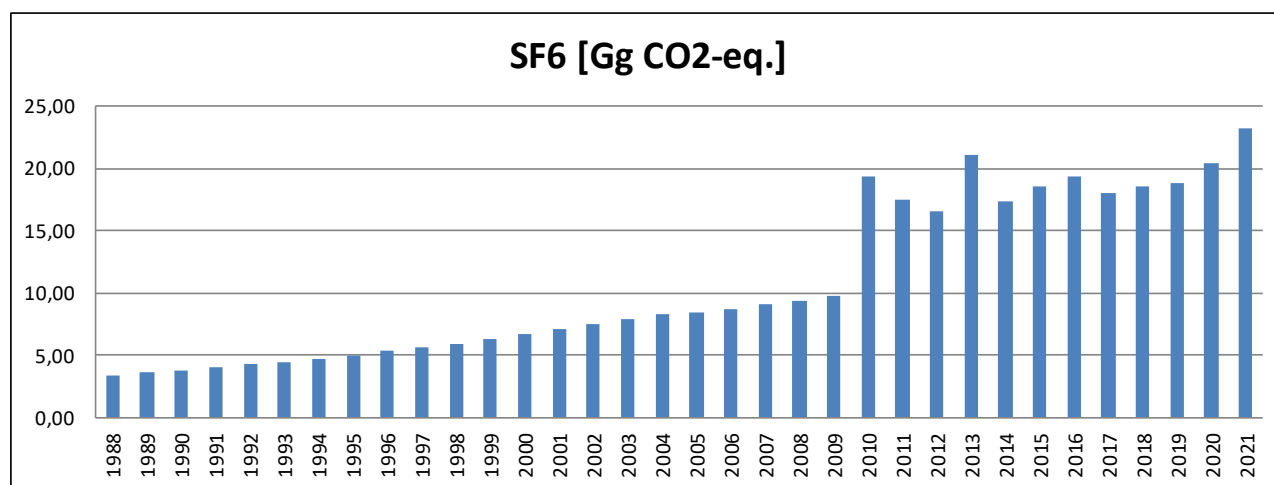


Figure 89 Sulfur hexafluoride (SF₆) – in CO₂ equivalent emissions.

The following table represents the activity data for the subsector:

Table 148 Activity data for Electrical 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	0,03	0,11	NO
1989	0,50	6,30	NO	0,03	0,12	NO
1990	0,53	6,67	NO	0,04	0,13	NO
1991	0,56	7,05	NO	0,04	0,13	NO
1992	0,59	7,46	NO	0,04	0,14	NO
1993	0,62	7,90	NO	0,04	0,15	NO
1994	0,66	8,36	NO	0,05	0,16	NO
1995	0,70	8,84	NO	0,05	0,17	NO
1996	0,74	9,35	NO	0,05	0,18	NO
1997	0,78	9,89	NO	0,05	0,19	NO
1998	0,83	10,47	NO	0,06	0,20	NO
1999	0,88	11,08	NO	0,06	0,21	NO
2000	0,93	11,72	NO	0,06	0,22	NO
2001	0,98	12,40	NO	0,07	0,23	NO
2002	1,04	13,12	NO	0,07	0,25	NO
2003	1,10	13,88	NO	0,08	0,26	NO
2004	1,16	14,68	NO	0,08	0,28	NO
2005	0,93	15,26	NO	0,07	0,29	NO
2006	0,97	15,85	NO	0,07	0,30	NO
2007	1,00	16,47	NO	0,07	0,32	NO
2008	1,04	17,11	NO	0,07	0,33	NO
2009	1,08	17,78	NO	0,08	0,34	NO
2010	8,06	25,02	NO	0,47	0,35	NO
2011	3,06	27,33	NO	0,26	0,48	NO
2012	2,01	28,63	NO	0,16	0,54	NO
2013	4,59	32,33	NO	0,32	0,57	NO
2014	1,34	32,94	NO	0,09	0,65	NO
2015	2,00	34,14	NO	0,13	0,66	NO
2016	2,09	35,41	NO	0,14	0,68	NO
2017	0,77	35,41	NO	0,06	0,70	NO
2018	1,01	35,64	NO	0,08	0,70	NO
2019	1,08	35,92	NO	0,09	0,71	NO
2020	1,82	36,87	NO	0,15	0,72	NO
2021	2,97	38,86	NO	0,25	0,74	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 SF₆, 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 SF₆ 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 SF₆ AND PFCS FROM OTHER PRODUCT USE (CRF 2.G.2)

Research showed that this activity is not applicable for Bulgaria and emissions are not occurring.

4.8.3 N₂O FROM PRODUCT USES - MEDICAL APPLICATION (CRF 2.G.3A)

4.8.3.1 Source category description

N₂O emissions are caused by medical uses of N₂O (for anaesthesia).

Calculation of N₂O 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 N₂O emissions from subcategory 2G3 N₂O from product use (2G3a - Medical application).

The N₂O emissions from 2G3a - Medical application are calculated for the entire time series 1988 – 2021.

The trend of N₂O emissions is presented in the following figure.

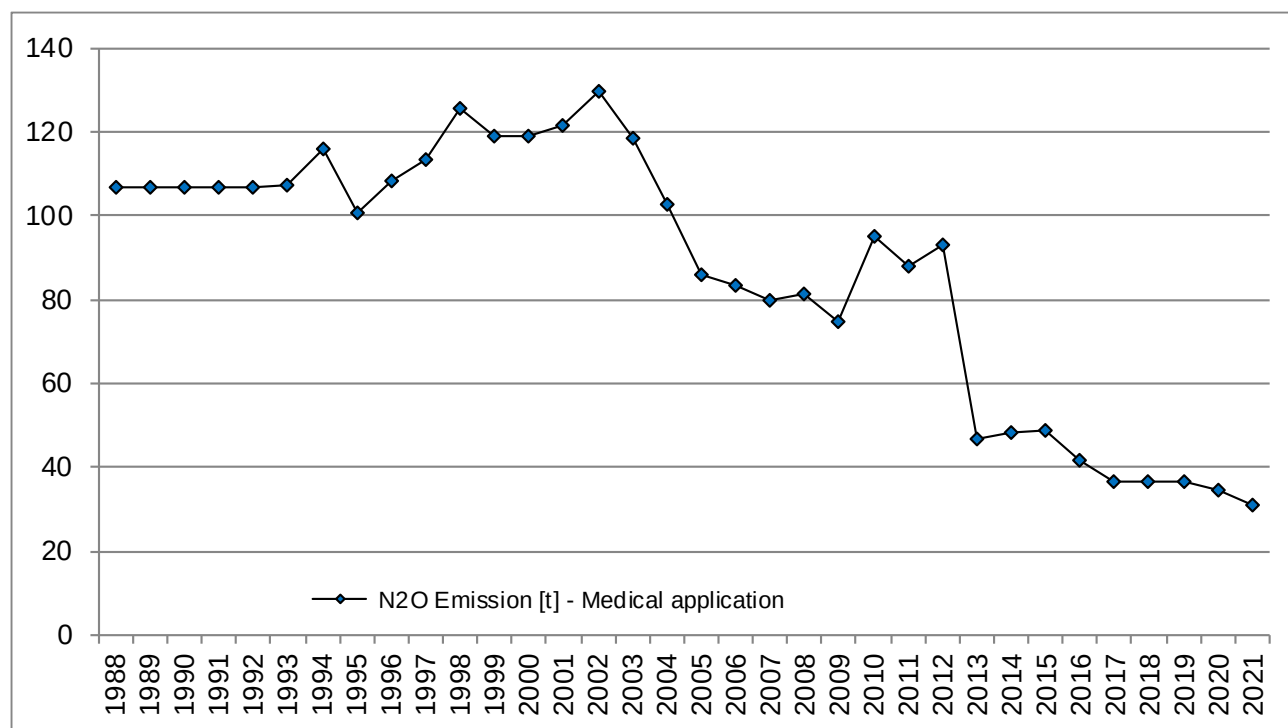


Figure 90 Medical application (Anaesthesia) – N₂O emissions.

4.8.3.3 Methodological issues.

Method

The N₂O 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 N₂O emissions from other product use is implemented. It is assumed that none of the administered N₂O is chemically changed by the body, and all is returned to the atmosphere. It is reasonable to assume an emission factor of 1.0.

Emission Factor

The default emission factors used for assessment of emissions of N₂O from 2G3a Medical application are presented in Table 149.

Table 149 Emission factor N₂O for 2G3a is 1.0.

2G3 N ₂ O from product uses (Medical application)				
SNAP activity	Name of activity	Emission factor	Unit	Reference
2G3a	Medical application	1.0	Mg/Mg	CORINAIR

4.8.3.3.1 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 working as it is not possible to meet the additional requirements for 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 N₂O in the country.

Due to lack of data, the activity data for the period 1988 – 1992 are taken the same as first available year.

Table 150 AD for N₂O emissions from 2G3 N₂O from product use (2G3a - Medical application), Mg

2G3a - N₂O from product uses (Medical application)	
Year	N₂O Emissions [t N₂O]
1988	106,95
1989	106,95
1990	106,95
1991	106,95
1992	106,95
1993	107,38
1994	115,87
1995	100,95
1996	108,32
1997	113,44
1998	125,73
1999	118,84
2000	119,30
2001	121,82
2002	129,62
2003	118,53
2004	103,01
2005	86,17
2006	83,39
2007	80,08
2008	81,31
2009	74,83
2010	95,36
2011	87,76
2012	93,12
2013	46,66
2014	48,47
2015	48,56
2016	41,83
2017	36,77
2018	36,74
2019	36,74
2020	34,42
2021	30,95

4.8.3.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 151 .

Table 151 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 ₂ O	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 N₂O FROM PRODUCT USES - PROPELLANT FOR PRESSURE AND AEROSOL PRODUCT (CRF 2.G.3.B)

4.8.4.1 Source category description

N₂O emissions are caused by uses of Propellant for pressure and aerosol product (aerosol cans).

Calculation of N₂O emission from subcategory 2G3b N₂O 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 N₂O emissions from subcategory 2G3b N₂O from product use (2G3b Propellant for pressure and aerosol product). The N₂O emissions from 2G3b - Propellant for pressure and aerosol product are calculated for the entire time series 1988 – 2021. The rate of use is not a steady one because of various factors (and probably some quantities remained in stock from the previous year).

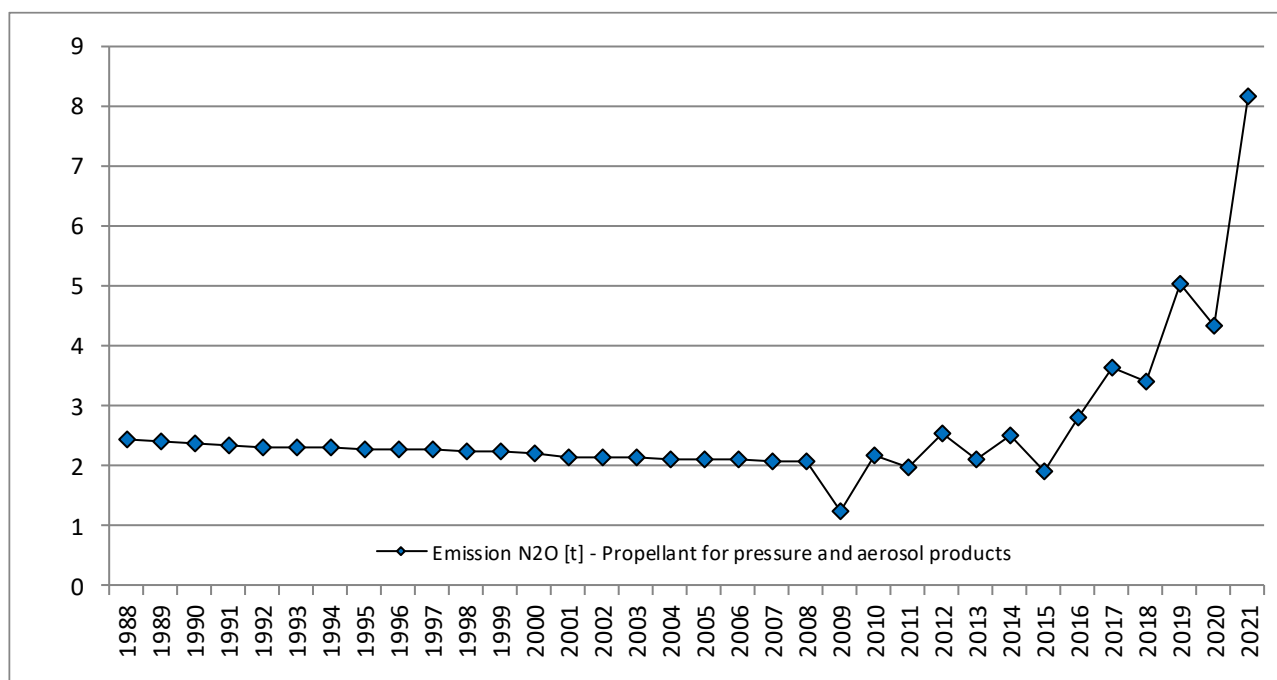


Figure 91 Propellants for pressure and aerosol product - N₂O emissions.

4.8.4.3 Methodological issues.

Method

The activity data are provided from the importing companies in the cream spray. Available data on the amount of cream sprayed are for the period 2009-2021 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.

Emission Factor

The default emission factors used for assessment of emissions of N₂O from 2G3b – 100% of the quantity of N₂O contained in the cans of cream spray imported to the country.

Activity Data

Data on the amount of N₂O 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 152 AD for N₂O emissions from 2G3 - N₂O from product use (2G3b - Propellant for pressure and aerosol product), Mg

2G3b - N ₂ O from product uses (Propellant for pressure and aerosol product)		
Year	N ₂ O Emissions [t N ₂ O]	Population [1000 number]
1988	2,453	8986,636
1989	2,393	8767,308
1990	2,366	8669,269
1991	2,346	8595,465
1992	2,316	8484,863
1993	2,309	8459,763
1994	2,300	8427,418
1995	2,289	8384,715
1996	2,277	8340,936
1997	2,261	8283,2
1998	2,246	8230,371
1999	2,236	8190,876
2000	2,224	8149,468
2001	2,154	7891,095
2002	2,141	7845,841
2003	2,129	7801,273
2004	2,118	7761,049
2005	2,107	7718,75
2006	2,096	7679,29
2007	2,085	7640,238
2008	2,076	7606,551
2009	1,254	7563,71
2010	2,168	7504,868
2011	1,978	7327,224
2012	2,549	7284,552
2013	2,102	7245,677
2014	2,506	7202,198
2015	1,912	7153,784
2016	2,809	7101,859
2017	3,624	7050,034
2018	3,391	7000,039
2019	5,027	6951,482
2020	4,354	6916,548
2021	8,166	6838,937

4.8.4.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 153

Table 153 Uncertainty of subcategory 2G3 - N₂O 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 ₂ O	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

There are no source specific recalculations for this category.

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.

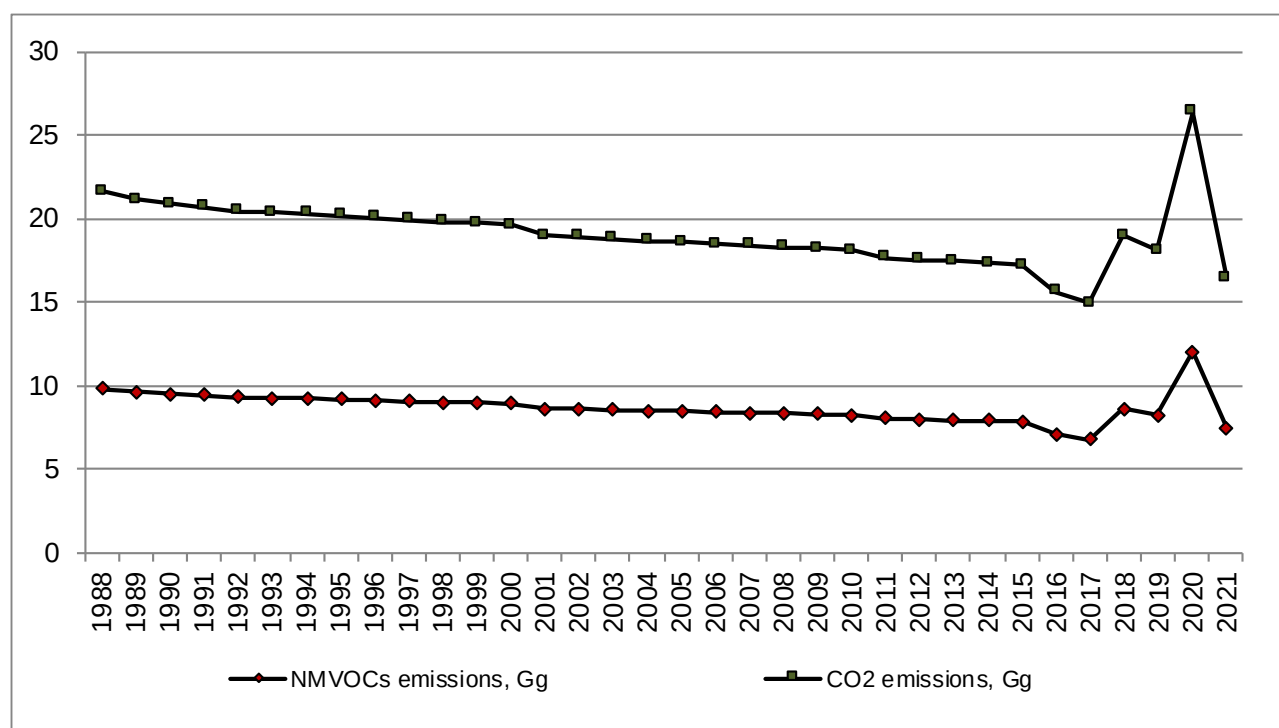


Figure 92 Trend of CO2 and NMVOC emissions in sector 2.G.4.i Domestic solvent.

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 CO₂ with conversion factor is provided in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO₂.

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 – CO₂, 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 2019.

The calculation of *Emissions_{NMVOC}* an ESIG research was used. (https://www.esig.org/wp-content/uploads/2021/03/ESIG_technical-paper-solvent-VOC-emissions-2019_v01_withoutEEA.pdf).

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 154 Activity data of 2G4i Domestic solvent

Years	Inhabitants, person	1000	NMVOCs emissions, Gg	CO ₂ emissions, Gg
1988	8986,6		9,84	21,66
1989	8767,3		9,60	21,13
1990	8669,3		9,50	20,89
1991	8595,5		9,42	20,71

1992	8484,9	9,29	20,45
1993	8459,8	9,27	20,39
1994	8427,4	9,23	20,31
1995	8384,7	9,18	20,21
1996	8340,9	9,14	20,10
1997	8283,2	9,07	19,96
1998	8230,4	9,02	19,83
1999	8190,9	8,97	19,74
2000	8149,5	8,93	19,64
2001	7891,1	8,64	19,02
2002	7845,8	8,59	18,91
2003	7801,3	8,55	18,80
2004	7761,0	8,50	18,70
2005	7718,8	8,46	18,60
2006	7679,3	8,41	18,51
2007	7640,2	8,37	18,41
2008	7606,6	8,33	18,33
2009	7563,7	8,29	18,23
2010	7504,9	8,22	18,09
2011	7327,2	8,03	17,66
2012	7284,6	7,98	17,56
2013	7245,7	7,94	17,46
2014	7202,2	7,89	17,36
2015	7153,8	7,84	17,24
2016	7101,9	7,10	15,63
2017	7050,0	6,78	14,92
2018	7000,0	8,64	19,02
2019	6951,5	8,24	18,12
2020	6916,5	12,02	26,44
2021	6838,9	7,49	16,48

4.8.5.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 153

Table 155 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

In 2022 it was suggested that there is an underestimation of the emissions in this category regarding the increased use of self hygiene agents and cleaning and disinfection agents during the Covid 19 pandemic. A research from ESIG was used and expert judgement.

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)

The emissions from subcategory 2H3 Vegetable Oil Production are included in the current subsector because of the source of AD. The NSI does not separate these snap codes for production.

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. In 2020 many bussines remained closed due to the pandemic and the restrictions and reduced their production rates.

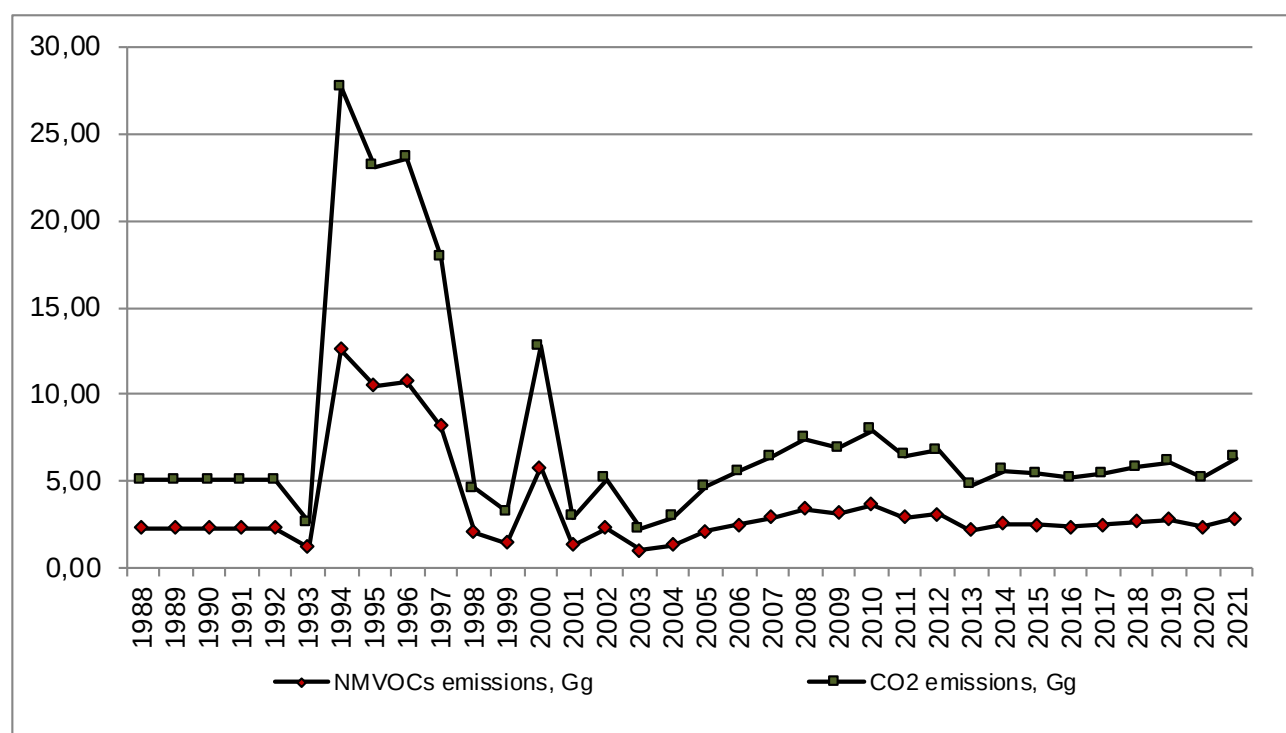


Figure 93 Trend of NMVOC and CO2 emissions in sector 2.G.4.I Other product use.

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:

$$E_{\text{pollutant}} = AR_{\text{production}} \times EF_{\text{pollutant}}$$

where:

$E_{\text{pollutant}}$ = the emission of the specified pollutant,

$AR_{\text{production}}$ = the activity rate (consumption of paint, chemical production data, solvent consumption)

$EF_{\text{pollutant}}$ = 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 156 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 2019
060405	Application of glues and adhesives	522	g/kg adhesives	EMEP/EEA guidebook 2019
060406	Preservation of wood: Creosote preservative type Waterborne preservative	945 105 0,5	g/kg preservative	EMEP/EEA guidebook 2019
060403	Printing	730	g/kg ink	EMEP/EEA guidebook 2019

* The other SNAP activities under CRF 2G4I Other product use are not estimated due to lack of activity data.

Converting of NMVOC into CO₂ with conversion factor is provided in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO₂.

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 – CO₂, the 2006 IPCC Guidelines, Volume 3, Chapter 5: Industrial Processes and Product Use, page 5.17, 2006 IPCC Guidelines, 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- 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 157 Activity data for sector 2.G.4.i – Other product use

2.G.4.i – Other product use			
Year	Other product use	NMVOC Emissions [kt NMVOC]	CO2 Emissions [kt CO2]
	[kt]	[kt]	[kt]
1988	11,14	2,30	5,07
1989	11,14	2,30	5,07
1990	11,14	2,30	5,07
1991	11,14	2,30	5,07
1992	11,14	2,30	5,07
1993	3,90	1,17	2,57
1994	27,16	12,60	27,73
1995	20,91	10,51	23,12
1996	60,14	10,72	23,59
1997	91,61	8,15	17,93
1998	66,16	2,07	4,56
1999	70,37	1,45	3,18
2000	121,36	5,79	12,74
2001	92,01	1,32	2,91
2002	46,14	2,31	5,08
2003	54,00	1,01	2,23
2004	47,69	1,32	2,91
2005	53,95	2,13	4,69
2006	68,75	2,50	5,51
2007	134,05	2,90	6,38
2008	165,40	3,37	7,41
2009	378,18	3,14	6,91
2010	355,48	3,61	7,94
2011	374,73	2,93	6,44
2012	354,40	3,08	6,78
2013	518,70	2,16	4,76
2014	724,33	2,54	5,58
2015	767,48	2,47	5,44
2016	740,71	2,34	5,16
2017	813,57	2,47	5,43
2018	890,00	2,63	5,79
2019	984,92	2,77	6,09
2020	818,40	2,35	5,17
2021	1234,17	2,87	6,31

4.8.6.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 153

Table 158 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

There are no source specific recalculations for this category.

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 CO₂ emissions from subcategory – 2H3i Other (vegetable oil production)

NMVOC emissions in Vegetable oil production 2H3i have been calculated for the period 1988 - 2020. The emission factor are in accordance with the EMEP/EEA air pollutant emission inventory guidebook –2006 and 2013²⁰. The activity data are provided mainly by the National Statistics Institute – NSI.

The trend of NMVOC and CO₂ emissions is presented in the following figure.

²⁰ In the following referred as EMEP/EEA Guidebook (2019)

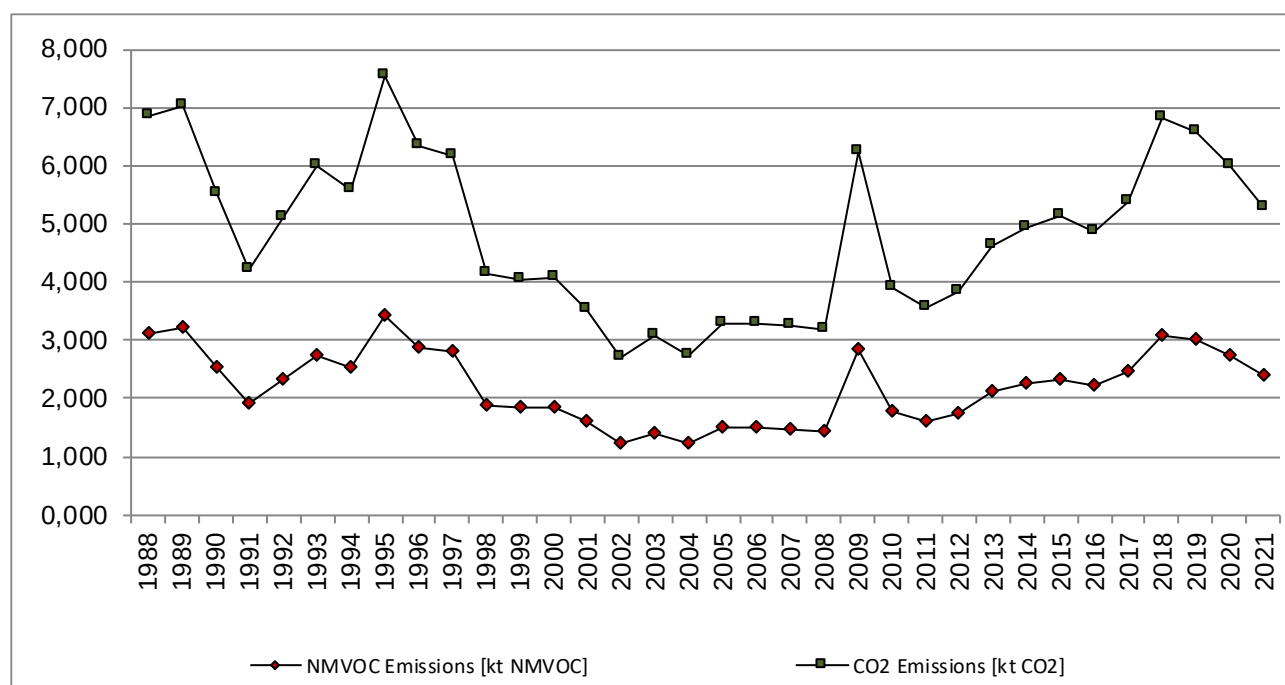


Figure 94 NMVOC and CO2 emissions in Vegetable oil production.

4.9.1.3 Methodological issues

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 2019ⁱ. The activity data are provided mainly by the National Statistics Institute – NSI.

Because of country specific way of activity data aggregation currently the emissions are reported in 2G4I.

CO₂ emissions from 2H3 Other (Vegetable oil production)

Converting of NMVOC into CO₂ with conversion factor is provided in the 2006 IPCC Guidelines, Volume 1, Chapter 7.2.1.5 Carbon Emitted in Gases Other than CO₂.

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 – CO₂, 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

Emission Factor

The default emission factors used for assessment of emissions of NMVOC from 2H3 are presented in Table 159.

Table 159 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

4.9.1.3.1 Activity Data

The activity data for estimation of emissions in 2H3, are provided by the NSI. Because of the way the AD is presented by the NSI the emissions from this subcategory are reported under the subsector 2G4i in order to avoid double counting.

Table 160 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
1989	3,198	7,035
1990	2,512	5,527
1991	1,917	4,218
1992	2,323	5,110
1993	2,721	5,986
1994	2,543	5,596
1995	3,428	7,541
1996	2,878	6,332
1997	2,798	6,156
1998	1,876	4,128
1999	1,830	4,027
2000	1,845	4,059
2001	1,607	3,535
2002	1,222	2,688
2003	1,393	3,064
2004	1,236	2,719
2005	1,487	3,271
2006	1,491	3,280
2007	1,480	3,255
2008	1,442	3,172
2009	2,840	6,247
2010	1,766	3,885
2011	1,616	3,554
2012	1,736	3,819
2013	2,103	4,627
2014	2,242	4,933
2015	2,339	5,146
2016	2,207	4,854
2017	2,446	5,381
2018	3,093	6,804
2019	2,997	6,593
2020	2,724	5,994
2021	2,393	5,266

4.9.1.4 Uncertainties and time series consistency

The uncertainty of the GHG emissions is presented in Table 161.

Table 161 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
- liming;
- urea fertilisation.

5.2 EMISSION TRENDS

In the year 2021 the sector agriculture contributed 11.33% to the total of Bulgaria's greenhouse gas emissions (without LULUCF). The trend of GHG emissions from 1988 to 2021 shows a decrease of 55.10 % for this sector due to decrease in activity data. (Figure 95)

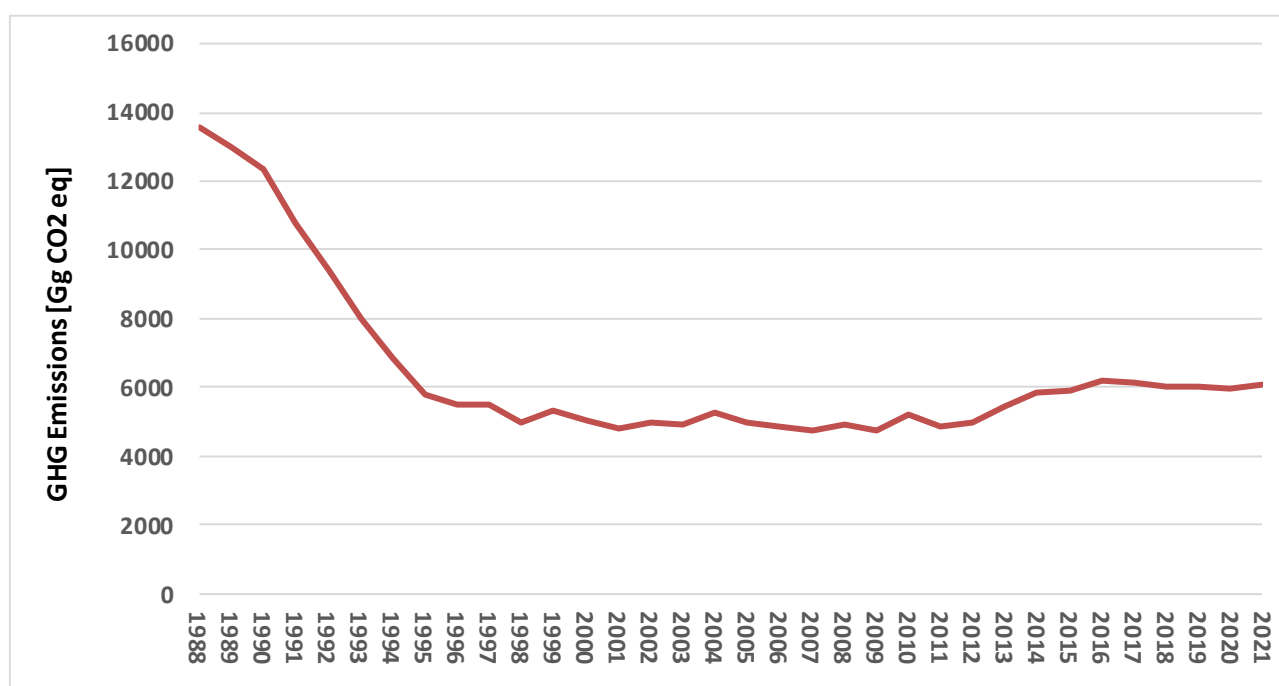


Figure 95 Trend of GHG Emissions from agriculture

5.3 EMISSION TRENDS PER GAS

CH₄ emissions are 37% from of the total emissions in the sector in CO₂-eq in 2021. A steady trend of emissions decrease is observed after 2004 due to reduction in animal numbers.

N₂O emissions from the sector are also significant. The share of N₂O emissions is 62% for the year 2021. The biggest share in these emissions has the Agricultural soils category with 93.07%. N₂O emissions from manure management and field burning of agricultural residues are of an order of magnitude smaller.

Since 1988 the CH₄ emissions from agriculture decreased by 68% and N₂O emissions by 41%. The trend is presented in Table 162.

CH₄ emissions were 79,88 Gg in the year 2021. The increase for the year 2021 is 2,83% compared to 2020. N₂O emissions increase from 14,14 Gg in 2020 to 14,38 Gg in 2021 year.

Table 162 Emissions of greenhouse gases from agriculture 1988 – 2021.

Year	GHG emissions [Gg]		
	CH ₄	N ₂ O	CO ₂
1988	252.45	24.30	91.30
1990	240.51	20.82	74.07
1995	111.97	9.86	41.58
2000	96.43	8.68	42.43
2005	89.31	9.21	41.80
2010	80.18	10.96	41.24
2015	79.87	13.58	55.87
2016	79.26	14.79	60.51
2017	78.31	14.77	58.00
2018	76.91	14.39	58.28
2019	74.96	14.52	57.56
2020	77.61	14.14	58.08
2021	79.88	14.38	58.56

5.3.1 EMISSION TRENDS PER SUB CATEGORY

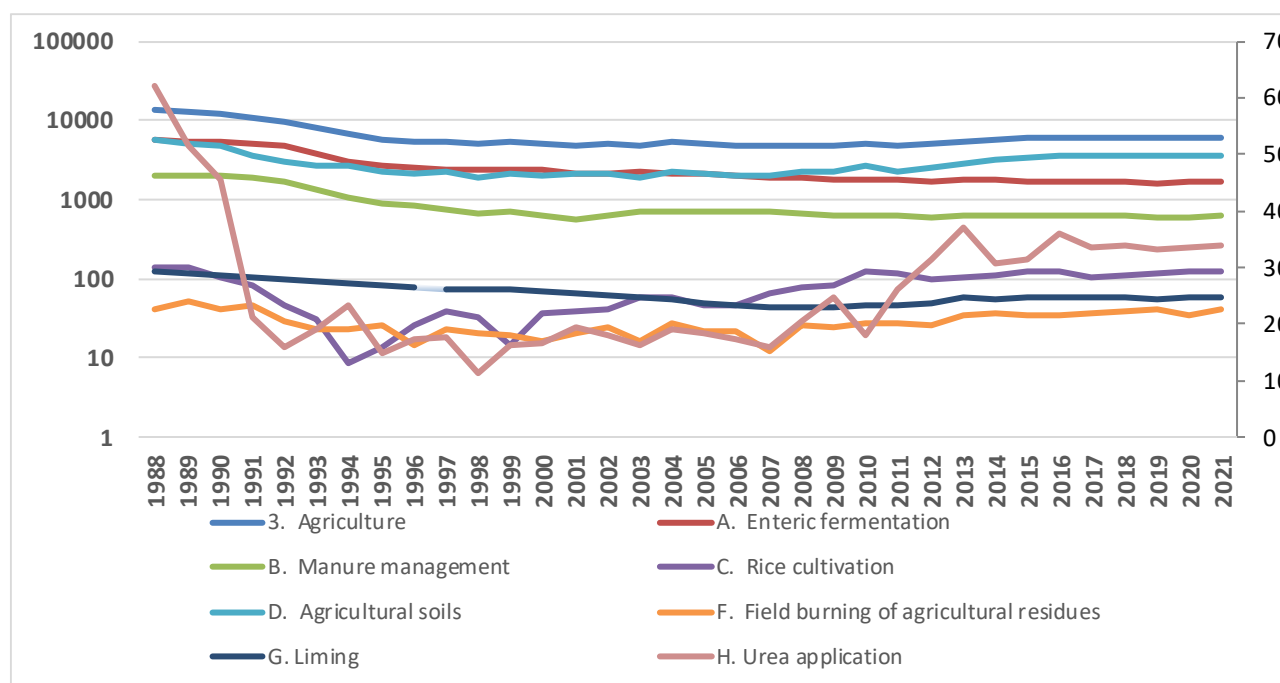


Figure 96 GHG emission trends 1988–2021 of agriculture by categories (Gg CO₂-eq)

Table 163 and Figure 96 present total GHG emissions and trend 1988–2021 from agriculture by sub-categories as well as the contribution to the overall inventory emissions. Important categories are 3.D Agricultural soils (58%) and 3.A Enteric Fermentation (28%) followed by 3.B Manure management (10%).

Table 163 GHG emissions 1988–2021 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.G	3.H
1988	13598.73	5679.74	2056.29	142.22	5589.20	39.97	29.14	62.17
1990	12326.28	5381.09	2003.26	106.82	4720.75	40.29	28.59	45.49

Year	GHG emissions [Gg CO ₂ equivalent] by categories							
	3	3.A	3.B	3.C	3.D	3.F	3.G	3.H
1995	5790.41	2609.24	889.07	13.92	2211.32	25.28	26.70	14.88
2000	5043.34	2367.48	624.32	36.02	1956.63	16.46	25.78	16.65
2005	4982.79	2094.00	686.79	45.40	2093.01	21.79	23.48	18.32
2010	5190.99	1754.56	626.92	120.81	2619.53	27.94	23.19	18.05
2015	5890.94	1719.75	631.71	125.18	3324.24	34.19	24.60	31.27
2016	6198.09	1704.49	628.59	120.92	3648.39	35.19	24.57	35.93
2017	6165.52	1693.88	620.34	105.25	3650.80	37.26	24.58	33.42
2018	6024.91	1655.99	616.16	111.00	3545.44	38.05	24.54	33.74
2019	6004.04	1607.01	597.31	119.25	3582.76	40.16	24.51	33.04
2020	5978.19	1671.85	602.78	124.56	3487.40	33.52	24.60	33.48
2021	6106.34	1713.56	624.02	121.58	3546.99	41.63	24.64	33.92
Share in Total 2021	-	28.06%	10.22%	1.99%	58.09%	0.68%	0.40%	0.56%

As can be seen in Table 163 and Figure 96, 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 164 Key sources of agriculture.

IPCC Category	Source Categories	Key Sources	
		GHG	KS-Assessment*
3.D.1	Direct N ₂ O emissions from Agricultural soils	N ₂ O	Yes
3.A.1	Enteric Fermentation - cattle	CH ₄	Yes
3.B2	Manure Management	N ₂ O	Yes
3.D.2	Indirect N ₂ O from Nitrogen used in Agriculture	N ₂ O	Yes

5.3.3 COMPLETENESS

Table 165 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 subcategory have been estimated.

Table 165 Overview of sub-categories of agriculture.

IPCC Category		CH ₄		N ₂ O	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

IPCC Category		CH ₄		N ₂ O	CO ₂
3.B.	Manure management	Manure management regarding organic compounds manure management regarding nitrogen compounds	✓ NO	NO ✓	NO
3.B.1.1 + 3.B.2.1	Cattle	–	✓	✓	NO
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, geese,...)	✓	✓	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 fertilizers	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	✓
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 submission 2023 Bulgaria included estimations of CO₂ emissions from sector 3.G- Liming.

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 2021, this source category was responsible for 28% of the total GHG emissions from the agriculture sector.

5.4.1 SOURCE CATEGORY DESCRIPTION

CH₄ emissions in CO₂-eq. were 1 713, 56 in the year 2021. Compared to base year a decrease of 70% is observed.

CH₄ emissions from the enteric fermentation of domestic livestock are given in Table 166.

Table 166 Greenhouse gas emissions from enteric fermentation 1988–2021.

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	29.56	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
2018	59.14	26.24	9.79	8.73	0.93	9.87	1.32	1.31	0.94
2019	57.39	24.20	10.39	8.47	1.06	9.79	1.25	1.37	0.86
2020	59.71	24.65	11.67	9.26	1.21	9.70	1.20	1.20	0.81
2021	61.20	24.05	13.60	9.54	1.37	9.47	1.17	1.02	0.97
Share 2021	-	39%	22%	16%	2%	16%	2%	2%	2%
Trend 1988–2021	-70%	-64%	12%	-79%	-18%	-85%	-46%	-83%	-84%

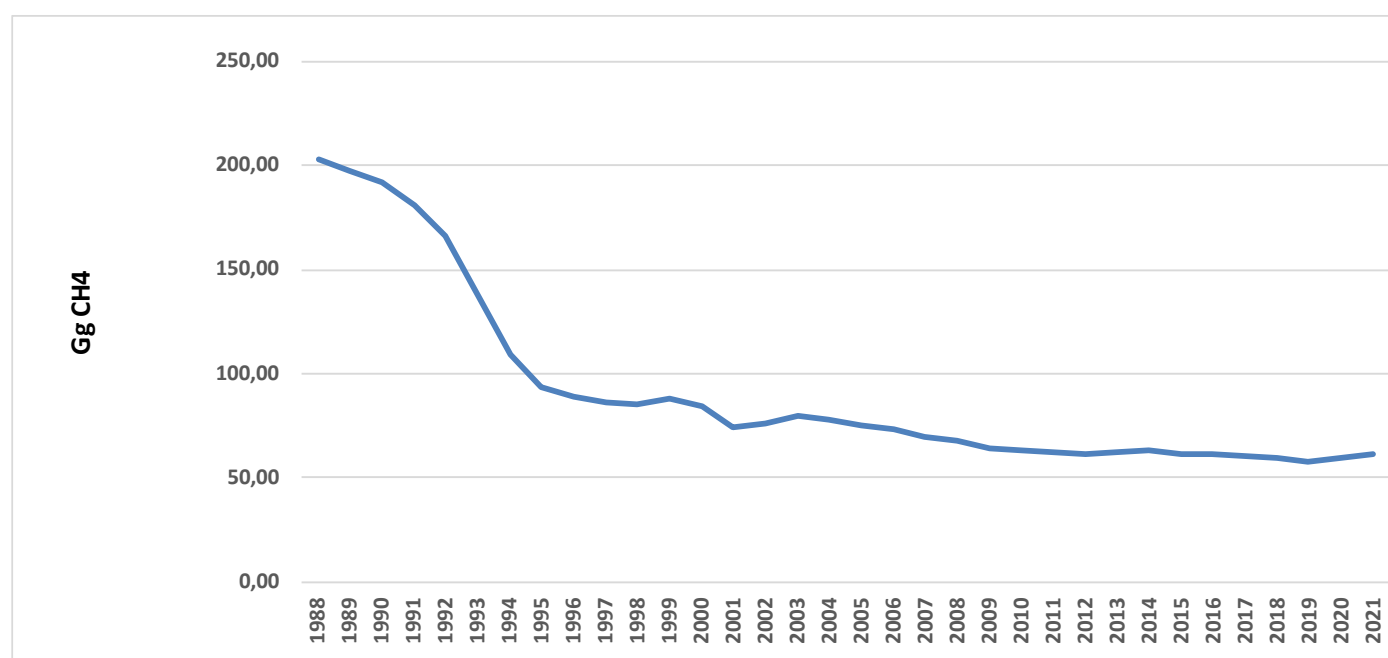


Figure 97 CH₄ emissions from enteric fermentation

Figure 97 shows steady decrease in CH₄ 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.

$$EF_i = [GE_i \bullet Y_{m_i} \bullet 365] / 55.65$$

With i = each livestock category
 EF_i expressed in kg CH₄/head/year
 Y_m Methane conversion rate
 Ge =Gross energy intake
 The factor 55.65 expressed in MJ/kg of CH₄

→ 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 167 Activity data and parameters used for IPCC Sub-category 3A1 – Cattle – Mature Dairy CattleTable 167.

For **dairy cattle**, the EF has been calculated by combining activity data, coefficients and parameters shown in Table 167. 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”²¹ published in *Bulgarian Journal of Agricultural Science*, 15 (No 2) 2009, 168-176, *Agricultural Academy*.

Table 167 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
Live Weight	Kg	Executive Agency for Selection and Reproduction in Animal Breeding (see Table 176)
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 174)
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 174)
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

²¹ 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)

Parameter	Unit	Source
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
CH ₄ conversion rate (average)	%	Table 10.12 - 2006 IPCC GL
Implied Emission Factor - CH ₄	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 168.

Table 168 Activity data and parameters used for IPCC Sub-category 3A1 – Cattle – Non-Dairy Cattle

Parameter	Unit	Source
Livestock	#	Ministry of Agriculture, Food and Forestry
Live weight	kg	Executive Agency for Selection and Reproduction in Animal Breeding (see Table 176)
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
CH ₄ 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 Ministry of Agriculture, Food and Forestry (please see table below).

Table 169 Activity data and parameters used for IPCC Sub-category 3A2 – Sheep:

Parameter	Unit	Source
Livestock (# of animals)	#	Ministry of Agriculture, Food and Forestry
Live Weight	kg	Ministry of Agriculture, Food and Forestry (see Table 176)
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
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
CH ₄ conversion rate (average)	%	Table 10.13 - 2006 IPCC GL
Implied Emission Factor - CH ₄	kg CH ₄ /head/year	Eq. 10.21 - 2006 IPCC GL

Table 170 Enteric fermentation emission factors for cattle and sheep:

Year	Emission Factor [kg CH ₄ /head*yr]			
	Mature Dairy Cattle	Mature Non-Dairy 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

Year	Emission Factor [kg CH ₄ /head*yr]			
	Mature Dairy Cattle	Mature Non-Dairy Cattle	Young Cattle	Sheep
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
2018	107.98	76.85	53.62	7.40
2019	107.74	76.73	53.49	7.44
2020	111.29	76.85	55.68	7.49
2021	108.65	76.94	52,69	7,56

For mature dairy cattle, over the period 1988-2021, the milk yield has increased by 10% (see Table 174). 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 CH₄/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 177), 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 following tables.

Table 171 Activity data, coefficients and parameters used for goats, horses, mules and asses, swine:

Parameter name	Unit	Parameter source
Livestock	#	-Ministry of Agriculture, Food and Forestry– Agrostatistics department -Bulgarian Foodsafety Agency, Animal Health and Welfare Directorate
Live Weight	kg	- Ministry of Agriculture, Food and Forestry– Agrostatistics department (see Table 176) - Executive Agency for Selection and Reproduction in Animal Breeding

Table 172 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 TERT 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 $(380/300)^{0.75}$ in accordance with table 10.10 of the 2006 IPCC Guidelines (Volume 4, Chapter 10.3.2 (p.10.28))

5.4.2.3 Activity data

5.4.2.3.1 Livestock populations

Table 173 Domestic livestock populations 1988–2021(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
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
2018	243.06	121.47	5.97	106.51	56.30	264.35	14.22
2019	224.64	129.67	5.78	101.24	57.15	250.11	16.18
2020	221.51	144.73	7.11	103.21	63.04	240.95	18.46
2021	221.37	167.89	8.87	113.86	67.14	234.20	20.93

Domestic livestock populations 1988–2021(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
2018	117.91	990.23	33.92	191.35	62.52	623.85	18.89	13 368.00	1 770.00
2019	128.06	969.20	32.62	185.63	61.55	573.18	25.82	13 807.00	1 735.00
2020	127.44	962.78	30.85	173.32	51.92	541.96	26.96	13 077.00	1 614.20
2021	141.46	918.05	29.45	164.71	45.36	643.38	20.84	12 293.50	1 698.70

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 Agrostistics Department, are published on the website of the MAFF.

Every year there are agrostistics 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/Agrostistics.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 with 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.

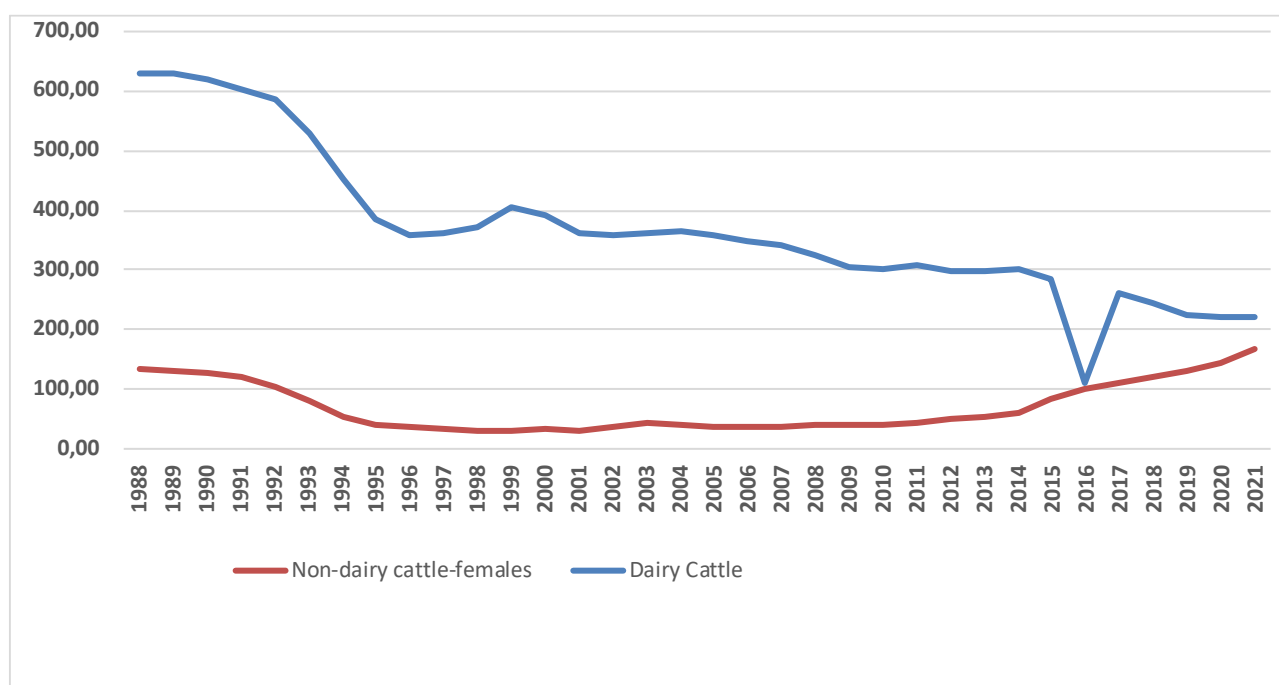


Figure 98 Domestic livestock populations (I)

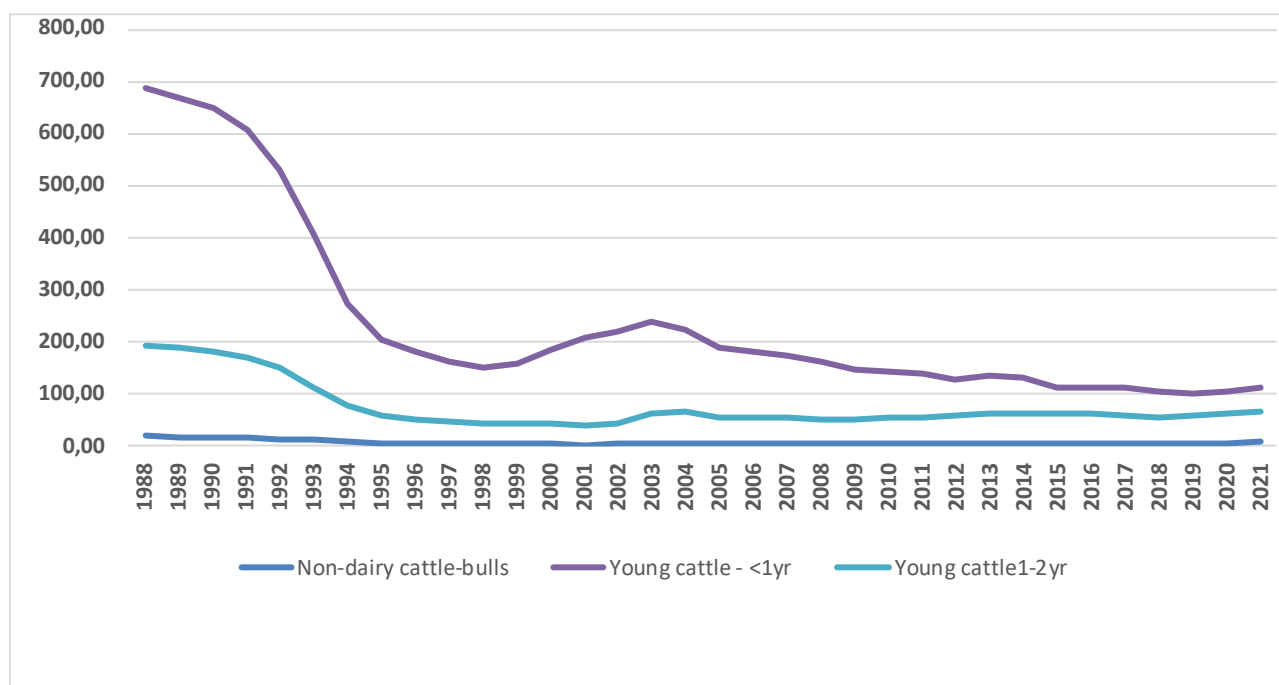


Figure 99 Domestic livestock populations (II)

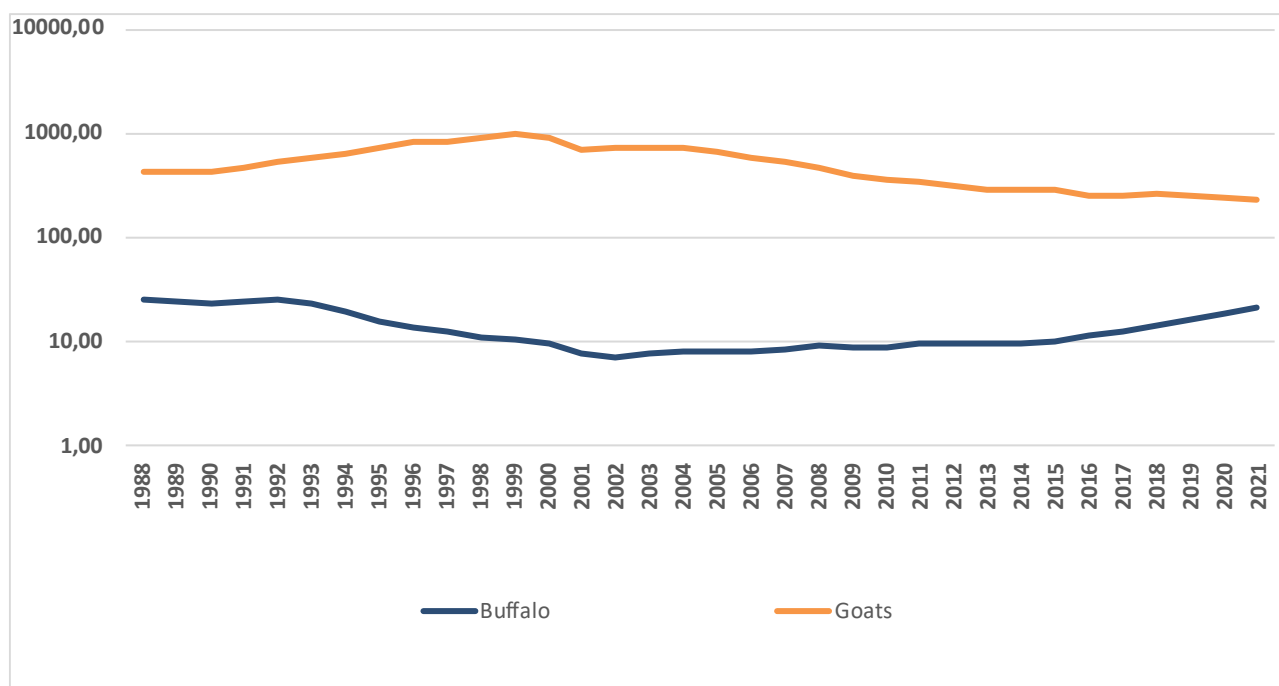


Figure 100 Domestic livestock populations (III)

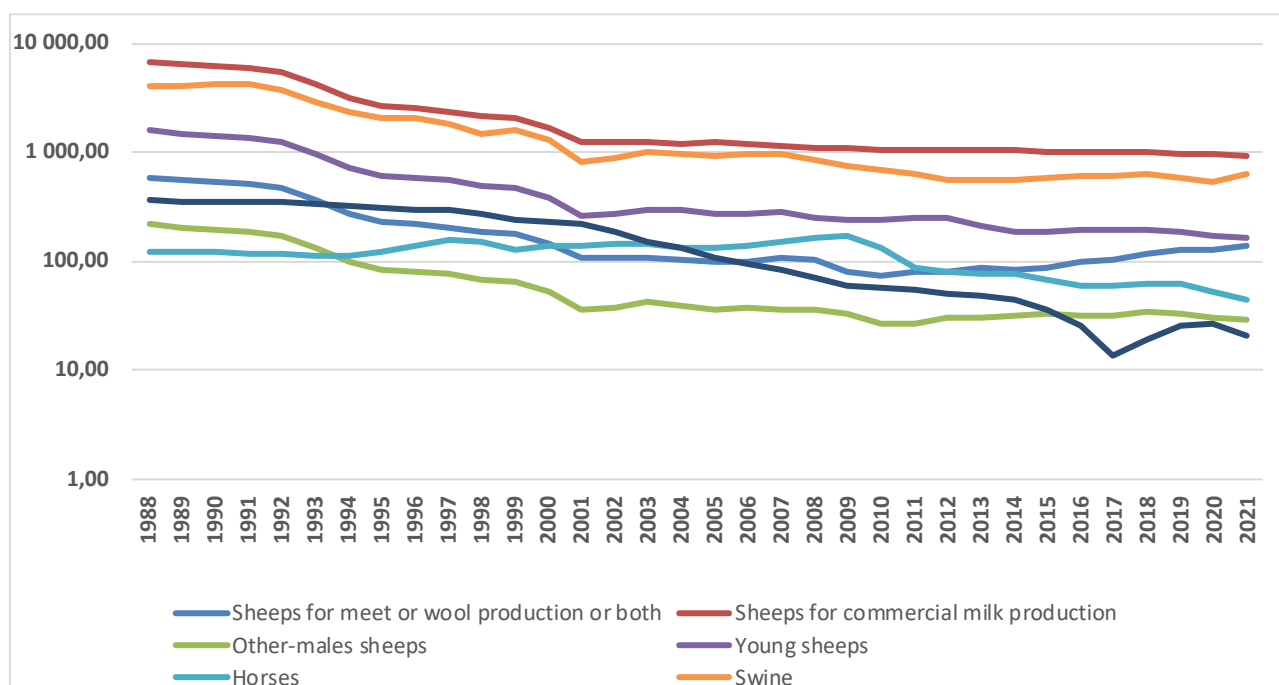


Figure 101 Domestic livestock populations (IV)

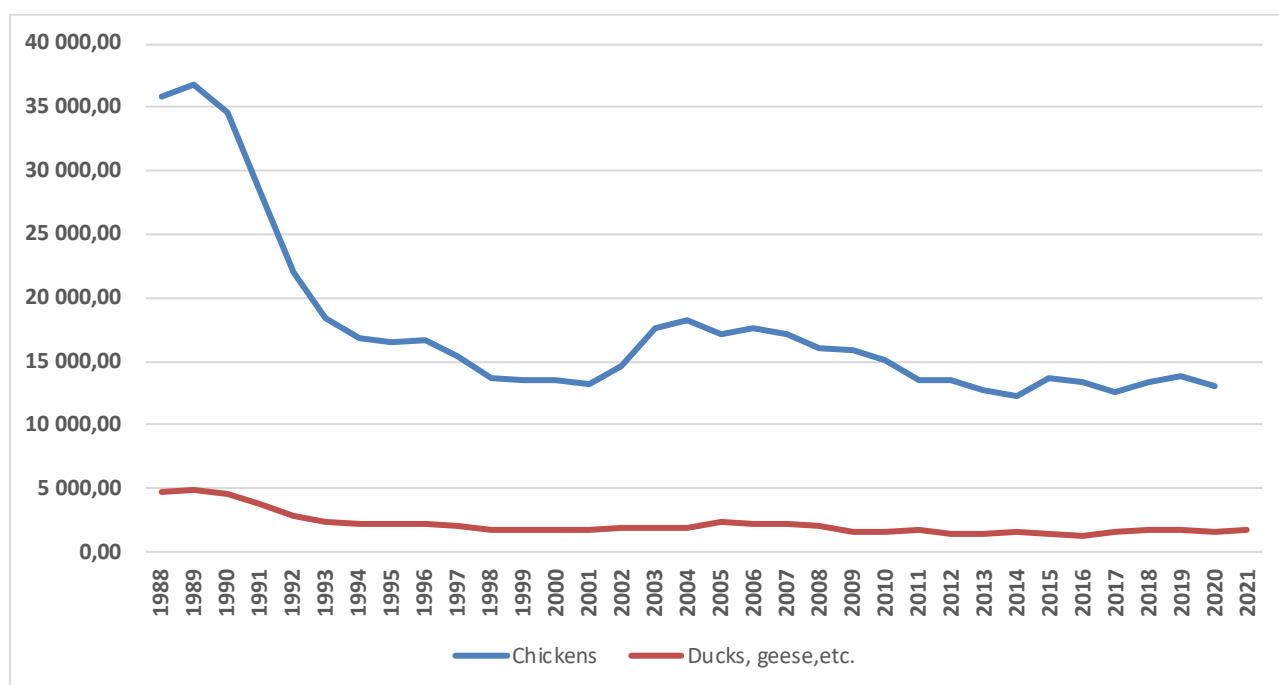


Figure 102 Domestic livestock populations (V)

- (1) broiler and layer chickens, roosters, chicks
- (2) ducks, geese, turkeys, guinea-fowls, wild poultry

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 Agrostistics 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 2021 is 3,62 %. Data on the fat content of milk is available in EUROSTAT.

Table 174 Milk yield, gross energy intake for dairy cattle: 1988 – 2021:

Year	Milk Yield	Gross Energy Intake
	[kg/cow*yr]	[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
2018	4425.25	253.28
2019	4380.69	252.71
2020	4763.85	261.03
2021	4518.30	254.86

Source: Ministry of Agriculture and Food, Agrostistics 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 Agrostistics 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 175 Milk yield, gross energy intake for sheep: 1988 – 2021

Year	Milk Yield	Gross Energy Intake
	[kg/sheep*yr]	[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	68.75	17.56
2018	72.24	17.64
2019	69.10	17.72
2020	79.44	17.83
2021	76.65	17.98

5.4.2.3.3 Live weight

Live-weight for most animal categories has been provided by the Agrostistics 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 176. 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 176 Live-weight for farm animals reported in the inventory

Livestock category	Live-weight in kg used for estimating enteric fermentation emissions	
Cattle – Mature Dairy Cattle	588	
Cattle – Mature Non-Dairy Cattle – Females	613	
Cattle – Mature Non-Dairy Cattle – Males	880	
Cattle – Young Cattle – Calves	199	
Cattle – Young Cattle – Growing Heifers	390	
Sheep-Mature ewes where either meat or wool production or both is the primary purpose	61.00	
Sheep-Mature ewes where commercial milk production is the primary purpose	45.20	
Mature Sheep-Other(males)	65.00	
Young sheep - Intact males, castrates & Females	Slaughter body weight	16,00
	Weight at weaning	12.90
Swine	104.00	
Poultry – Chickens	2.10	
Other – Other Poultry	4.48	
Buffalo	380.00	
Goats	38.50	
Horses	377.00	
Mules and asses	130.00	

Source: Ministry of agriculture and Food, Agrostistics 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 Agrostistics department of Ministry of Agriculture, Food and Forestry(see Table 177). Due to lack of data, for the period 1988 – 1999 average value have been used.

Table 177 Live-weight for young cattle 1988 – 2021:

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
2018	204.20	384.35
2019	206.55	370.40
2020	220.10	380.50
2021	201.85	361.65

5.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty from methane emissions from this source is 50%.

Table 178 Uncertainty of sub-sector Enteric Fermentation for 2021, %

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

There are no source-specific recalculations.

5.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Bulgaria makes great efforts to improve the estimations, using year-specific values for the digestibility of feed in its emissions calculations for 3A1 Enteric Fermentation Dairy Cattle.

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 (CH₄), and treatment of manure before it is applied to land (N₂O). In accordance with the IPCC guidelines, the term “manure” is used here collectively to include both dung and urine produced by livestock.

In 2020, this source category was responsible for 10% of the total GHG emissions from the agriculture sector.

5.5.1 SOURCE CATEGORY DESCRIPTION

CH₄ and N₂O emissions from manure management are given in Table 179 and Table 180

Table 179 CH₄ emissions from Manure management 1988 –2021, 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	43.36	10.45	1.81	6.67	0.13	1.87	0.06	0.47	20.80	1.11
1990	43.32	10.23	1.70	6.28	0.12	1.70	0.06	0.46	21.74	1.04
1995	17.54	5.42	0.48	1.77	0.08	0.71	0.10	0.42	7.93	0.57
2000	10.10	4.68	0.30	1.24	0.05	0.46	0.12	0.39	2.35	0.43
2005	12.26	5.74	0.46	1.84	0.04	0.34	0.09	0.29	2.92	0.50
2010	12.39	5.93	0.60	1.73	0.04	0.29	0.05	0.25	3.08	0.40
2015	12.99	6.34	1.35	1.91	0.05	0.29	0.04	0.13	2.54	0.34
2016	13.04	6.15	1.60	1.74	0.06	0.29	0.03	0.11	2.72	0.33
2017	12.96	5.88	1.76	1.81	0.06	0.29	0.03	0.11	2.69	0.33
2018	12.69	5.46	1.92	1.71	0.07	0.29	0.03	0.11	2.74	0.35
2019	12.14	5.03	2.04	1.66	0.08	0.28	0.03	0.12	2.53	0.35
2020	12.49	5.13	2.29	1.82	0.09	0.28	0.03	0.10	2.40	0.34
2021	13.10	5.00	2.67	1.87	0.10	0.27	0.03	0.09	2.73	0.33
Share 2021		38.17%	20.38%	14.29%	0.80%	2.10%	0.23%	0.66%	20.85%	2.51%
Trend 1988–2021	-69.78%	-52.14%	47.95%	-71.93%	-17.31%	-85.31%	-46.13%	-81.41%	-86.86%	-70.33%

*Code 3.B.1 indicates CH₄ from Manure management

Table 180 N₂O emissions from Manure management 1988 –2021, Gg

N ₂ O emissions from manure management (without indirect emissions) [Gg]										
Livestock categories										
Year	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	1.82	0.39	0.06	0.29	0.00	0.36	0.02	0.03	0.03	0.65
1990	1.75	0.38	0.06	0.27	0.00	0.32	0.02	0.03	0.03	0.56
1995	0.88	0.23	0.02	0.08	0.00	0.14	0.04	0.03	0.06	0.27
2000	0.80	0.22	0.01	0.07	0.00	0.09	0.05	0.03	0.09	0.23
2005	0.80	0.23	0.02	0.08	0.00	0.06	0.04	0.02	0.04	0.30
2010	0.65	0.19	0.02	0.07	0.00	0.05	0.02	0.02	0.01	0.26
2015	0.62	0.19	0.04	0.06	0.00	0.05	0.02	0.01	0.00	0.24
2016	0.61	0.18	0.05	0.06	0.00	0.05	0.01	0.01	0.00	0.23
2017	0.59	0.17	0.05	0.06	0.00	0.05	0.01	0.01	0.00	0.22

Year	N ₂ O 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
2018	0.60	0.16	0.06	0.06	0.00	0.05	0.01	0.01	0.00	0.23
2019	0.60	0.15	0.06	0.06	0.00	0.05	0.01	0.01	0.00	0.24
2020	0.58	0.15	0.07	0.06	0.00	0.05	0.01	0.01	0.00	0.23
2021	0.58	0.15	0.08	0.07	0.00	0.05	0.01	0.01	0.00	0.21
Share 2021		25.35%	11.61%	10.45%	0.37%	8.85%	2.35%	1.37%	0.71%	38.92%
Trend 1988–2021	-68.42%	-62.14%	6.40%	-79.07%	-27.09%	-85.57%	-44.58%	-75.22%	-86.96%	-65.18%

*Code 3.B.2 indicates N₂O from Manure management

5.5.2 METHODOLOGICAL ISSUES

5.5.2.1 CH₄ 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 188.

Buffalos, goats, horses, mules, asses are of minor importance in Bulgaria, therefore the CH₄ 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 CH₄ 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):

$$EF_i = VS_i * 365 [\text{days yr}^{-1}] * B_{oi} * 0.67 [\text{kg m}^{-3}] * \sum_{jk} MCF_{jk} * MS\%_{ijk}$$

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_{oi} = maximum methane producing capacity (m³ 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.

$$VS = [GE * (1 - \frac{DE\%}{100}) + (UE * GE)] * [\frac{1 - ASH}{18.45}]$$

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 188), 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 slaughterhouses – pure (without being in contact with the floor).

The emission factor of CH₄ from manure management of swine is according Equation 4.17 from Good practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

$$EF_i = (VS_i \cdot 365) \cdot \left[B_{oi} \cdot 0,67 \text{ kg/m}^3 \cdot \sum_{(jk)} MCF_{jk} \cdot MS_{ijk} \right]$$

VS = volatile solid excretion per day on a dry-organic matter basis, kg VS day⁻¹

B_{oi} = CH₄ Producing Potential according Table 10A-8 - IPCC 2006

MCF - based on Table 10,17 - IPCC_2006

MS - please see Table 183

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 determined 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.

Maximum methane producing capacity (B_o) values are from 2006 IPCC GL for all farm animals (Table 10A-4 to Table 10A-9).

Methane conversion factors (MCF) are default 2006 IPCC GL presented in Table 181, and are based on cool allocation by climate.

Table 181 Methane conversion factors

AWMS	Allocation by climate	MCF
Liquid system	Cool	20%
Solid storage	Cool	2%
Dry lot	Cool	1%
Other	Cool	1%

Table 182 Average value of air temperature (for regions with altitude up to 800 m) for the period 1988 – 2021 [C°]

1988	1989	1990	1991	1992	1993	1994
11.90	12.40	11.80	10.60	11.70	11.60	12.90
1995	1996	1997	1998	1999	2000	2001
11.20	11.00	11.30	12.10	12.10	12.40	12.30
2002	2003	2004	2005	2006	2007	2008
11.90	11.40	11.60	11.10	11.50	12.60	12.50
2009	2010	2011	2012	2013	2014	2015
12.30	12.10	11.30	12.40	12.50	12.30	12.70
2016	2017	2018	2019	2020	2021	
12.60	12.30	12.60	13.30	13.00	12.30	

The average annual temperature for the country for the whole time series is provided by National Institute of Meteorology and Hydrology.

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 183.

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 Agrostistics 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 – 2021 provided in Table 183 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.

Table 183 AWMS distribution for cattle, swine, and sheep:

	Cattle			Swine			Sheep	
	Solid storage	Liquid systems	Pasture range paddock	Liquid systems	Solid storage	Dry lot	Solid storage	Pasture range paddock
1988	33.54%	46.96%	19.50%	92.00%	8.00%	0.00%	35%	65%
1989	33.54%	46.96%	19.50%	92.00%	8.00%	0.00%	35%	65%
1990	33.54%	46.96%	19.50%	92.00%	8.00%	0.00%	35%	65%
1991	33.54%	46.96%	19.50%	92.00%	8.00%	0.00%	35%	65%
1992	33.54%	46.96%	19.50%	92.00%	8.00%	0.00%	35%	65%
1993	35.20%	44.60%	20.20%	84.00%	16.00%	0.00%	35%	65%
1994	36.70%	42.30%	21.00%	75.70%	24.30%	0.00%	35%	65%
1995	38.40%	40.00%	21.60%	67.80%	32.20%	0.00%	35%	65%
1996	40.00%	37.70%	22.30%	59.70%	40.30%	0.00%	35%	65%
1997	41.60%	35.40%	23.00%	51.60%	48.40%	0.00%	35%	65%
1998	43.20%	33.10%	23.70%	43.50%	56.50%	0.00%	35%	65%
1999	44.80%	30.70%	24.50%	35.40%	64.60%	0.00%	35%	65%
2000	46.40%	28.40%	25.20%	27.35%	72.65%	0.00%	35%	65%
2001	45.00%	31.50%	23.50%	32.60%	67.40%	0.00%	35%	65%
2002	43.60%	34.30%	22.10%	37.90%	62.10%	0.00%	35%	65%
2003	42.20%	37.50%	20.30%	43.20%	56.80%	0.00%	35%	65%
2004	40.70%	40.60%	18.70%	48.40%	51.60%	0.00%	35%	65%
2005	39.30%	43.60%	17.10%	53.60%	46.40%	0.00%	35%	65%
2006	36.80%	46.10%	17.10%	58.70%	41.30%	0.00%	35%	65%
2007	34.30%	48.70%	17.00%	63.60%	36.40%	0.00%	35%	65%
2008	32.80%	51.10%	16.10%	68.60%	31.40%	0.00%	35%	65%

	Cattle			Swine			Sheep	
	Solid storage	Liquid systems	Pasture range paddock	Liquid systems	Solid storage	Dry lot	Solid storage	Pasture range paddock
2009	29.20%	53.70%	17.10%	73.50%	26.50%	0.00%	35%	65%
2010	26.70%	56.10%	17.20%	78.60%	21.40%	0.00%	35%	65%
2011	25.40%	58.10%	16.50%	81.23%	18.77%	0.00%	35%	65%
2012	24.00%	60.30%	15.70%	83.86%	16.14%	0.00%	35%	65%
2013	22.70%	62.30%	15.00%	86.48%	13.52%	0.00%	35%	65%
2014	21.30%	64.40%	14.30%	89.11%	10.89%	0.00%	35%	65%
2015	20.00%	66.50%	13.50%	91.74%	8.26%	0.00%	35%	65%
2016	20.00%	66.50%	13.50%	91.74%	8.26%	0.00%	35%	65%
2017	20.00%	66.50%	13.50%	91.74%	8.26%	0.00%	35%	65%
2018	20.00%	66.50%	13.50%	91.74%	8.26%	0.00%	35%	65%
2019	20.00%	66.50%	13.50%	91.74%	8.26%	0.00%	35%	65%
2020	20.00%	66.50%	13.50%	91.74%	8.26%	0.00%	35%	65%
2021	20.00%	66.50%	13.50%	91.74%	8.26%	0.00%	35%	65%

5.5.2.2 Direct N₂O emissions from manure management

Following the guidelines, all emissions of N₂O taking place before the manure is applied to soils are reported under manure management.

For the estimation of N₂O 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 N₂O 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:

$$Nex_{(AWMS)} = \sum(T) [N_{(T)} \times Nex_{(T)} \times AWMS_{(T)}]$$

$Nex_{(AWMS)}$ = 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

N₂O emission per animal waste management system:

$$N_2O_{(AWMS)} = \sum [Nex_{(AWMS)} \times EF_{3(AWMS)}]$$

$N_2O_{(AWMS)}$ = N₂O 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]

$EF_{3(AWMS)}$ = N₂O emissions factor for an AWMS [kg N₂O-N per kg of Nex in AWMS]

AWMS

The animal waste management systems distribution data applied to estimate N₂O emissions from Manure Management is the same as used for the estimation of CH₄ emissions from Manure Management (see Table 183).

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 submission 2019 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:

$$\text{Daily N intake} \times \text{amount of non-digested N(\%)} \times 365 = \text{Annual Nex}$$

The daily N intake for the different cattle categories is as follows:

Table 184 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 calves 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 185 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
2018	243056		1227440		106505		56303	166.14
2019	224637		135451		101241		57147	165.84
2020	221507		151840		103212		63035	165.21
2021	221366		176755		113863		67136	165.16

- **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:

$$(Daily\ N\ intake + 8) \times Amount\ of\ non-digested\ N(\%) \times 365 = Annual\ Nex$$

The equation for sows is:

$$Daily\ N\ intake\ (in\ pregnancy) \times Amount\ of\ non-digested\ N\ (\%) \times 302 + Daily\ N\ intake\ (when\ lactating) \times Amount\ of\ non-digested\ N\ (\%) \times 63 = Annual\ Nex.$$

The ratios of undigested N are as follows:

Table 186 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%
Pregnant	70%
lactating	65%

The amount of N the animals receive with the food is as follows:

Table 187 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 188 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	25347	61329
2017	133,951	149,962	114500	128,271	19369	58,283

	Population size					
	Pigs < 20 kg	Pigs 20-50 kg	Pigs 50 -80 kg	Pigs 80 -110 kg	Pigs > 110 kg, and boars	Breeding pigs
2018	142848	147677	128041	129768	9450	66072
2019	122162	143945	114578	126024	6051	60422
2020	111433	131218	121433	113148	6411	58314
2021	143078	163095	157420	105739	8290	65760
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 189). Data have been provided by Agriculture university of Plovdiv.²²

Table 189 Activity data for estimating nitrogen excretion from poultry

Layer hen		Broilers		Turkey		Ducks and others	
TAM	Kg N in 1000 Kg manure	TAM	Kg N in 1000 Kg manure	TAM	Kg N in 1000 Kg manure	TAM	Kg N in 1000 Kg manure
2.03	0,82	2.57	1.10	9.00	0.74	5	0.83

- **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):

$$Nex_{(T)} = Nrate_{(T)} \times TAM/1000 \times 365$$

$Nex_{(T)}$ = N excretion of animals of type T in the country [kg N animal⁻¹ yr⁻¹]

$Nrate_{(T)}$ = 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 176, chapter Enteric fermentation)

Values of nitrogen excretion of animal of type are present in Table 190.

Table 190 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	60.64
Buffalo	44.38
Sheep	14.02
Goats	17.99
Horses	41.28
Mules & Asses	14.24
Swine(weight average)	11.66
- 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
Layer hen	0.61

²² D. PENKOV, V. GERZILOV et al, 2012 Data on the chemical content and management of waste from industrial poultry breeding

Livestock category	Nitrogen excretion [kg/animal*yr.]
Broilers	1.03
Turkey	2.43
Ducks & other	1.51

5.5.2.2 Emission factors

N₂O 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 191 Emission factors for N₂O from manure management

Animal Waste Management System	Emission factor [kg N ₂ O-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 N₂O emissions from manure management

Table 192 Indirect N₂O emissions from Manure Management

Year	Total N volatilised as NH ₃ and NO _x (kg N/year)	N ₂ O emissions (Gg)
1988	85557673	1.34
1990	82363192	1.29
1995	39427420	0.62
2000	31313418	0.49
2005	32023529	0.50
2010	26417188	0.42
2015	25368374	0.40
2016	25111699	0.39
2017	24644304	0.39
2018	24871675	0.39
2019	24304875	0.38
2020	23941102	0.38
2021	24800380	0.39

Indirect N₂O emissions from manure management are result from diffusion into the surrounding air (volatilisation) and from leaching and runoff. All indirect N₂O 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 N₂O emissions resulting from volatilisation:

$$N_2O_{G(mm)} = (N_{volatilization-MMS} \times EF_4) \times \frac{44}{28}$$

$N_2O_{G(mm)}$ – indirect N₂O emissions due to volatilization of N from Manure Management, kg N₂O/year

EF_4 – emission factor for N₂O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N₂O-N/kg NH₃-N + NO_x-N volatilised – default value is 0,01 kg N₂O-N/kg NH₃-N + NO_x-N volatilised (table 11.3, 2006 IPCC GL);

$$N_{volatilization-MMS} = \sum_s [\sum_T [(N \times Nex \times MS) \times (\frac{FracGasMS}{100})]]$$

$N_{volatilization-MMS}$ - amount of manure nitrogen that is lost due to volatilization of NH₃ and NO_x, kg N/year;

N – number of head of livestock species

Nex – annual average N excretion per head of species, kg N/animal/year (see

Table 190);

MS – fraction of total annual nitrogen excretion for each livestock that is managed in manure management system;

$FracGasMS$ – present of managed manure nitrogen for livestock category that volatilises as NH₃ and NO_x in the manure management system, % (see below).

Table 193 2006 IPCC GL values for nitrogen loss due to volatilisation of NH₃ and NO_x 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	Solid storage	30 %
	Liquid system	40 %
Poultry	Poultry without litter	55 %
Other cattle	Liquid system	40 %
	Solid storage	45 %
Other	Solid storage	12 %

The 2006 IPCC GL Tier 1 methodology for determining indirect N₂O 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 194 Uncertainty of sub-sector Manure Management for 2021, %

CRF categories	Key Category	GHG	Activity data uncertainty, %	Emission factor uncertainty, %	Combined uncertainty, %
3.B.2.1	Cattle	N ₂ O	0.64	50	50
3.B.2.4	Buffalo	N ₂ O	0.64	100	100
3.B.2.2	Sheep	N ₂ O	1.63	50	50
3.B.2.4	Goats	N ₂ O	1.65	100	100
3.B.2.4	Horses	N ₂ O	2	100	100
3.B.2.4	Mules and Asses	N ₂ O	2	100	100
3.B.2.3	Swine	N ₂ O	0.51	50	50
3.B.2.4	Poultry	N ₂ O	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

There are no source-specific recalculations.

Source-specific planned improvements

Bulgaria makes great efforts to improve the estimations, using year-specific values for the nitrogen excretion rate in this emissions calculation for 3.B.1 Manure Management, Dairy Cattle.

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 12 053ha in 2021.

121.58 Gg CH₄ CO₂-eq. has been emitted in 2021. Emission decrease by 2.4% compared to the year 2020 (124.56Gg CH₄ CO₂-eq) which is due to the increase 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

CH₄ emission calculation is carried out according to the default method from the 2006 IPCC GL for continuously flooded water regime.

$$CH_4 \text{ Rice} = EF \times t \times A \times 10^{-6}$$

EF – daily emission factor, kg CH₄/ha/day (see 5.6.2.2);

t – cultivation period of rice = 125 days²³;

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:

$$EF = EF_c \times SF_w \times SF_p \times SF_o$$

Table 195 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

SF_o have been calculated with equation 5.3 from the 2006 IPCC GL.

²³ According NAAS (National Agricultural Advisory Service)

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 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 2021 this category generates 93,07% of N₂O emissions from Agricultural sector. There is a decrease of 36,54 % for this category from 1988 to 2021 (Figure 103). The reasons are structural changes in agricultural holdings and decrease in arable land area.

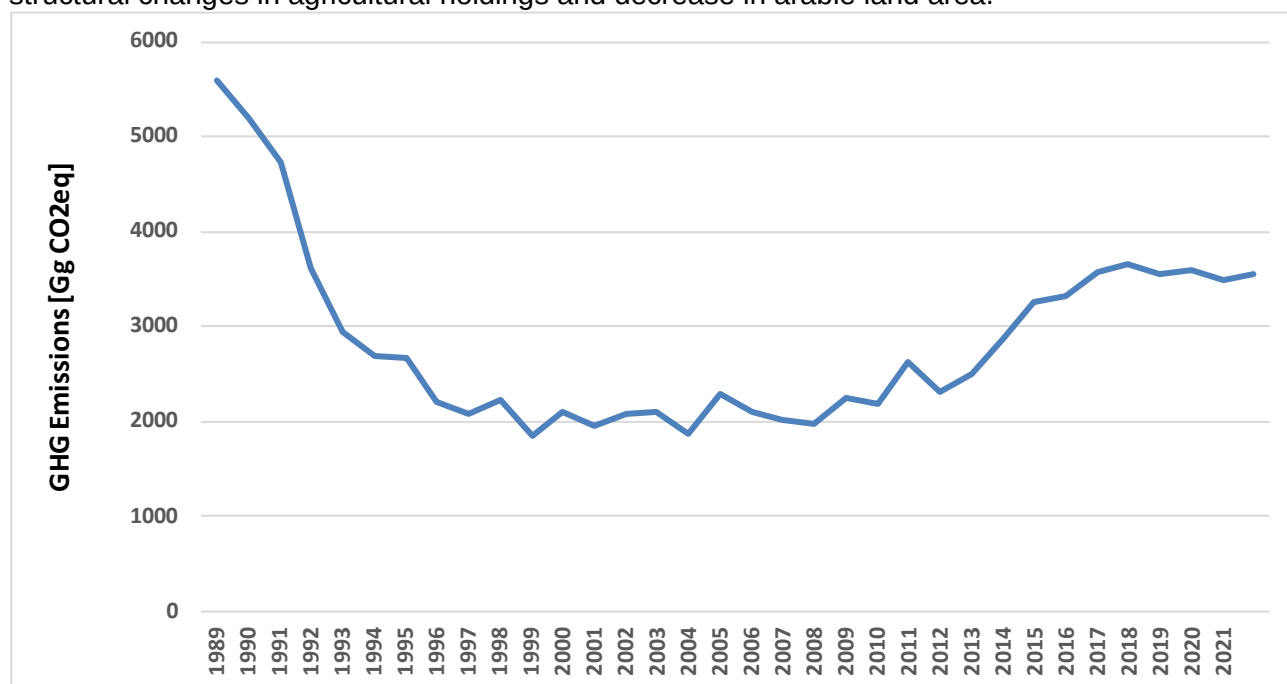


Figure 103 Trend of GHG Emissions from agricultural soils

5.7.1 SOURCE CATEGORY DESCRIPTION

The emissions from this subsector include the two main categories N₂O emissions:

- Direct emissions;
- Indirect emissions.

These two categories above are key sources in the year 2021.

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 N₂O emissions are 3 546.99Gg CO₂-eq. in 2021.

Indirect N₂O emissions are 761.93Gg CO₂-eq. in 2021.

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).

$$N_2O_{Direct} - N = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1] + (F_{OS, CG, Temp} \times EF_{2CG, Temp}) + (F_{PRP, CPP} \times EF_{3PRP, CPP}) + (F_{PRP, SO} \times EF_{3PRP, SO})$$

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/yr *F_{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

EF₁, *EF_{2CG, Temp}*, *EF_{3PRP, CPP}*, *EF_{3PRP, SO}* – default emission factors (kg N₂O-N/kg N), see Table 197

- *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.
 - Annual amount of sewage sludge applied to soil in Bulgaria have been calculated since 2007 year. Bulgaria became a member of the EU in 2007 and due to the current national legalisation no activity did occur before 2007. The main legal framework for the use of sewage sludge in the Member States is ensured by Directive called the Sewage Sludge Directive (86/278 / EEC), which deals entirely with the use of sludge in agriculture
 - The 2006 IPCC GL included in *F_{ON}* annual amount of total compost N applied to soils. Composting in Bulgaria is pretty new technology (there are three composting installation

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 recommendations, 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 2019, 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 $NH_3 - N$ emissions ($Frac_{GASF}$) the sales data from IFA for 2010 were used (Table A1-2, Chapter 3.D, EMEP 2019). Furthermore, the NH_3 emission factor for each fertiliser is given, based on the values from the EMEP/EEA Guidebook 2019. 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 2018 submission, $Frac_{GASF}$ have been recalculated, according new data in the EMEP/EEA Guidebook 2019.

Table 196 Activity data for the estimations of $Frac_{GASF}$ for 2021.

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%	106295.9	0.064
Ammonium nitrate (AN)	0.015	55%	188589.5	
CAN	0.008	1%	3428.9	
Ammonium sulphate (AS)	0.09	4%	13715.6	
Ammonium phosphate (AP)	0.05	9%	30860.1	

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 197.

Table 197 N_2O emissions factors for agricultural soils.

Category	Emission Factor [kg N ₂ O-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	0.02	Table 11.1 - 2006 IPCC GL
- Sheep and “other animal”	0.01	
3.D.1.6. Cultivation of organic soils	8 kg N ₂ O–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 199) (1988-2016). Since 2017 the data is provided with official letter by Ministry of Agriculture, Food and Forestry. Also it is cross-checked 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

https://ec.europa.eu/eurostat/databrowser/view/aei_fm_usefert/default/table?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). „IE” is reported for sludge under wastewater treatment and discharge in CRF table 5.D to avoid double counting.

- **Annual crop production:**

Data have been provided by the Agrostistics 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 Institute of Soil, Agrotechnology and Plant Protection "Nikola Pushkarov"

Table 198 Activity data for Agricultural soils

Category	Data Sources
3.D.1 Direct soil emissions	
Synthetic fertilizers (mineral fert.)	Ministry of agriculture food and forestry
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	Institute of Soil, Agrotechnology and Plant Protection "Nikola Pushkarov "
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 199 Area of crop land (ha)

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Wheat	1162775	978575	1101807	1131565	1105916	1192589	1144519	1212012	1198682	1200175	120687
Barley	359950	251962	264519	245328	175957	159830	128365	103570	112029	130757	126310
Maize	424428	466475	298713	327525	498644	406942	398152	444623	560911	581532	573023
Oats	35225	40600	30571	24353	11076	15323	13266	11339	12153	13397	9937
Rye	24499	21200	8782	10795	6304	7468	8237	8316	6097	5352	7633
Rice	10590	3571	4501	11977	12410	11988	10434	11004	11822	12349	12053
Maize for silage	424317	57758	32211	20314	26555	31102	29930	27242	27500	30439	30108
Bean	39381	30762	8552	1410	3314	2410	2749	1809	1396	2254	2524
Peas	38138	5500	1402	1981	8758	18286	766	479	919	870	699
Soya	16816	3000	272	725	34468	14162	11530	2315	3862	4510	1986
Chick peas	4600	2500	593	911	2466	4722	22564	59841	11373	4076	3335
Lentils	7720	3500	2064	2879	1449	3853	4471	3179	1273	1432	1791
Potatoes	41000	53000	23999	13805	11017	8376	12806	14096	9291	9946	10902
Sugar beet	36479	2210	1294	0	0	0	0	0	0	0	0
Cotton	8995	9260	1119	558	2171	4490	4805	3157	3461	3280	2354
Feet beet	310000	341000	87302	337313	117853	140679	172723	183218	165052	138988	124504
Peanuts	11738	600	1094,3	519	222	222	443	605	471	636	676
Sunflower	280203	511015	635003	729889	810841	817511	898844	788656	815561	821922	836469
Tobacco	52897	28523	40869	24518	13360	9963	7721	5812	3536	3186	3782
Alfalfa	399576	150741	64851	74832	64802	84685	88182	91592	69361	92075	92745

Table 200 Parameters for estimating N₂O emissions in Crop Residues returned to Soils

Parameter description	Parameter Source
Area	Input of Ministry of Agricultural
Crop	Eq. 11.7, IPCC 2006 GB
Yield fresh	Input of Ministry of Agricultural
Dry matter fraction	CS (University of Plovdiv)
Above-ground residue dry matter	Table 11.2 IPCC 2006 GB
Slope	Table 11.2 IPCC 2006 GB

Intercept	Table 11.2 IPCC 2006 GB
Ratio of above-ground residues	Above-ground residue dry matter x 1000/Crop
N content of above-ground residue for crops	Table 11.2 IPCC 2006 GB
Ratio of below-ground residues TO above-ground biomass	Table 11.2 IPCC 2006 GB
Ratio of below-ground residues	RBG-BIO * (AGDM x 1000 + Crop)/Crop
N content of below-ground residue for crops	Table 11.2 IPCC 2006 GB
Annual amount of N in crop residue (Fcr)	Eq. 11.7A, IPCC 2006 GB
Emission Factor - N ₂ O-N	Table. 11.1 IPCC 2006 GB
N ₂ O-N emissions	(Fcr x EF1) / 1000000 GB

Table 201 Total emissions from N₂O [Gg] in Crop Residues returned to Soils 1990-2021

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Total emissions from N₂O in Crop Residues Returned to Soils [Gg]	3.18	2.18	1.52	2.07	3.37	3.30	3.92	4.19	4.05	3.98	3.50	4.02

Table 196 Consumption of synthetic fertilizers for the period 1988 – 2021:

	1988	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Amount of synthetic fertilizers (kt N/year)	541	396	130	145	160	199	342	366	351	339	352	364	343

Table 202 Sewage sludge spreading, 2008 – 2021:

	2008	2009	2010	2011	2012	2013
Sewage sludge spreading (t/dm)	52 117	16644	13644	17561	21241	16680
	2014	2015	2016	2017	2018	2019
	16363	30444	26229	22251	29797	25665
	2020	2021				
	16929	18490				

The data is available in EUROSTAT:

http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_usefert&lang=en.

5.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty from the direct N₂O emissions from this source is 200% and from the indirect emissions - 500%.

Table 203 Uncertainty of sub-sector Agricultural soils for 2019, %

CRF categories	Key Category	GHG	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
3D1	Direct soil emissions	N ₂ O	3	200	200
3D2	Indirect Emissions	N ₂ O	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

There is no specific recalculations in this sub-sector.

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-CO₂ 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.

41.63Gg CO₂-eq. aggregated GHGs were emitted in 2021 (0.68% 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 204.

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 204 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 205).

Table 205 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 ratio 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
Soybeans	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
Sunflower	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
Footbeet	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 CH₄ emission factor is 50%, and for the N₂O – 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 source-specific recalculations.

5.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

There are no planned improvements for this category.

5.9 CO₂ EMISSIONS FROM LIMING (CRF sector 3G)

5.9.1 Source category description

CO₂ emission's estimations are based on expert judgement of percent cultivated area and grassland area which need potentially liming. The activity data for Grassland and Cropland are reported under Chapter Land use Land use change and forestry.

According expert judgement 10% of grassland and 17% of cropland are potentially liming. The recommended lime application is 0,15 t/ha. The emissions from liming are estimated according 2006 IPCC Guidelines, Volume 3 AFOLU, Chapter 11: N₂O Emissions from Managed Soils, and CO₂ Emissions from Lime and Urea Application sub-chapter 11.3.2. The chosen emission factors is on page 11.28.

5.9.2 Methodological issues

A Tier 1 method as given in the 2006 IPCC GL is used

Table 206 CO₂ emissions from Liming 1988-2021

	1988	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Total amount of Lime used in agriculture [t]	66221	64970	60679	58585	53356	52704	55917	55848	55855	55772	55707	55903	55994
CO ₂ emission from 3.(II).G Liming [Gg]	29,14	28,59	26,70	25,78	23,48	23,19	24,60	24,57	24,58	24,54	24,51	24,60	24,64

5.9.3 Uncertainties and time-series consistency

The uncertainty of emissions from this source is 20%.

5.9.4 Source – specific qa/qc

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

5.9.5 Source – specific recalculations

There is no source specific recalculations

5.9.6 Source – specific planned improvements

There are no planned improvements in this category

5.10 CO₂ EMISSIONS FROM UREA FERTILIZATION (CRF sector 3H)

5.10.1 SOURCE CATEGORY DESCRIPTION

Adding urea (CO(NH₂)₂) to soils during fertilization leads to a loss of CO₂. Emission of CO₂ from use of urea contributes with less than 1% of the CO₂ emission from the agricultural sector. The recommended lime

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 207 Consumption of urea fertilizers (t/year) for the period 2006 – 2021

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Urea (t/year)	23348	21481	27686	33891	24619	35840	42712	50739	42082	42639	49000	45577	46007	45061	45657	46261

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

CO₂ emissions from urea fertilization were estimated with Equation 11.13 from the 2006 IPCC GL:

$$\text{CO}_2 - \text{C Emission} = M \times EF$$

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 CO₂ – C emissions in CO₂, emissions were multiply by 44/12.

Table 208 CO₂ emissions from urea fertilisation

	2006	2007	2008	2009	2010	2011	2012
CO ₂ emissions (Gg)	17.12	15.75	20.30	24.85	18.05	26.28	31.32
	2013	2014	2015	2016	2017	2018	2019
	37.21	30.86	31.27	35.93	33.42	33.74	33.04
	2020	2021					
	33.48	33.92					

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 CO₂ 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.

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 2023 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 CH₄ and N₂O 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 209 Overview of subcategories of CRF Sector 4 – LULUCF: status of emission estimates for CO₂, CH₄ and N₂O

Land-Use Categories	Net CO ₂ emissions/removal	CH ₄	N ₂ O
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	x
1. Grassland remaining Grassland	X	NO	x
2. Land converted to Grassland	X	NO	NO
D. Wetlands	X	NO	x
1. Wetlands remaining Wetlands	NO, NE	NO	NO
2. Land converted to Wetlands	X	NO	x
E. Settlements	X	NO	x
1. Settlements remaining Settlements	NO, NE	NO	NO
2. Land converted to Settlements	X	NO	x
F. Other Land	NO	NO	NO
1. Other Land remaining Other Land	NO	NO	NO
2. Land converted to Other Land	NO	NO	NO

Land-Use Categories	Net CO ₂ emissions/removal	CH ₄	N ₂ O
G Harvested Wood Products (HWP)	X		
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 210 Key sources of LULUCF sector (T1)

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.B.2 Land Converted to Cropland	CO ₂	x	x
4.C.1 Grassland remaining Grassland	CO ₂	x	
4.C.2 Land Converted to Grassland	CO ₂	x	x
4.D.1 Wetlands remaining Wetlands			
4.D.2 Land Converted to Wetlands	CO ₂		
4.E.1 Settlement remaining Settlements	CO ₂		
4.E.2 Land Converted to Settlements	CO ₂	x	x
4.A.1 (V) Forest fires FLrFL	CO _{2 eq}	x	x
4.A.2 (V) Forest fires LUC to FL	CO _{2 eq}		
4.G Harvested Wood Products	CO ₂	x	x

6.1.3 Emission Trends

The emissions and removals in the different categories are presented in Table 211

Table 211 Net emissions and removals of greenhouse gases from land use, land use changes and forestry by categories in CO₂ 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	Indirect N ₂ O emissions
1988	-16112.02	-14475.94	-784.77	-934.59	128.27	475.66	NO	-583.27	62.63
1989	-16305.20	-14595.38	-791.93	-990.22	121.51	473.55	NO	-583.27	60.54
1990	-16344.26	-14720.28	-767.79	-913.12	114.76	467.19	NO	-583.27	58.24
1991	-16416.61	-14837.16	-773.81	-1015.54	108.01	484.44	NO	-438.26	55.70
1992	-15952.39	-14947.41	-773.15	-1202.59	101.26	502.23	NO	314.37	52.89
1993	-16290.11	-15048.32	-745.84	-1507.17	94.51	460.85	NO	406.06	49.80
1994	-16415.96	-15193.78	-676.14	-1522.53	87.76	465.43	NO	376.59	46.72
1995	-16528.10	-15411.06	-612.57	-1450.92	111.07	447.43	NO	344.00	43.96
1996	-15942.03	-14625.40	-617.62	-1539.95	119.60	445.87	NO	234.26	41.20
1997	-16191.83	-14804.51	-619.92	-1555.89	125.41	463.65	NO	160.83	38.60
1998	-15971.33	-14952.58	-680.90	-1213.38	132.92	472.29	NO	234.33	36.00
1999	-15838.26	-15091.83	-251.94	-1171.61	140.40	499.92	NO	1.55	35.25
2000	-17083.34	-14991.97	-732.10	-1775.94	148.50	503.14	NO	-268.48	33.51
2001	-14428.65	-12243.84	-681.30	-1802.76	156.61	445.39	NO	-334.31	31.57
2002	-14770.21	-12328.39	-652.71	-1989.05	164.85	466.41	NO	-461.21	29.90

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	Indirect N ₂ O emissions
2003	-14365.28	-12372.53	-552.06	-1662.90	172.78	448.34	NO	-427.32	28.42
2004	-15136.22	-12410.26	-601.72	-1916.94	180.91	438.64	NO	-853.91	27.06
2005	-16460.11	-12450.17	-735.04	-3057.31	189.03	527.74	NO	-961.02	26.66
2006	-13137.03	-10414.95	-544.03	-2043.31	197.25	543.25	NO	-901.76	26.52
2007	-14079.24	-10270.69	-630.94	-2332.14	205.59	624.40	NO	-1702.25	26.79
2008	-12395.02	-10403.03	-354.59	-1817.82	220.47	823.83	NO	-892.71	28.82
2009	-12489.43	-10430.19	-352.30	-1743.43	235.67	618.11	NO	-847.07	29.79
2010	-11876.88	-10360.39	70.50	-1685.48	250.60	771.70	NO	-957.18	33.39
2011	-8519.19	-6739.73	139.22	-1620.92	265.57	695.64	NO	-1294.93	35.96
2012	-8021.08	-6674.32	434.17	-1534.16	280.48	704.83	NO	-1271.18	39.09
2013	-6886.46	-6668.52	1285.91	-1414.25	298.38	756.19	NO	-1189.39	45.21
2014	-8163.99	-6648.08	175.68	-1420.13	288.53	653.28	NO	-1258.22	44.95
2015	-7689.09	-6498.34	467.18	-1269.31	276.95	818.90	NO	-1530.65	46.18
2016	-9487.74	-8403.36	218.26	-1237.58	265.34	760.59	NO	-1136.75	45.77
2017	-9426.01	-8376.12	325.27	-1073.33	254.42	754.78	NO	-1356.29	45.26
2018	-9563.65	-8364.42	290.68	-1187.86	243.58	642.48	NO	-1232.72	44.62
2019	-9365.55	-8299.69	181.18	-1283.82	232.78	791.44	NO	-1030.12	42.70
2020	-9405.54	-8279.44	352.72	-1179.51	221.83	639.19	NO	-1202.99	42.66
2021	-9144.09	-8139.83	268.06	-957.86	210.78	617.41	0.00	-1185.31	42.66

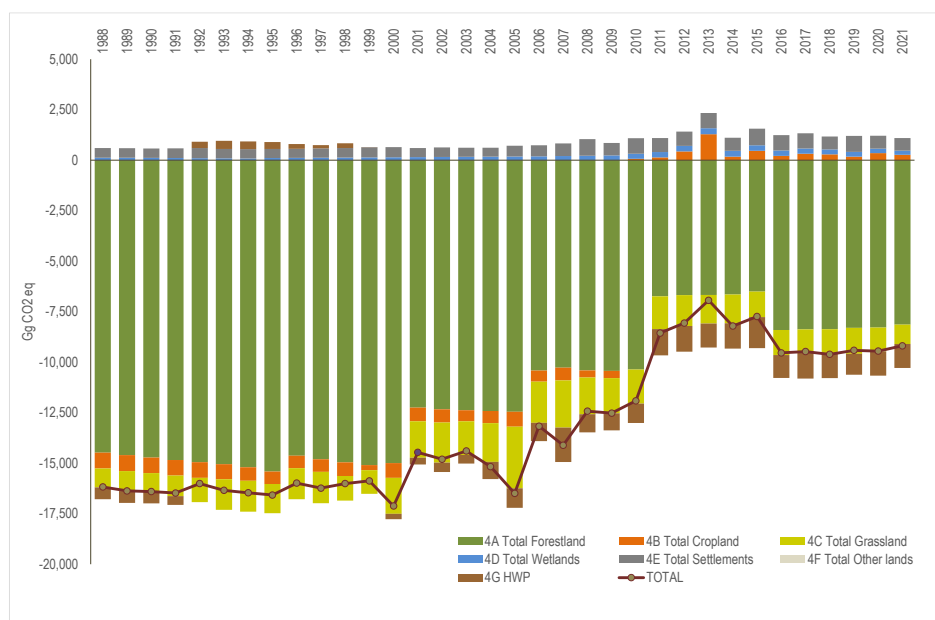


Figure 104 LULUCF emissions and removals 1988 – 2021 CO₂ eq.

The figure shows that the LULUCF sector is serving as a sink of greenhouse gases for Bulgaria. The category “Forest land” is a sink of CO₂ during the whole time series. The HWP, Cropland, Grassland, and Other Land categories contribute to the emissions/removals from LULUCF category in both directions – as source and as a sink of emissions. All remaining categories (Settlements and Wetlands) are sources of CO₂ emissions. The trend of net CO₂ removals (CO₂ eq) from the LULUCF decreases by 43% compared to the base year. The main reason for the overall decrease of the uptakes of CO₂ emissions from LULUCF is due to the drop 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 a constant increase in harvesting. Although the increase in the wood removals, the harvesting in these years is still below to what was planned to be harvested. In 2019 the harvesting is by 20% higher than in 2010 as since 2012 it reaches the planned quantities according to FMPs. The increase in harvesting since 2011 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 – 14.2% from the total GHG emissions in CO₂eq, while in the inventoried year the share is – 17%.

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 2023, all the emissions from N mineralization associated with the loss of soil organic matter, resulting from the change of land use or management of mineral soils, have been included. More information on the estimations is presented in the relevant chapters.

6.1.4 Methodology

The inventory follows the methodologies and principles envisaged in the IPCC 2006 and 2013 KP Supplement. 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.

Table 212 Summary of the methodological tier applied in LULUCF sector

IPCC Categories	Carbon pools					Non-CO ₂	
	Living biomass	Dead wood	Litter	Mineral Soil	Organic soil	CH ₄	N ₂ O
4A1 FLrFL	Tier 2	Tier 2	Tier 1	Tier 1	NO	Tier 1	Tier 1
4A2 LUC to FL	Tier 2	NO	Tier 2	Tier 2	NO	Tier 1	Tier 1
4B1 CLrCL	Tier 1	Tier 1		Tier 2	NO	NO	
4B2 LUC to CL	Tier 1, Tier 2	Tier 1		Tier 2	NO	NO	Tier 1
4C1 GLrGL	Tier 1	Tier 1		Tier 2	NO	NO	Tier 1
4C2 LUC to GL	Tier 1, Tier 2	Tier 1		Tier 2	NO	NO	
4D1 WLrWL	NO	NO		NO	NO	NO	Tier 1
4D2 LUC to WL	Tier 1, Tier 2	Tier 1, Tier 2	Tier 1, Tier 2	Tier 2	NO	NO	
4E1 SMrSM	Tier 1	Tier 1		Tier 1	NO	NO	
4E2 LUC to SM	Tier 1, Tier 2	Tier 1, Tier 2	Tier 1, Tier 2	Tier 2	NO	NO	Tier 1
4F OL							

6.1.4.1 Activity data

Bulgaria reports the LUC areas within the LUC categories for a transition period of 20 years following the 2006 IPCC Guidelines. 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).

6.1.4.2 Emission Factors

The calculation of the emission factors follows to a great extent the methods, described in the 2006 IPCC Guidelines and IPCC 2019. 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, and the scientific research database in Bulgaria and other European countries.

6.1.5 Uncertainty

The uncertainties of gas emission estimations (CO₂ and other contaminants) were determined by IPCC categories ("Forest land", "Cropland", "Grassland", "Settlements", "Wetlands", "Other land") and sub-categories, and sources within sub-categories using empirical data, expert judgments and recommended by FAO (FAO, 2006) reference values (Table below). Efforts towards uncertainty reduction were made by extending the empirical data range to derive country-specific activity data and emission factor input values. Additional sources of CO₂ emissions and removals (e.g. Deadwood in Forests) and other gases (e.g. N₂O from soils), not taken into consideration earlier, were also accounted for. Uncertainty data 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. 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. Inferences by sub-categories and sources as well as general conclusions about the IPCC categories "Forest land", "Cropland", "Grassland", "Settlements", "Wetlands", "Other land" was derived.

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
Cropland remaining cropland, ha	3	expert judgment
Grassland remaining grassland, ha	5	expert judgment
Land use changed to forest land, ha Land use changed to cropland, ha Land use changed to grassland, ha	10	expert judgment
Merchantable growing stock, m ³ ha ⁻¹	Conifers, Broadleaved – 8 Combined - 10	default, 2006 IPCC GNGGI; expert judgment
Biomass expansion factor (BEF)	20	expert judgment
Bulk density of wood (D), kg/m ³	Conifers – 12.0 Broadleaved – 12.2 Combined – 8.7	country specific data Blaskova (Wood science textbook), Belyakov et al. (Bio-productivity and wood properties of Scots pine, unpublished)
Bulk density of dead wood (D), kg/m ³	Conifers – 38.1 Broadleaved – 45.3	default, Di Cosmo et al. / Forest Ecology and Management 295 (2013) 51–58, Table 4
Ratio of below-ground biomass to above-ground biomass (R)	Conifers – 18.1 Broadleaved – 11.4 Combined – 73.1	default, 2006 IPCC GNGGI
Emission factor, g kg ⁻¹ dry matter burnt (Gef)	CO ₂ - 16.7 CH ₄ – 80.9	default, 2006 IPCC GNGGI

Activity/Emission factor	Uncertainty %	Source of information
	NO ₂ – 53.8	
Dead wood stock, m ³ ha ⁻¹	Conifers – 9.5 Broadleaved – 6.6	empirical data
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), (tonne d.m.) ⁻¹	Conifers – 7.8 Broadleaved – 4.2 Combined – 5.3	default, 2006 IPCC GNGGI
Yield biomass from grassland (pastures and meadows) (B cut), tonnes d.m	32.5	empirical data
Biomass of the growth in the grassland (pastures and meadows) (B peak), tonnes d.m	75	default, 2006 IPCC GNGGI
Annual accumulation of C in the aboveground biomass of grassland (pastures and meadows), tonnes Cyr ⁻¹	79.4	empirical data
Annual accumulation of C in the aboveground biomass of grassland (shrubs and grasslands), tonnes Cyr ⁻¹	50	default, MediNet Project
Maximum above-ground biomass carbon stock at harvest of perennials (tonnes C ha ⁻¹)	28.1	MediNet, 2019 Refinement to the 2006 IPCC GNGGI
Accumulation rate ABG biomass of perennials, t/ha/yr	13.3	MediNet, 2019 Refinement to the 2006 IPCC GNGGI
Aboveground biomass of other land(tonnes C ha ⁻¹)	75	default, 2006 IPCC GNGGI
Aboveground biomass of settlements (tonnes C ha ⁻¹)	35	country specific data Zhiyanski et al. / Journal of Chemical, Biological and Physical Sciences 5(3) (2015), 3114-3128, Table 5
Annual accumulation of C in the aboveground biomass of perennials, tonnes C yr ⁻¹	25	default, 2019 Refinement to the IPCC GNGGI
Annual accumulation of C in the aboveground biomass of annuals, tonnes C yr ⁻¹	23.0	empirical data
C stock in litter pool, tonnes C	29.8	empirical data
Soil C stock in forestland, tonnes C	4.3	empirical data
Soil C stock in annual cropland, tonnes C	0.04	empirical data
Soil C stock in annual cropland remaining annual, tonnes C	3.2	empirical data, 2019 Refinement to the 2006 IPCC GNGGI
Soil C stock in perennial cropland, tonnes C	1.2	empirical data

Activity/Emission factor	Uncertainty %	Source of information
Soil C stock in perennial cropland remaining perennial cropland, tonnes C	3.1	empirical data, 2019 Refinement to the 2006 IPCC GNGGI
Soil C stock in other land, tonnes C	75	expert judgment
Soil C stock in settlements, tonnes C	51.5	country specific data Zhiyanski et al. / Journal of Chemical, Biological and Physical Sciences 5(3) (2015), 3114-3128, Table 2
C:N ratio of the soil organic matter	Forest Land, Other Land – 66.7 Cropland, Grassland - 35	2006 IPCC GNGGI
Emission Factor - N ₂ O-N, kg N ₂ O-N/kg N	85	2006 IPCC GNGGI

More information on the category-specific uncertainty assessment is presented in the respective subchapter of each category.

6.1.6 QA/QC

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).

In terms of QA/QC of the activity data, the correctness of the data on the areas and the tree stock is controlled during the preparation, adoption, and execution of the Forest Management Plans (FMP). The quality control is exercised by the Executive Forest Agency and its subdivisions and could be exercised by other institutions, e.g. the Ministry of Environment and Waters, municipal authorities as well as by the 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 (BANCİK) 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 databases are aggregated on the national level by the Agrostistics and Strategies Directorate of MAFF. The data entry from the filled-in questionnaires into computer software was followed by crosschecks and coherence control to ensure the data quality.

6.1.7 Recalculations

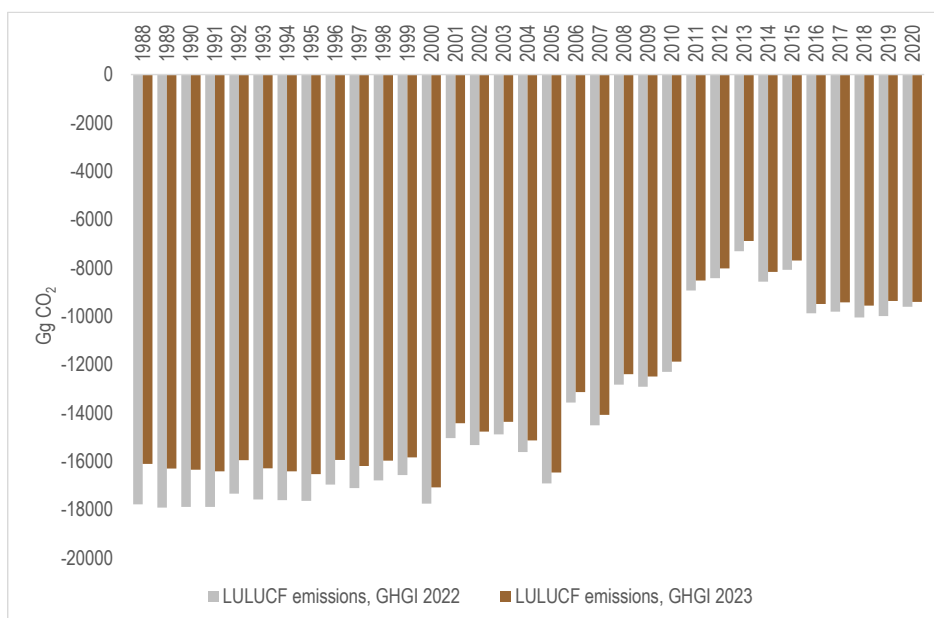


Figure 105 Recalculations in LULUCF sector

The main recalculations in Submission 2023 are related to improved estimate of the emissions and removals in subcategory LUC to FL due to differentiating the gains in biomass between coniferous and deciduous forests.

In addition, there are some recalculations that come as a result of refinement in land representation and fixing a technical error which in the previous submission resulted in small discrepancies between the initial and final areas in LUC matrices.

Another change in the calculations is related to the updated GWP of CH₄ and N₂O emissions.

6.1.8 Planned Improvements

1. Update the estimates of CSC in soils when there is a LUC with the improved methodological approach in processing the available data on soil carbon stock in Bulgaria.
2. Update the average CS in soil under different LU
3. Derive country-specific data on soil carbon stock under coniferous and deciduous species.

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 12.03.2021, SG №21):

“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 the 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 recovery and are still under the parameters, but it is expected to reach forest crown cover of over 10% and tree height of 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

Category Cropland consists of two subcategories - **annual and perennial crops**.

Under the subcategory “annual crops” we define arable lands which are regularly ploughed and regularly cultivated under a system of crop rotation. These lands are occupied by cereals and dry pulses, industrial crops, fodder and other field crops or vegetables. Arable lands which are laying fallow as well as cornfields and kitchen gardens are defined as annual croplands as well.

Perennial crops include orchards, vineyards, fruit and berry plantations, other permanent crops, nurseries for wine, fruits, ornamental plants etc. The orchards are uniformly kept plantations (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 at least 10 trees per 0.1 ha and therefore the maximum distance between the trees a 10x10m.

Grassland

As grasslands are defined herbaceous lands which are not classified as croplands. These lands are further stratified into two subcategories:

- 1) Pastures and Meadows and
- 2) Shrubs and grasslands.

The subcategory Pastures and Meadows include lands that are subject to grazing or mowing - permanent pastures, high mountain pastures, and natural meadows.

The subcategory Shrubs and Grasslands includes low productive grasslands and secondary lawns, areas with scattered thorns and shrubs, abandoned arable land, naturally covered with thorns, grasses, and herbs, unsuitable for grazing.

Wetlands

The Wetlands category includes lands covered with water or water-saturated lands (throughout the year or partially in the year) which does not fall into the other categories. These are natural or artificial watercourses serving as water drainage channels, natural or artificial stretches of water, wetlands areas and bogs.

Settlements

The Settlements refer to all classes of urban formation - buildings, roads, streets and areas with artificial surfaces, roads and railways, their facilities and the appropriate area, mines, landfills and construction sites, city parks, gardens, cemeteries, sports facilities. These areas are functionally or administratively associated with public or private lands in cities, villages or other settlement types.

Other land

Other land category includes bare lands, rock, sands, and sparsely vegetated areas.

6.2.2 Sources Of Activity Data

There are different data sources available in the country which collect and store information on the area, land cover and land use. These sources represent information systems that are usually maintained by different administrative institutions and serve to monitor and manage the resources for which the respective administration is responsible. Very often there is little or lack of synchronization between the different information systems which is their main disadvantage. However, we could assume that the quality of the information that any single institution manages and maintains is good enough to provide the overall picture of the land area representation. The main challenges here are related to:

1. the lack of systematically collected information on land use changes between different land use classes during the years;
2. the discontinuity of some statistics;
3. the use of different definitions and terms.

For example, some institutions store and maintain the information based on the designation of the land parcels whereas others work with the actual land use. All these specifics are considered in the process of land representation to ensure consistency in definitions and land use classes. The activity data was threatened in hierarchical order when LUC matrices were elaborated to ensure accuracy as much as possible.

Activity data on forest land

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, yield class, density of stand, tree growing stock etc. Forest inventory presents the 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 forest's 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 № 18/2015 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).

Activity data on Agricultural lands

BANCIK – Bulgarian Survey of the Agricultural and Economic Conjuncture, is a large-scale survey carried out throughout the territory of Bulgaria and aiming at the implementation of a unified data system showing the agricultural production and conjuncture. Basically, the survey is oriented to the agriculture, but since its character of a universal device, it also offers opportunities for throwing light on both environmental and urban set-up issues. The BANCIK survey studied the land use and cover over more than 111000 points identified on the grounds of 3123 square segments spread over 1410 km of the country area and containing 36 points each, the distance between these points being 234 m. The sample is based on the implementation of a network of North-South, East-West oriented straight lines with 6 km of distance between them. Each point of intersection of the network stands for the centre of a segment, supposedly considered random. A zone 827m large separates the borders of Bulgaria in order to correct possible inaccuracies of the standard cartography.

The annual evaluation under BANCIK is based on two detailed nomenclatures – physical nomenclature (providing information on the land cover and vegetation of the observed point and functional nomenclature providing information on the land use (socio-economic dimension of the observed territory).

IACS-LPIS - The Agricultural Land Parcel Identification System (LPIS) is a part of the Integrated Administration and Control System (IACS), which has been developed in all Member States of the European Union following the main EU regulations. The LPIS in Bulgaria is developed based on a digital orthophoto map of aerial/satellite photography. The reference plot is a physical block. LPIS information is available since 2007 covering in a “wall to wall” the entire territory of Bulgaria. In case of LPIS, one-fourth of the country is systematically updated every year. From 2020 onwards, it is expected that one-third of the country will be updated each year. The main benefits of the dataset are the accurate spatial representation (1:5000 scale), the explicit management of temporal information and the thematic accuracy (classification correctness) of agricultural area (managed cropland and managed grassland).

National Statistical Institute – owns information on Cropland and Grassland areas for the years before 1998. The information is not georeferenced, and it is stored in the National Statistical Yearbooks.

Activity data on other non-agricultural lands

As these data sources store information for the entire country territory and not only on agricultural lands, they are also used to present information on WL, SM and OL.

Additional data on land cover

Data from Corine Land Cover is used to verify the assumptions regarding the land use changes and to double check some of the information regarding specific classes of land use which could be classified differently into the varied information systems in the country.

6.2.3 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 214). 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 orthophotos. This data is used to present the total area of each particular land use category for the whole time series. When there is a discontinuity of the statistical information appropriate splicing techniques were applied.
- 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 a higher priority than estimates of LUCs based on data gaps
- Data gaps

Table 214 Information on data sources and providers

Land use category	Main data source		Data provider	
	1988-1997	1998-2020	1988-1997	1998-2020
4A Forest land	Forest Inventory, Forestry Management Plans and their Forestry fund reporting forms		Executive Forest Agency (ExFA)	
<i>Coniferous</i>				
<i>Deciduous</i>				
<i>forests out of yield</i>				
4B Cropland	National Statistical Yearbooks	BANCİK and LPIS	National Statistical Institute (NSI)	Ministry of agriculture, food and forestry (MAFF)
<i>annual cropland</i>				
<i>perennial cropland</i>				
4C Grassland	National Statistical Yearbooks	BANCİK and LPIS	National Statistical Institute (NSI)	Ministry of agriculture, food and forestry (MAFF)
4D Wetlands	Cadastral maps of the agricultural fund for single years 1994 and 1996; LPIS, CLC		Cadastre Agency, MAFF, Executive Environment Agency	
4E Settlement				
4D Other land	Forest Inventory		Executive Forest Agency (ExFA)	

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, a combination of the approaches 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.

The area representation in FL for the whole time series is in general based on data from Executive Forest Agency (EFA) and their aggregated statistics (RF1) on forest land which is updated on annual basis. However, an adjustment in the annual data is necessary to obtain more accurately the net changes in area for the inventory period. More information on that is provided in chapter 6.3.2. The LUC from FL to other LUs are reported based on annual data from EFA on forest territories subject to change

in designation of lands. The LUCs to FL are reported based on a spatially-explicit study, performed in 2021, for identification of the afforestation/reforestation units according to KP definitions. The assessment of the former land use on the identified new forest areas is based on expert judgment on basis of likelihoods and/or combining information from other sources like Cadastre.

The area representation in CL and GL for the whole time series is based on data from NSI, BANCİK and LPIS. NSI data is used for the year 1988-1998, when the information published in the National Statistical Yearbooks represent the only information on agricultural activities i.e. agricultural areas. The agricultural statistic methodology has changed since 1998 when BANCİK was introduced. To ensure the time series consistency the totals of CL and GL area from 1988 to 1998 was adjusted by interpolation. Like this any differences between the methods in the statistics were eliminated. As regards LUC to and from CL and GL, activity data and probability assumptions are used. All LUC from agricultural lands (including CL and GL) to other land uses are known and reported. However, information on whether the change in the designation of the agricultural lands happened on CL or GL is not known explicitly but calculated based on the relative share of these land categories to the total agricultural lands. Concerning the gains in the area it was assumed that it is mostly due to exchange between CL and GL. This assumption is confirmed by the agricultural statistics and when comparing the annual gross changes in the area of CL and GL (*Figure 133*). In addition to changes from CL to GL it considered that another possible change is from OL to GL. Any conversions and re-conversions from wetlands and settlements are considered as unlikely.

LUCs to wetlands have been assumed to stem from grasslands 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 the previous submissions 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 forest land 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 forest land 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 cropland to other land use categories (FL and GL), which are based on specific data and expert judgment, fit very well with the observed decrease in the total grassland area since the base year. Therefore, no land-use changes from cropland to wetlands have been assumed and reported.

Concerning the LUCs to settlements there is information for LUCs from forest land to settlements, which is available for the period 1990-1994 and for the years 2001 to 2020. 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 LUCs from agricultural lands (e.g. cropland and grassland) to settlements is available for the years 2001 to 2020. 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 2020 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 increase in settlement area.

Considering the definition of the OL, only conversions from OL to other LU categories are reported. In most cases these changes are estimated to fit the trend in the land use changes between categories.

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.

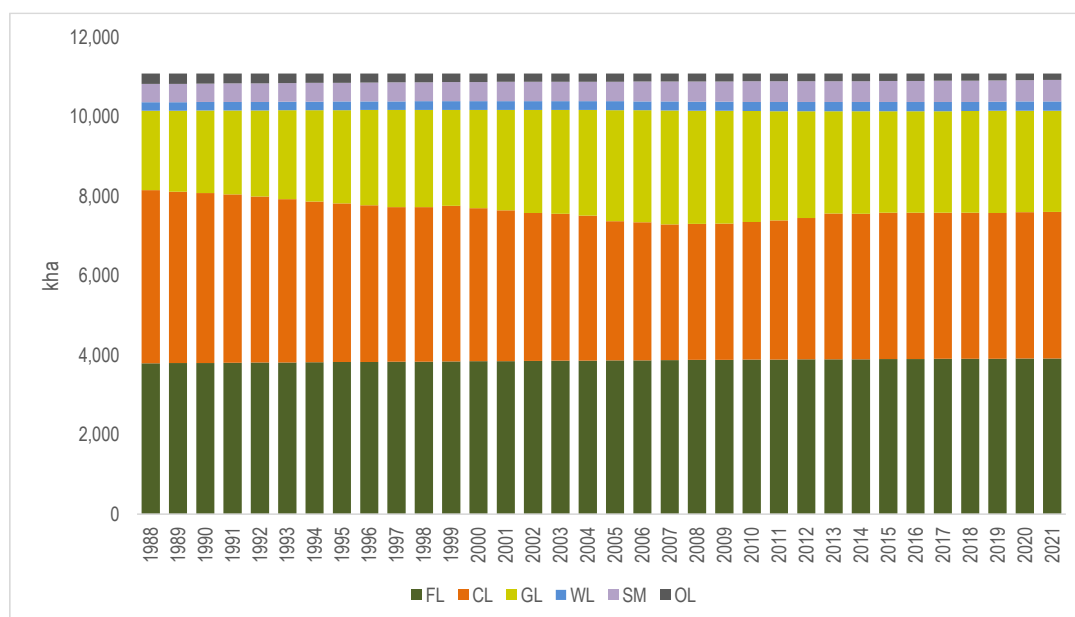


Figure 106 Annual land representation by land-use categories

Table 215 Area by type of land use and land-use changes for the base year and the last year of inventory (20 years)

Area in kha	1988	2021	2021 -1988
4.A Forest Land - Total	3800,93	3920,20	119,27
Forest land - coniferous - Total	1175,93	1032,43	-143,50
Forest land - deciduous - Total	2603,35	2863,81	260,46
Forest land - out of yield - Total	21,65	23,96	2,31
4A1. Forest land remaining forest land	3339,00	3849,29	510,29
4A1. Forest land remaining forest land - coniferous	762,83	1007,38	244,56
4A1. Forest land remaining forest land - deciduous	2554,53	2817,96	263,43
4A1. Forest land remaining forest land - out of yield	21,65	23,96	2,31
4A2. LUC in forest land	461,93	70,90	-391,02
4A2. LUC in forest land - coniferous	413,11	25,05	-388,06
4A2.1.a Annual CL to FL	4,70	5,17	0,48
4A2.1.b Perennial CL to FL	0,32	0,28	-0,04
4A2.2.a Pastures and meadows to forest land	100,01	11,09	-88,92
4A2.2.b Shrubs and grasslands to forest land	298,51	8,12	-290,39
4A2.3 Wetland to forest land	0,00	0,00	0,00
4A2.4 Settlement to forest land	0,00	0,00	0,00
4A2.4 OL to FL	9,57	0,39	-9,19
4A2. LUC in forest land - deciduous	48,82	45,86	-2,96
4A2.1.a Annual CL to FL	1,01	8,35	7,35
4A2.1.b Perennial CL to FL	0,07	0,42	0,35
4A2.2.a Pastures and meadows to forest land	12,62	20,63	8,01
4A2.2.b Shrubs and grasslands to forest land	34,00	15,92	-18,08
4A2.3 Wetland to forest land	0,00	0,00	0,00
4A2.4 Settlement to forest land	0,00	0,00	0,00
4A2.4 OL to FL	1,12	0,53	-0,60

4.B Cropland - Total	4363,20	3691,02	-672,18
<i>Cropland annual – Total</i>	4067,40	3541,97	-525,43
<i>Cropland perennial – Total</i>	295,80	149,04	-146,76
4B1. Cropland remaining cropland - total	4312,37	3369,25	-943,12
4B1a annual cropland remaining annual cropland	3962,87	3174,85	-788,01
4B1b perennial cropland remaining perennial cropland	227,03	72,21	-154,81
4B1c LUC perennial cropland in annual cropland	57,34	58,77	1,43
4B1d LUC annual cropland in perennial cropland	65,13	63,41	-1,72
4B2. LUC in cropland	50,83	321,77	270,93
4B2.1a Forest land in annual cropland	0,00	0,00	0,00
4B2.1b Forest land in perennial cropland	0,00	0,00	0,00
4B2.2a Pastures and meadows in annual cropland	32,36	168,03	135,67
4B2.2b Pastures and meadows in perennial cropland	2,50	7,33	4,83
4B2.2a Shrubs and grasslands in annual cropland	14,83	140,32	125,49
4B2.2b Shrubs and grasslands in perennial cropland	1,14	6,09	4,95
4B2.3a Wetlands in annual cropland	0,00	0,00	0,00
4B2.3b Wetlands in perennial cropland	0,00	0,00	0,00
4B2.4a Settlements in annual cropland	0,00	0,00	0,00
4B2.4b Settlements in perennial cropland	0,00	0,00	0,00
4B2.4a Other land in annual cropland	0,00	0,00	0,00
4B2.4b Other land in perennial cropland	0,00	0,00	0,00
4.C. Grassland -Total	1995,37	2552,90	557,53
<i>Pastures and meadows total</i>	1717,53	1397,08	-320,45
<i>Shrubs and grasslands total</i>	277,84	1155,82	877,98
4C1. Grassland remaining grassland	1747,70	2124,95	377,25
4C1.a Pastures and meadows remaining pastures and meadows	1448,93	1072,56	-376,37
4C1.b Shrubs and grasslands remaining shrubs and grasslands	163,57	892,32	728,76
4C1.c LUC Shrubs and grasslands to Pastures and meadows	101,35	90,63	-10,72
4C1.d LUC Pastures and meadows to Shrubs and grasslands	33,85	69,43	35,58
4C2. LUC in grassland	247,68	427,95	180,27
4C2.1 Forest land in grassland	0,00	0,00	0,00
4C2.2.a Annual cropland in Pastures and meadows	150,53	210,50	59,97
4C2.2.b Perennial cropland in pastures and meadows	16,73	23,39	6,66
4C2.2.a Annual cropland in Shrubs and grasslands	24,35	135,79	111,44
4C2.2.b Perennial cropland in Shrubs and grasslands	2,71	15,09	12,38
4C2.3 Wetlands in grassland	0,00	0,00	0,00
4C2.4 Settlements in grassland	0,00	0,00	0,00
4C2.4 Other land in PGM	0,00	0,00	0,00
4C2.4 Other land in MGL	53,37	43,18	-10,19
4 D Wetlands - Total	213,50	232,41	18,91
4D1. Wetlands remaining wetlands	205,55	219,85	14,30
4D2. LUC in wetlands	7,95	12,57	4,61
4D2.1 Forest land in wetlands	0,00	0,00	0,00
4D2.2.a Annual Cropland in wetlands	0,00	0,00	0,00
4D2.2.b Perennial Cropland in wetlands	0,00	0,00	0,00
4D2.3.a Grassland in wetlands, PMG	0,00	0,00	0,00
4D2.3.b Grassland in wetlands, MGL	6,33	10,62	4,29
4D2.4 Settlement in wetlands	0,00	0,00	0,00
4D2.4 Other land in wetlands	1,62	1,94	0,33
4 E Settlements - Total	461,71	538,27	76,55
4E1. Settlements remaining settlements	423,11	486,86	63,75
4E2. LUC in settlements	38,60	51,40	12,80
4E2.1 Forest land in settlements	1,43	5,77	4,35
4E2.2.a Annual Cropland in settlements	22,29	27,76	5,47
4E2.2.b Perennial Cropland in settlements	1,50	1,46	-0,04

4E2.3.a Grassland in settlements, PMG	9,84	8,77	-1,08
4E2.3.b Grassland in settlements, MGL	3,47	5,84	2,38
4E2.4 Wetlands in settlements	0,00	0,00	0,00
4E2.4 Other land in settlements	0,07	1,80	1,73
4 F Other land- Total	265,477	165,40	-100,08
4F1. Other land remaining other land	265,48	165,40	-100,08
4F2. LUC in other land	0,00	165,40	165,40
Total area Bulgaria	11100,19	11100,19	11100,19

The data shows that over the period 1988-2021 the areas in the categories “Forest land”, “Grassland”, “Wetlands”, “Settlements” have increased by 119.27, 557.23, 18.91, 76.55 kha respectively, while they have decreased in the categories “Croplands” and “Other land” by 672.18 kha and 100.08 kha, respectively.

6.3 Forest Land (4.A)

6.3.1 Description Of The Category

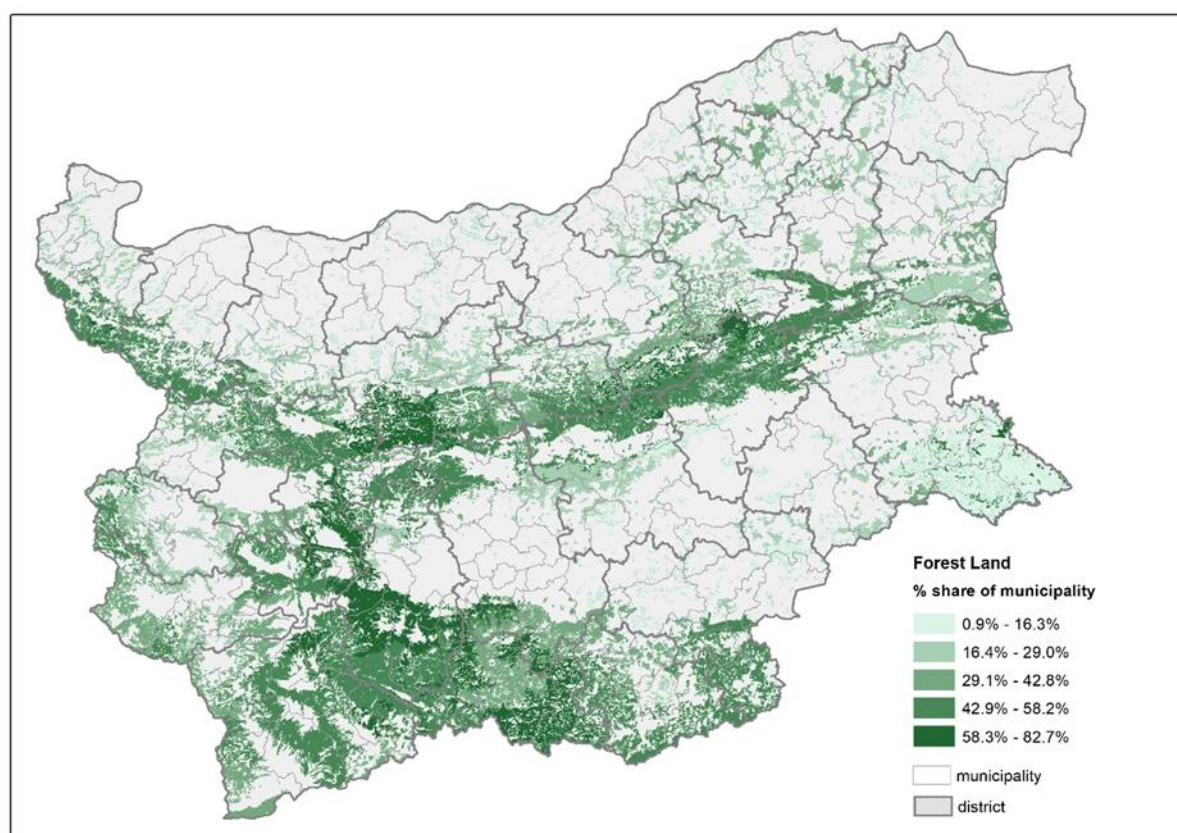


Figure 107 Share of municipality area occupied by Forest land. The map is elaborated based on CLC, 2018

In 2021, forest territories in Bulgaria cover an area of 4270 kha. Forested areas are 3921 kha which represents 35.32 % of the country's territory. There is a constant increase in forested area since the base year, nevertheless the trend of LUC to FL has decreased substantially in the past 20 years. As a result the total forested area is 3.08 compared comparing to the base year, and varies from 3800 kha in 1988 to 3921 kha in 2021. The figure below presents data on the area of Forest land for the reporting period.

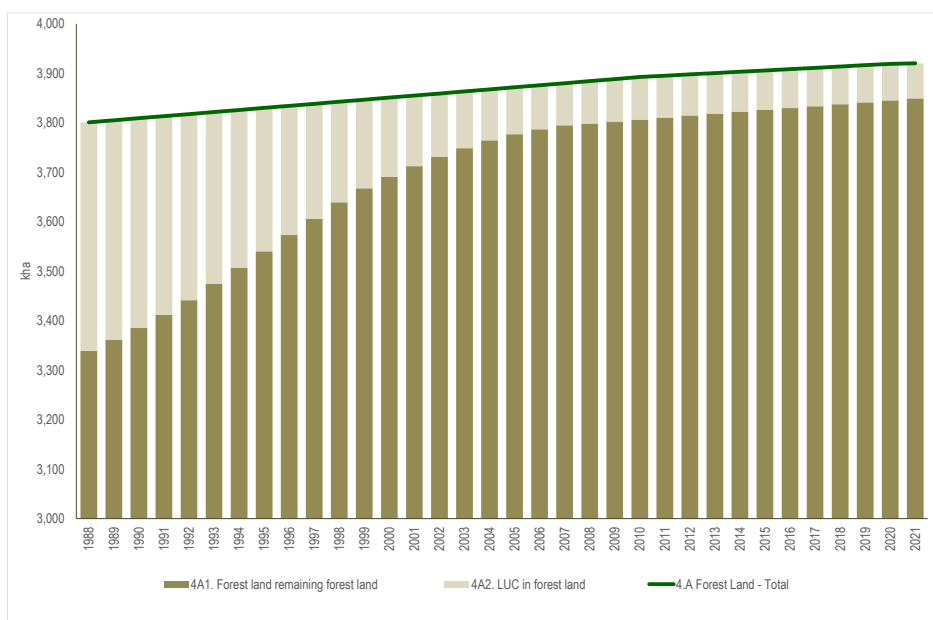


Figure 108 Trends in forested area in Forest land category 1988-2021

For the reporting year Forest land category includes 1032 kha of coniferous forests, which represent 26.32% of these lands, 72.02% of the category or 2863 kha represent deciduous forests and the rest 0.61%, or 24 kha are forests out of yield – presented in the following figure.

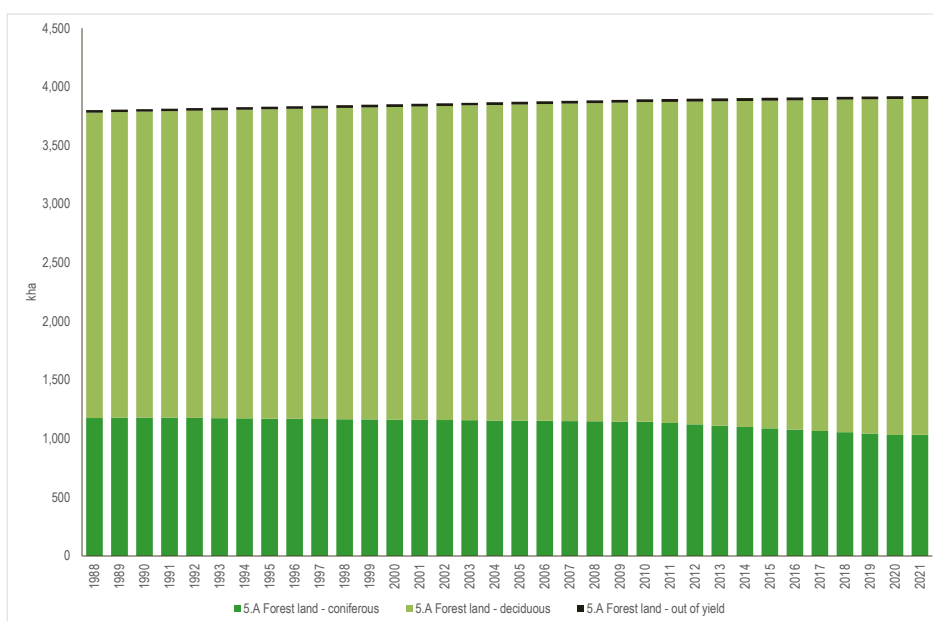


Figure 109 Forest type distribution under FL category

Most of the forest territory in Bulgaria is state's own – 73% (according to data from 2015). The municipalities and religious organizations own around 13% of the forests. The share of private forests in Bulgaria has increased in recent years up to 11% of the total forest area. 94% of these private forests are properties with an area below 2 ha.

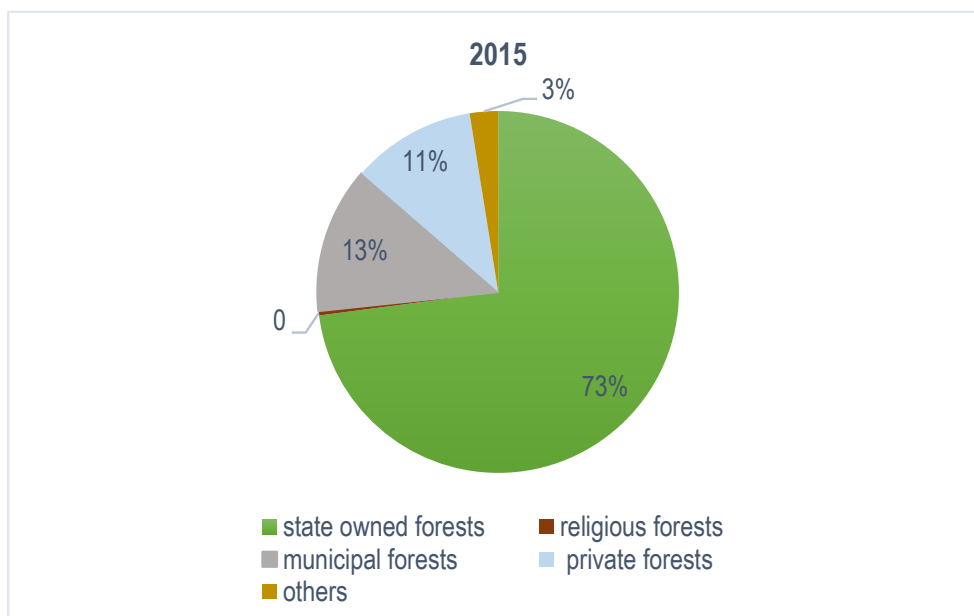


Figure 110 Breakdown of forest ownership in 2015, Source: EFA

The forest territories are managed according to the provisions of the Forest Law whatever their ownership. 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 of up to 50 hectare forestry programmes shall be developed. The forestry plans and programs shall be drawn up based on of forestry maps, cadastre maps, maps of the restored 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 reporting of the emissions/removals from Forest land category is provided by the ExFA and it covers both the state and private forests.

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 FL-FL Bulgaria provides estimates for carbon stock changes in living biomass and dead wood at Tier 2 - with country specific data and emission factors. The carbon stock change in litter and soil pools for subcategory FL-FL is reported under T1 assuming that the pool is not a source. All the calculations in FL-FL on carbon stock changes in the living biomass and dead wood are carried out at the level of tree species and then summed up to coniferous and deciduous strata for the reporting in CRF tables. To fully cover the forest definition in Bulgaria and to be consistent in terms of the area there is a need to have an additional stratum – so called “out of yield”. This stratum includes areas covered by Mountain pine (*Pinus mugo*) which is common for the high elevation habitats in Bulgaria. Most of the areas covered by the mountain pine are part of protected areas – as part of the territory of National Parks or Natural Reserves. These forests are included in the Forest management planning in Bulgaria, they are mapped and monitored, but no data on growing stock of these forests is available in the country. There is no commercial use of the wood, therefore, it is assumed that all the gains are equal

to the losses and T1 approach in reporting emissions and removals from biomass in “out of yield” stratum is used – NA.

Concerning the **subcategory LUC to Forests**, Bulgaria estimates and reports carbon stock changes in all pools – living biomass, DOM (only litter) and soil.

Non-CO₂ emissions from wildfires (Figure 114) are allocated between the subcategories 4.A.1 and 4.A.2 according to their area share in total forest land. N₂O emission from N mineralization associated with loss of soil organic matter resulting from the 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-CO₂ emissions associated with drainage of organic soils are reported as NO, since such activity is not occurring in Bulgarian forests.

The Forest category is serving as a sink of CO₂ emissions over the entire time series. The amount of CO₂ removals from the category range between -14474.48 Gg CO₂ eq. for 1988 and -8152.14 Gg CO₂ eq for 2021. Despite the observed increase in forest area (*Figure 108*), there is a drop in the amount of the removals from the category, driven by the overall decrease in the removals from living biomass in FL-FL and losses of carbon in soils of GL and CL converted to FL.

Table 216 Emissions and removals from Forest Land category, Gg CO₂ eq

Year	4.A Forest Land	4.A.1 FLrFL		4.A.2 LUC to FL		
	Total emissions, Gg CO ₂ eq.	CO ₂ emissions and removals	Non-CO ₂ emissions associated with biomass burning, CO eq	CO ₂ emissions and removals	Non-CO ₂ emissions associated with biomass burning, CO ₂ eq	N ₂ O associated with N mineralization in soils, CO ₂ eq
1988	-14474.48	-13236.86	1.61	-1427.63	0.22	188.18
1989	-14594.45	-13402.35	0.78	-1372.68	0.10	179.69
1990	-14719.89	-13584.08	3.67	-1310.15	0.46	170.21
1991	-14837.35	-13763.02	1.81	-1236.04	0.21	159.68
1992	-14948.21	-13964.41	18.76	-1152.58	2.05	147.97
1993	-15049.74	-14190.99	65.55	-1065.79	6.56	134.93
1994	-15195.83	-14416.96	65.87	-972.64	5.99	121.91
1995	-15413.74	-14642.74	2.01	-882.07	0.16	108.89
1996	-14628.71	-13944.19	7.95	-788.94	0.58	95.88
1997	-14808.47	-14198.60	2.90	-695.84	0.19	82.89
1998	-14957.18	-14452.90	26.19	-601.83	1.46	69.89
1999	-15097.06	-14667.76	31.38	-520.97	1.53	58.76
2000	-14997.82	-14817.72	220.37	-459.67	9.55	49.65
2001	-12250.29	-11965.07	77.12	-406.79	2.97	41.48
2002	-12335.46	-12039.27	25.00	-356.22	0.86	34.18
2003	-12380.20	-12113.17	19.67	-314.92	0.60	27.62
2004	-12418.52	-12166.82	4.40	-277.98	0.12	21.75
2005	-12459.03	-12233.26	5.60	-248.65	0.14	17.15
2006	-10424.40	-10221.43	14.38	-231.24	0.34	13.56

Year	4.A Forest Land	4.A.1 FLrFL		4.A.2 LUC to FL		
	Total emissions, Gg CO ₂ eq.	CO ₂ emissions and removals	Non-CO ₂ emissions associated with biomass burning, CO ₂ eq	CO ₂ emissions and removals	Non-CO ₂ emissions associated with biomass burning, CO ₂ eq	N ₂ O associated with N mineralization in soils, CO ₂ eq
2007	-10280.74	-10247.87	168.65	-216.10	3.78	10.79
2008	-10413.32	-10243.49	21.12	-202.41	0.48	10.99
2009	-10440.61	-10241.26	8.82	-219.49	0.20	11.13
2010	-10370.97	-10195.48	25.35	-212.69	0.57	11.28
2011	-6750.49	-6582.77	27.82	-207.14	0.62	10.99
2012	-6685.25	-6553.58	50.69	-194.16	1.10	10.69
2013	-6679.70	-6523.55	12.89	-179.74	0.28	10.43
2014	-6659.43	-6494.19	3.59	-179.02	0.08	10.11
2015	-6509.94	-6381.83	21.35	-159.75	0.44	9.85
2016	-8415.18	-8294.48	24.66	-155.43	0.51	9.56
2017	-8388.14	-8268.10	17.78	-147.44	0.36	9.25
2018	-8376.60	-8242.76	5.66	-148.52	0.11	8.91
2019	-8312.09	-8216.25	22.35	-127.26	0.44	8.63
2020	-8291.99	-8190.71	20.48	-130.44	0.39	8.29
2021	-8152.14	-8203.48	212.58	-172.97	3.92	7.82

The major reason behind this dramatic decline is that in Bulgaria, since 2000, there is a constant increase in harvesting. Although the increase in the wood removals, the harvesting in these years is still below to what was planned to be harvested. In 2019 the harvesting is by 20% higher than in 2010 as since 2012 it reached the planned quantities according to FMPs. The drop in 2020 is related to the COVID crisis. The increase in harvesting since 2011 is in response to the market demand and 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 (Figure 112).

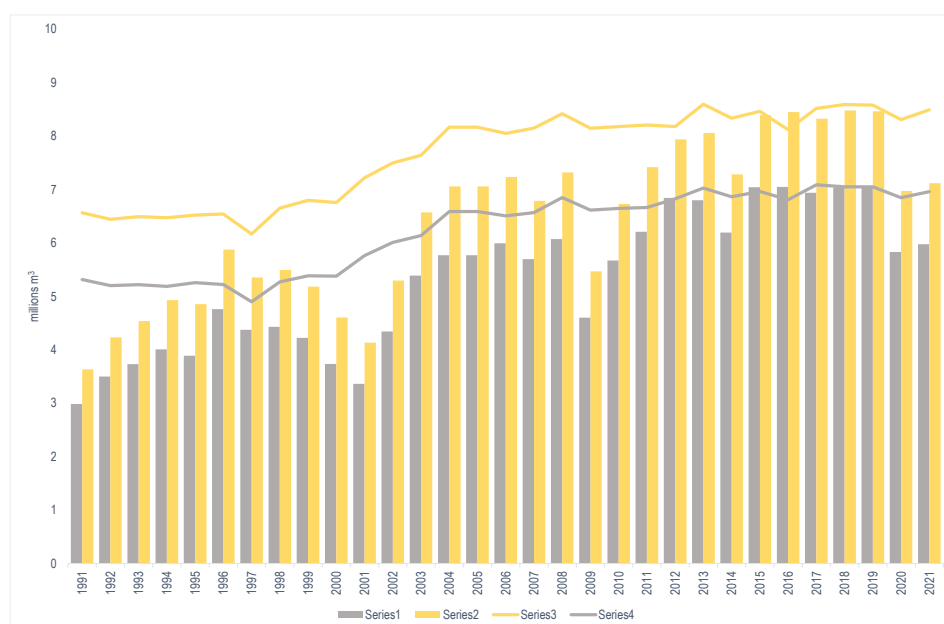


Figure 111 Trend in wood harvested vs planned harvest (mill m³ o.b.)

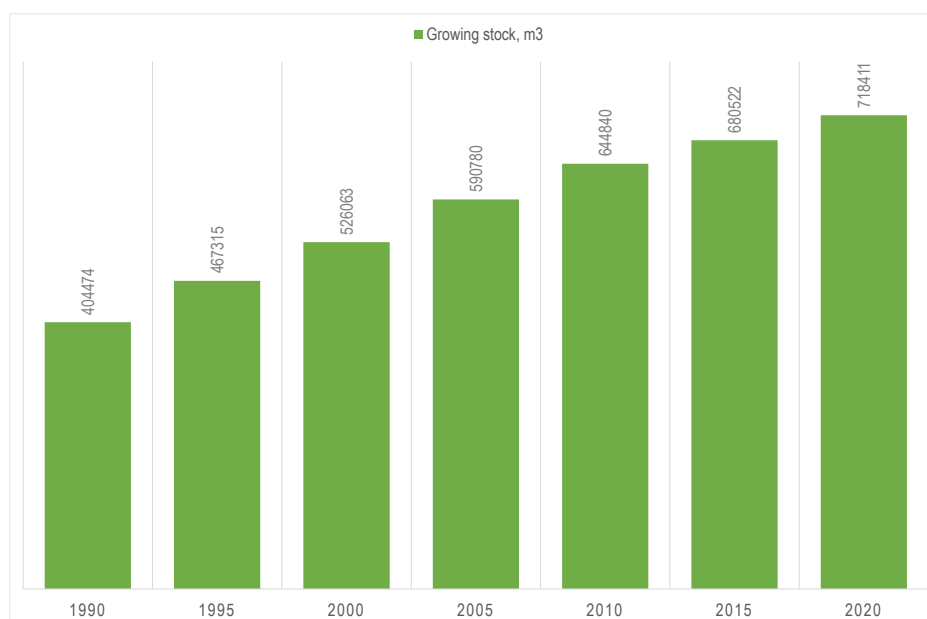


Figure 112 Standing growing stock in Bulgaria, official data

In addition to the observed increase in harvest, there are other peculiarities of Bulgarian forest which could affect the rate of biomass accumulation. Concerning the broadleaves, these are the big shares of coppice forest (>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, which is the result of a long-lasting policy to convert them into seed forests. In most cases the policy was not implemented successfully and any 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 (Popov et al., 2019). 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 at lower altitudes (below 1000 m a.s.l.) 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 (Popov et al., 2013, 2014, 2018). Thus, these stands are intensively thinned now.

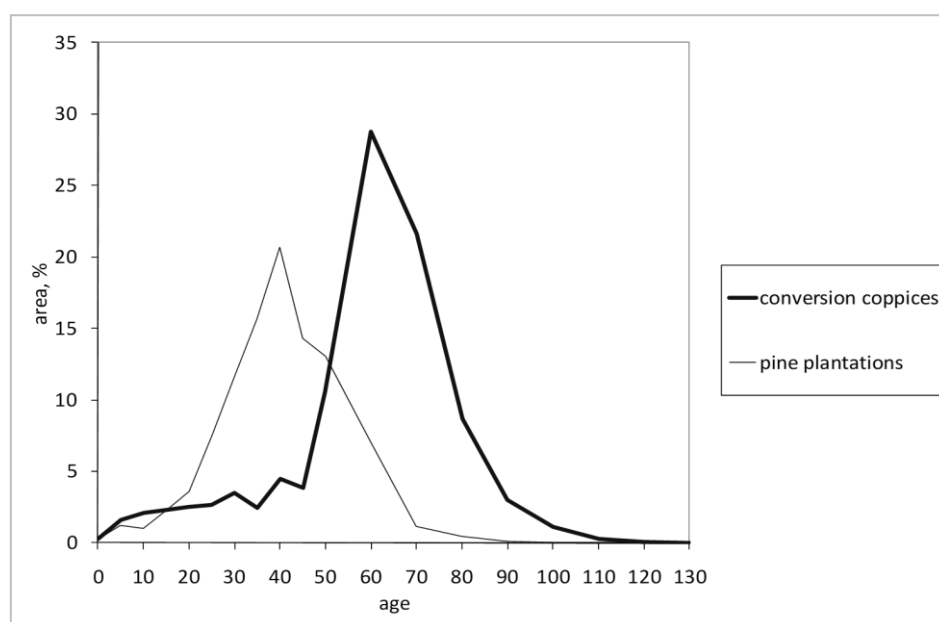


Figure 113 Forest area of pine plantations and conversion coppices by age

The trend in Non-CO₂ emissions from biomass burning (wildfires) is shown in the figure below. Only emissions of CH₄ and N₂O 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.

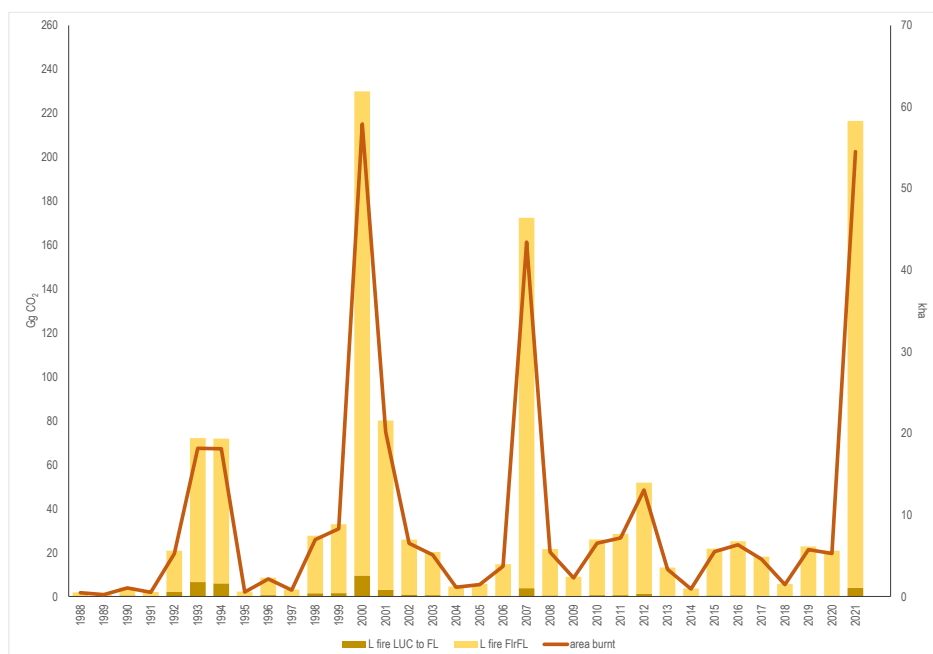


Figure 114 Non-CO₂ emissions associated with biomass burning from wildfires

6.3.2 Information On The Approaches Used For Presenting The Data For The Areas And The Database On The Land-Use Used For The Inventory

Sources of activity data

The main sources of quantitative information about forests in Bulgaria are the Forest Management Plans (FMP) and the forestry fund reporting forms (RF). For the elaboration of the continuous time

series on the total forest land reporting form 1 (RF1) has been used. RF1 provides annual information on 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 RF1 is the sum of the data at the level of sub-compartments. Land use changes to forest lands are traced and reported according to Forest Management Plans.

Area data and Forest area adjustment

When compiling the data on forest areas, data from the forestry reporting form 1 (RF1) have been used. According to the official statistics on forest areas in Bulgaria, there is an increase in the forest territories by 20% since 1990. But not all of the increase is due to afforestation and reforestation activities. Many of these areas were forests before 1990. Thus, special consideration is needed when developing the land transition matrix. This was addressed with two studies. The first one was implemented in the period 2012-2014. The project has been launched following the plan for improvement of the estimation of LUC to FL (AR units of land) as accepted by the ERT team as an 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. The study extracted the potential AR areas based on the FMP, but it was not spatially explicit.

Due to financial and technical constraints and considering that Bulgaria accounts at the end of the CP, It was decided that it is not necessary to carry out such an assessment for each year, thus Bulgaria reported the AR unit based on extrapolation.

In 2021 Bulgaria assessed the AR areas since 1990 in response to its commitment to assessing these units once again at the end of the commitment period. The approach used in that study is spatially explicit and is based on the intersection between the forest map and the cadastral map. More details are provided below.

The Law on Territorial Structure defines the main designation of lands in terms of spatial planning and development. According to their main purpose, defined by the concepts and schemes of spatial development and general development plans, the territories in the country are: urbanized areas (settlements, settlements and industrial parks outside the settlements and settlements), agricultural areas, forest areas, protected areas, disturbed areas for restoration, areas occupied by waters and water bodies, and areas of transport. The territories with a designation of agricultural, forest or urbanized territories may be simultaneously and with designation protected territories determined by law.

The Executive Forest Agency owns and maintains the digitalized information on forest territories, which include forested and non-forested areas such as pastures and meadows in between the forested lands, rocks, forest roads etc. The geospatial information on forest territories is part of the forest management plans of the State Forest Enterprises (SFE). This information is fragmented at a national level and has different temporal coverage, because the data is collected in different years (when FMP is developed). Thus, an unified forest map could be elaborated by combining the forest maps of all state forest enterprises in the country (approx. 160). Currently, such unified maps are available for the years 2010 and 2020²⁴ by combining the information for all SFE for two consecutive forest inventories. As the forest inventory is conducted once per 10 years, it was considered that the information in the unified maps represents the state of the forest territories at two points in time – 2010, which is representative for the old digitized forest management plans, and 2020 which is representative for the currently acting plans.

The geospatial information for the territories with an agricultural and urbanized designation of lands is stored and maintained by the [Cadastral agency](#) into cadastral maps. Up until recently there was no full

²⁴ <https://maps.iag.bg/mapstore/#/viewer/openlayers/6>

coverage of the cadastre in the country. For the areas, where no cadastre was available, the source for geospatial information for the agricultural territories was the map of the restored property²⁵.

Thus, to assess the AR units of lands since 1990, the approach consists of spatial intersection of the forest territory map with the cadastre and/or the map of restored properties. Like this, all forests land that meet the forest definition but are outside the forest territories are identified. The intersection is carried out twice. First, the forest map for 2010 is intersected with the geospatial information for agricultural lands. The difference between the two maps is further analysed in order to identify only the newly developed forest. This is done by differentiating the forested areas by age, origin and tree species based on the attributes in the forest map. Like this only the forest areas with an age up to 20 years and seed origin are taken into account and reported as AR. All the remaining forests – with an age bigger than 20 years, or forests with an age less than 20 years but with of shoot origin are not considered as AR units. The same approach is made between the forest map for 2020 and the cadastre and the map of the restored property, but the differentiating by age is done considering the forest stands with an age of 30 years. Like this, all the AR outside the forest territories since 1990 until 2020 are identified. In addition, to define the AR units within the forest territories (for example on non-forested areas) the forest maps for 2010 and 2020 have been intersected. This is not applicable for the years before 2010, because there is not unified forest map available before 2010. However, we can suggest that the increase within forest territories before 2010 was lower than now (there were more cattle, sheeps and goats animals in villages and countryside), thus the land use changes from non-forested to forested lands within the forest territories before 2010 have been ignored in the assessment of AR.

The following step is to reconstruct the annual forest area data since the base year. The results of the intersection and the further analysis provide the information for the net increase in forest for two points in time – 2010 and 2020. Therefore, the net increase in forest areas in 2020 plus the annual deforestation areas since 1991 must represent the total ARD areas since 1990. Then the reconstruction of the forested area in 1990 is made as follow:

$$FL_{1990} = FL_{2020} - NiFL_{30} + D_{SM1991-2020}$$

Where,

FL_{1990} – forested area in 1990

FL_{2020} – forested area in 2020

$NiFL$ – net increase in FL for the period 1990-2020

D_{SM} – D area for settlements since 1990

The annual change was estimated by interpolation in two periods according to the result's of the study – 1991-2010 and 2011-2020.

The assessment of the former land use of the identified AR units of land was made by using the attributes of the cadastre map combined with an expert judgment. Land use (cropland, grassland, other land) typically follows ecological site conditions. The dominating land uses in a single district or SFE region is known, which facilitates the expert judgment of former land use on basis of likelihood. 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.

The LUC to FL before the base year has been recalculated as well. Data on afforestation/reforestation were extracted from the National Statistical Institute and adjusted to meet the requirements for reporting

²⁵ *Map of the restored property ownership (since 1995) – combines the data from the land division plan, the map of the existing old real borders, the map of the restored old real borders of agricultural lands created under the Law on the Property and Use of Agricultural Land (LAPP), and the map of the restored property on Forests and lands from the forest fund, established by the order of the Law for restoration of ownership of forests and lands from the forest fund*

land use changes in the period before 1988. This improvement led to a significant change in the trend of subcategory LUC to FL as the period before 1988 is characterized by a massive afforestation programme (Popov et al., 2018).

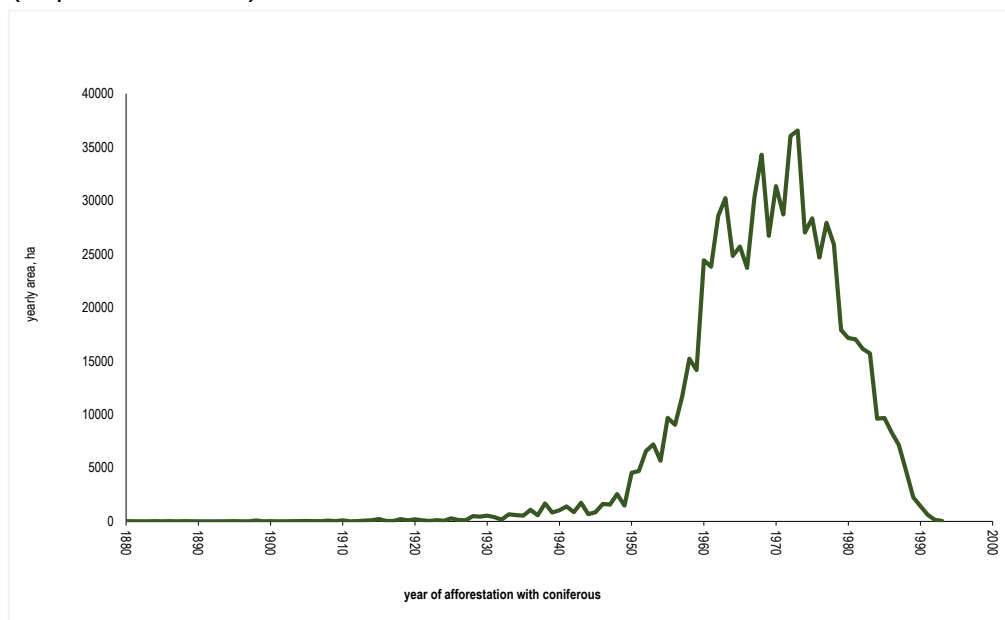


Figure 115 Trend of afforestation with coniferous species outside their natural habitat²⁶

6.3.3 Methodology

Sources of information

Forest Stand Descriptions (Description sheets)

The Forest Management Plans (FMPs) and their forest stand descriptions are the most detailed and accurate information on forests available in Bulgaria. The FMPs are updated in a 10-years period – i.e. one tenth of the territory is surveyed each year. Practically all forest stands are surveyed once every 10 years. The survey produces detailed maps, as well as description of the forest stands (e.g. species composition, age of the stand, yield class, mean height, volume of growing stock, stocking rate, etc.). The survey (stand-wise forest inventory) is made for each sub-compartment or each forest stand. According to the latest available data on forest Management plans, the sub-compartments are currently 1.340 million with an average area of 3.15 ha. They are distributed into 176 territorial units or state forest enterprises for which a Forest Management Plan is prepared. The data from forest stand descriptions are stored in a national database which is publicly available on the website of the Executive Forest Agency. Although, the description sheets are the most detailed data on forest stands, they have drawback of being updated over a 10-years period. They also do not contain data on the current activities of the territorial units.

The information in FMP serves as a basis for producing more aggregated data (statistics) for operational use such as reporting forms (RF 1-7) for the state of the forests in Bulgaria.

Aggregated data

Another source of data used in the estimation of emissions and removals from FL category is forestry fund reporting forms (RFs). These are aggregated data (overview tables) that are updated and collected in a national database maintained by EFA. On basis of these reporting forms, data for the national statistics and for the internal use of EFA are provided.

²⁶ Popov et al, 2018 [Coniferous plantations in Bulgaria created outside of their natural habitat](#)

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 – on forest territories and RF5 – on wood removals, are collected annually. The other forms are collected over 5 years. In electronic form, they are available for the years 1995, 2000, 2005, 2010, 2015 and 2020.

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 sub-compartments. For example, the area of a sub-compartment in which the conifers predominate will be added to the row of "conifers", although it may contain some deciduous species. The main purpose of RF1 is to monitor the "development of the forest fund" – i.e. the inclusion of new forests in the forest territory and the transfer of land from one territorial unit to another.

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 - each tree species in a forest stand has an assigned area and stock, and in RF2 and RF3 they are added to the row of these tree species. RF2 and RF3 do not provide information about the site and do not provide some necessary details about the origin, in particular, what part of the areas are covered by natural stands and what are 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 according to RF1 and RF2, and also of the other forest types.

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 the total cutting areas 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, conversion coppices, conifers) and fellings (final fellings and thinnings). In Bulgaria, RF5 is the only data source for actual timber harvesting.

RF6 is a distribution of the area by forest types (conifers, etc.), stand age and stocking rate. 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 other broad-leaved tree species, etc.) and site index. It aimed 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.

Updating RF is done manually, without considering the increment. In the year of a forest inventory, the reporting forms of forested areas for a given territorial unit are taken from its plan. In the year, the employees register their activity - there is a letterhead for each purpose in each description sheet. Based on the recorded data, they subtract from the RF tables the harvested wood (in m³) and hectares and add the afforested hectares to them. They do not measure nor calculate any increment. Therefore, all growing stocks in the RFs are slightly underestimated - they should be added to about 9/10 of the 5-year current increment.

Table 217 Description of the content of the wooded area reporting forms (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 90-95-00-05-10-15-20

Reporting form №	Description	Update period
3	Growing stock by age classes	Every 5 years since 1960; data used for the years 90-95-00-05-10-15-20
4	Forested area distributed by forest functions	Every 5 years since 1960; data used for the years 90-95-00-05-10-15-20
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 90-95-00-05-10-15-20
7	Forested area distributed by age classes and yield classes	Every 5 years since 1960; data used for the years 90-95-00-05-10-15-20

Data on forest litter and soil

The source of information about the physical and chemical properties of the forest soils is The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests). ICP Forest has been launched in 1985 under the Convention on Long-range Transboundary Air Pollution (Air Convention, formerly CLRTAP) of the United Nations Economic Commission for Europe (UNECE) to monitor forest condition at two monitoring intensity levels – Level I, which aims gaining insights into the geographic and temporal variations in forest condition and Level II, which monitors selected forest ecosystems aiming to clarify cause-effect relationships.

In Bulgaria, the Programme started in 1986. There are three sample plots at Level II. The observation plots part of Level I have been first established at 16x16 km grid, with a focus on the coniferous plantations as these forests have been considered as more vulnerable to atmospheric pollution. For these sample plots where pollution has been found, additional sampling plots have been set at 8x8 km or 4x4 km grid. Thus, the number of the plots in the beginning has reached almost 360. Throughout the first years of the programme the number of the sample plots has been reduced based on expert judgment and circumstances related to the terrain. Thus, a shift in the grid has been introduced, so the grid became randomly distributed among the forest territories in the country and the sample plots were reduced to 256 until 2009. Since 2009, the sample plots have been revised in connection to the implementation of the EU project FUTMON after which the observation network numbers 159 permanent plots.

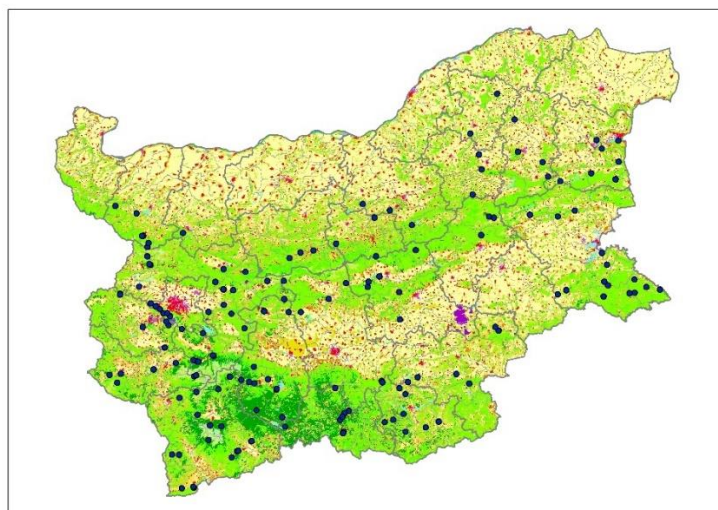


Figure 116 Distribution of the 159 sample plots at Level I since the FutMon project

Throughout the years, all the sample plots at Level I are monitored annually and an expert assessment of the crown condition and phytosanitary observations are conducted, as well as an analysis of other

damaging factors, incl. windbreaks, snowbreaks and icebreakers, droughts, fires etc. Once in every 5 years a full inspection of the sample plots is conducted. The full survey includes, an assessment of soil conditions, nutritional status, dendrometrical assessments of the stands, phytoecanotic characteristics and floristic composition. All the information from the annual assessments of the sample plots is stored in a specific database maintained by the Executive Environment Agency. The information from the full surveys incl. also data on soil carbon content is stored as part of the expert's reports on hard copies and/or electronically. Currently, these data are the only data source information about the carbon content in forest's soil and litter gathered from systematically measured and monitored sample plots for long enough period, which encompasses most of the inventory period as well.

6.3.3.1 Forest Land remaining Forest Land (4.A.1.)

6.3.3.1.1 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.

$$C_B = (C_{t2} - C_{t1}) / (t_2 - t_1)$$

The carbon stock in the biomass is calculated using the equation:

$$C = A \cdot V \cdot BCEF_s \cdot (1 + R) \cdot CF$$

Where:

A – area of land remaining in the same land-use category

V – tree stock (stemwood and branches) $m^3 \cdot ha^{-1}$

$BCEF_s$ – biomass conversion and expansion factor for expansion of merchantable growing stock volume to above-ground biomass, tonnes above-ground biomass (m^3 growing stock volume)

$$BECF_s = BEF_2 \cdot D$$

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 2020, 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. In 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 follows:

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 assesses 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, 2015 and 2020.

Table 218 Growing stock (o.b) - stemwood and branches by stratum

Stratum	unit	1990	1995	2000	2005	2010	2015	2020
Scots pine	m3/ha	151.54	184.56	216.15	230.29	248.84	259.93	274.44
Norway spruce	m3/ha	225.92	242.40	285.88	306.54	344.86	371.06	407.34
Black pine	m3/ha	71.60	125.07	184.16	214.19	244.18	268.52	278.73
Silver fir	m3/ha	328.85	342.51	372.32	383.41	405.65	453.31	494.98
Other conifers	m3/ha	148.25	187.59	213.31	194.71	285.47	322.08	350.06
Oak	m3/ha	83.04	88.42	95.73	102.63	103.98	102.84	104.81
Beech	m3/ha	194.37	213.63	223.76	240.69	251.07	265.19	277.76
Poplar	m3/ha	86.36	89.08	82.46	96.99	115.73	117.52	114.68
Others	m3/ha	69.22	77.81	79.61	83.45	89.03	90.63	92.01

To convert the volume stock into aboveground biomass, Bulgaria applies conversion factors – BEF₂ to add the leaf biomass and D (wood density). There are no country-specific values for BEF₂ which have to add leaf biomass as the data on growing stock in Bulgaria contains also the volume of the branches. To estimate this specific BEF₂ 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*). BEF₂ values are age-dependent. The BEF₂ 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 BEF₂ 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 BEF₂ 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 219 Calculated BEF₂ 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

Tree species	BEF ₂ estimated based on the actual age-class distribution	BEF ₂ literature
Other broadleaves	1.015	Average of oak and beech

The tree specific values for basic wood density are presented in the table below.

Table 220 Wood density (D)

Tree species	kg/m ³
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 time series.

Table 221 Root to shoot ratio (R)

Tree species	R	R	R
<i>Above-ground biomass</i>	<i><50 tonnes d.m ha⁻¹</i>	<i>50-150 tonnes d.m ha⁻¹</i>	<i>>150 tonnes d.m ha⁻¹</i>
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
<i>Above-ground biomass</i>	<i><75 tonnes d.m ha⁻¹</i>	<i>75-150 tonnes d.m ha⁻¹</i>	<i>>150 tonnes d.m ha⁻¹</i>
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 from 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, 2020). Then the stock changes by tree species are multiplied by their respective area in order to estimate the annual emissions/removals from the pool.

6.3.3.1.2 Changes in the carbon stock in the dead organic matter

In Submission 2017 and 2018 Bulgaria reported emissions and removals from DOM – litter and dead wood, by using results from a study on the application of CBM-CFS model at EU level (Pilli et al, 2016). Back in 2017, this was the only option to report CSC from these pools in response to the encouragements of several ERT's to apply higher tier in FL-FL for these pools, as BG does not have proper data to account for the changes in soil pool of the remaining lands. Subsequently, we acknowledged that this leads to a methodological inconsistency in the methods and tools in assessing the CSCs from forest carbon pools (e.g CBM for DOM and SOC, and own calculations from biomass).

In addition, the Pilli's results on CSC in soil and DOM for Bulgaria have not been validated or verified and come from a non-adjusted model for the Bulgarian conditions.

As there were no proper data to accurately estimate the emissions and removals in that pools, there was not any other alternative than to apply again T1 approach in Submission 2022 for these pools until proper data and/or model are available.

Referring to the dead wood pool, Bulgaria developed its own calculations on emissions and removals for Submission 2020 based on its own model, which approximate the dead wood stock to the ratio of the mortality and age class. The model was revised and improved for the Submission 2021 and applied for Submission 2022. More information on the estimation approach and model description is provided in the next sub-chapter.

Referring to the litter pool, it is still reported under Tier 1 approach. In response to a recommendation to *“Develop a method to accurately estimate litter C stock changes on FL-FL or provides a robust justification demonstrating quantitatively that emissions from litter on Forest Land remaining Forest Land are insignificant as required per para 37 (b) of the UNFCCC Annex I reporting guidelines”*, Bulgaria dedicated time and efforts to analyse properly the soil and litter information available in the country. More information on the results of that work is presented in chapter 6.3.3.1.2.2.

6.3.3.1.2.1 Changes in carbon stock in dead wood

The dead wood includes coarse woody debris like downed woody debris, standing dead trees, stumps. Litter includes mostly the leaves/needles, twigs and small woody materials (including bark, fruits etc.) There is no systematically collected quantitative data on dead wood in BG which could enable us to derive CSCF (carbon stock change factors) for DW in FLrFL from official statistics. Based on national and international data on average stock of dead wood, a provisional estimate of the total amount of dead wood and its stock change could be estimated. For better results such estimates needed to be differentiated by tree species and age. For doing so, the data of dead wood stock from the bibliography available in Bulgaria have been approximated to the ratio of mortality to the standing volume per tree species and age class, which can be determined from available growth and yield tables. In doing so, we assume that forests that produce more dead trees also have more remaining dead wood. The model we used to determine mortality is the classic growth and yield tables.

The following equations were derived from the growth tables to perform the calculations:

$$p = \frac{a}{e^{kt} - 1},$$

Where p is the percentage of mortality (the volume of mortality mass, expressed as a percentage of the volume of the entire standing mass), t is the age of the forest in years, a and k are regression coefficients.

Such an equation is derived through regression for each tree species represented in the total forest land. Hence, the mortality in the forests was determined by multiplying the stock of the living biomass (derived by the reporting form 3-RF3) by the appropriate percentage:

$$M_{ij} = p_{ij} V_{ij}$$

where M_{ij} is the amount of mortality i in the forest age j , p_{ij} is the percentage of mortality as defined above, and V_{ij} is the standing biomass of the species and age reported by RF3.

The obtained model coefficients are presented in the table below. The quality of the approximation is demonstrated in the following figure.

Table 222 DW Model coefficients

Tree species	a	k
<i>Pinus peuce</i>	0.002048888	0.002125
<i>Scots pine</i>	0.001659772	0.002329
<i>Spruce</i>	0.017467732	0.014025
<i>Fir</i>	0.076737258	0.026636
<i>Black pine</i>	0.010731931	0.017589
<i>Douglas fir</i>	0.025102229	0.017036
<i>European larch</i>	0.005978804	0.006899
<i>Beech</i>	0.004459419	0.00533
<i>Beech coppices</i>	0.00008442	0.000153
<i>Oak</i>	0.006509801	0.00985
<i>Oak coppices</i>	0.02413713	0.021924
<i>Birch</i>	0.012103951	0.018783
<i>Linden</i>	0.000129637	0.000207
<i>Ash</i>	0.033223041	0.026642
<i>Alder</i>	0.004337363	0.009891
<i>Aspen</i>	0.047494468	0.041061
<i>Poplar</i>	0.000260787	0.000887
<i>Locust</i>	0.000106149	0.000142
<i>Oriental hornbeam</i>	0.004894046	0.008702

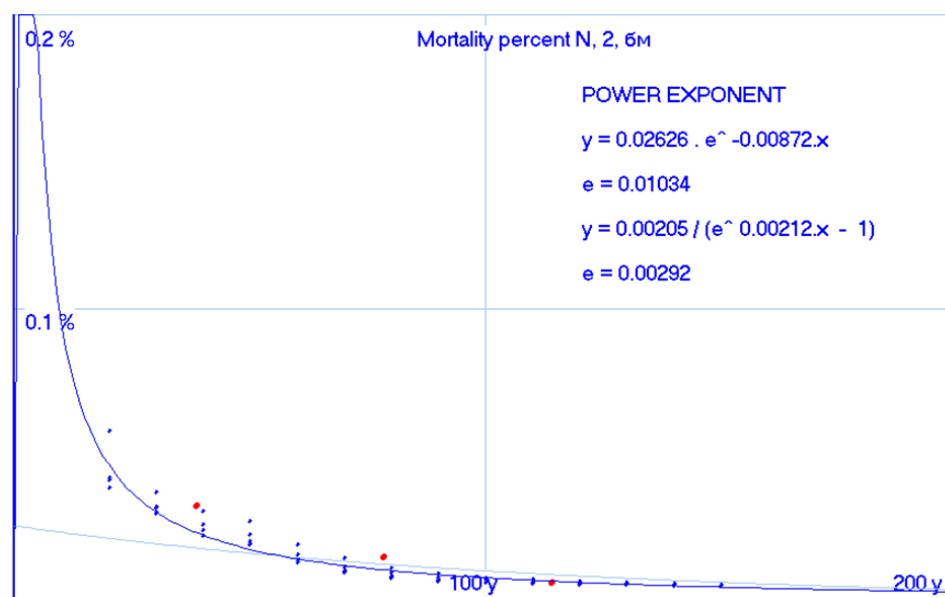


Figure 117 Annual mortality rate according to yield table for *Pinus peuce*

In the formula the dependence of the mortality rate from the yield class is ignored, which is a weakness. This is mainly due to the available data (RF3) which does not account for the yield class. The coefficients are obtained by a regression according to the tables, which covers all yield classes and corresponds approximately to the yield class III, which is the most common in natural conditions. An illustration of the approach is given in the figure below. It demonstrates that the obtained model curve is average with respect to the output data.

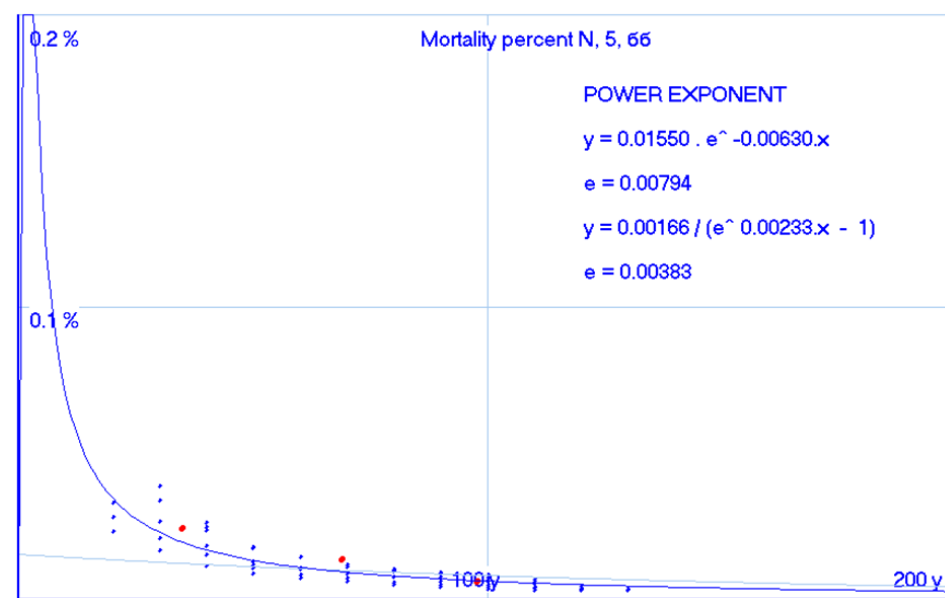


Figure 118 Annual mortality rate coefficient approximated to yield class III, (example for *Pinus sylvestris*)

To estimate the dead wood stock in forest lands, information on dead wood stock in m³ per ha has been derived from local scientific studies aiming at defining a complex index for identification and evaluation of old-growth forests (Zlatanov et al., 2013). The studies have been conducted in coniferous and deciduous forests across the country (n=99 for Rodopi mountain, n=56 for Stara Planina). The report of the study provides ranges for dead wood stock for the main tree species in Bulgaria based on their own observations or based on other studies (Panayotov, Alexandrov, Zlatanov, not published).

Table 223 Dead wood stock in forest stands

Tree species	Year of stands	DW stock, m3/ha	Range
Norway spruce, Silver fir, Other conifers	<100	70	100-150
Scots pine, Black pine	<140	50	50-100
Oak	<140	50	50-100
Beech	<140	70	40-140
Other broadleaves	<140	35	30-40
Oak, coppice	<61	30	30-60
Beech, coppices	<61	40	30-50

Table 224 Dead wood stock in forest stands

Tree species	Year of stands	DW stock, m3/ha	Range, m3/ha
Norway spruce, Silver fir, Other conifers	>100	150	100-180; 200-300
Scots pine, Black pine	>140	60	50-100
Oak	>140	110	110-140
Beech	>140	120	100-180
Other broadleaves	>140	45	30-60
Oak coppices	>61	40	30-60
Beech, coppices	>61	45	30-60

To convert the data on volume stock to carbon content the following conversion factors have been used.

Table 225 Factors used for conversion of the biomass volume stock to carbon content

Conversion factors	coniferous	broadleaves	Source:
Density, t/m3	0.362	0.427	L. Di Cosmo et al., 2013
CF	0.510	0.480	IPCC 2006

Table 226 Carbon stock in dead wood per tree species and age of stands

Tree species	Year of stands	Carbon stock in DW, tC/ha	Year of stands	Carbon stock in DW, tC/ha
Norway spruce, Silver fir, Other conifers	<100	13	>100	28
Scots pine, Black pine	<140	9	>140	11
Oak	<140	10	>140	23
Beech	<140	14	>140	25
Other broadleaves	<140	7	>140	9

Tree species	Year of stands	Carbon stock in DW, tC/ha	Year of stands	Carbon stock in DW, tC/ha
Oak, coppice	<61	6	>61	8
Beech, coppices	<61	8	>61	9

The average stock of dead wood (tC/ha) then was differentiated by age classes by using the mortality ratio derived for the years 1995, 2000, 2005, 2010, 2015 and 2020. Changes in the carbon stock of DW for FLrFL are estimated based on the stock change approach. The annual carbon stock change for the inventory year is obtained by dividing the change in carbon stock by the period (years) at two points in time. Calculating carbon stock changes as the difference of carbon stocks at two points in time requires that the area at time t1 and t2 is identical to ensure that reported carbon stocks are not the result of changes in the area. That is why the 2020 data on the area is used to calculate the DW stock in all years. Therefore only the changes due to shift in the age classes and their mortality rate is reported and the change is not affected by the increase in the FL area. The results showed an increase in the accumulation of the dead wood stock which is normal taking into consideration that the forest management in the country follows the sustainable management practices. Over the years there has been a steady decrease in the amount of extracted (harvested) dried and fallen mass (figure below). In the recent past, it was mandatory to remove all usable dead wood from the forest. The scattered, naturally occurring dry and fallen mass was sold to the population at symbolic prices but nowadays due to financial and environmental reasons these quantities remain in the forests. This is because the harvesting and removal of this wood is economically unprofitable. In addition, there is a regulatory requirement on the minimum amount of dead wood in forests to maintain biodiversity.

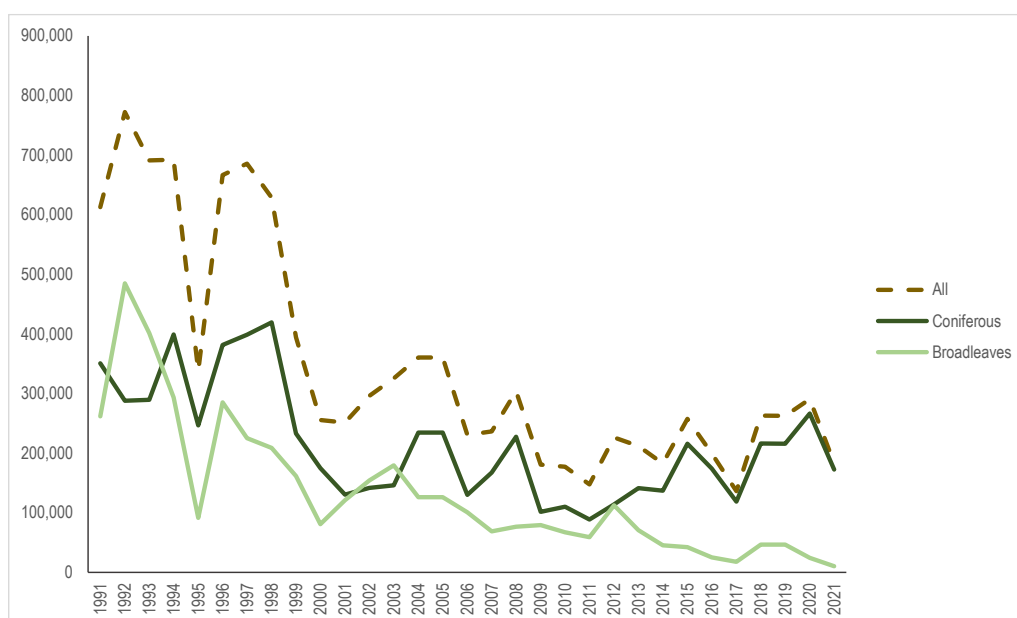


Figure 119 Harvest of dry and fallen mass, m³

6.3.3.1.2.2 Changes in carbon stock in litter

Since the last ERT review in 2020 a lot of efforts and resources are dedicated to collecting and analyse appropriate data, and to quantitatively providing evidence that the pool is not a source of emissions. For that the information from the ICP Forest programme at Level I since 1998 until today was gathered, processed, and analysed as this represents the only data source of monitoring for that pool in the country.

According to IPCC definition, litter pool includes all non-living biomass in a various state of decomposition, so this means – the litter layer (fresh dead plant material), fomic and humic layers.

Referring to the ICP Forests Manual the definition of litter is (methodological approach http://www.icp-forests.org/pdf/FINAL_soil.pdf (see Annex 7 Soil horizon designation p.195)):

OL-horizon (Litter, Förrna): 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 discolored 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 account 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.

OFH horizons (OH+OF, the fomic 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 an organic horizon, it should fulfill 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).

First, the data about soil and litter was collected from the ICP Forest yearly reports. Information about the carbon content in litter layer have been reported since 2001. All the available information from the ICP Forest reports consists of data for 163 sample plots and 254 observations. The data have been split into two periods – 1998-2008 and 2009-2019. The periods have been defined in connection with the number of the samples analysed through the years and by taking into consideration that the observation network have been revised since 2009 according to the implementation of the FUTMON project. This enabled us to extract only these paired samples which have been analysed at least once in each period – 54 plots in total and 111 observations. For 3 observation plots there are more than 1 observation per period, so for these plots the average carbon stock have been used. The carbon stock change in each plot have been obtained as a difference in the carbon stock for each plot and divided by the number of years between the beginning of the first period and at the end of the second period. The obtained CSCs have been checked for outliers (greater than twice the standard deviation of the CSC). Like this, 4 outliers have been detected and removed from the sample size. The remaining data have been further analysed with paired difference test to assess whether their population means differ. The carbon stock in litter among the sample size of these 50 plots does not follow the normal distribution

(Figure 120 and Figure 121), thus the Wilcoxon signed-rank test has been used to compare whether their population mean ranks differ. The outcome of the test confirms the null hypothesis (p -value = 0.1156), that difference in means is not significant (Stoeva and Kirova, 2021). Thus, Tier 1 approach assuming that the pool is at equilibrium has been used. The summary statistics for the carbon stock and the carbon stock changes for the plots for the two periods are presented below.

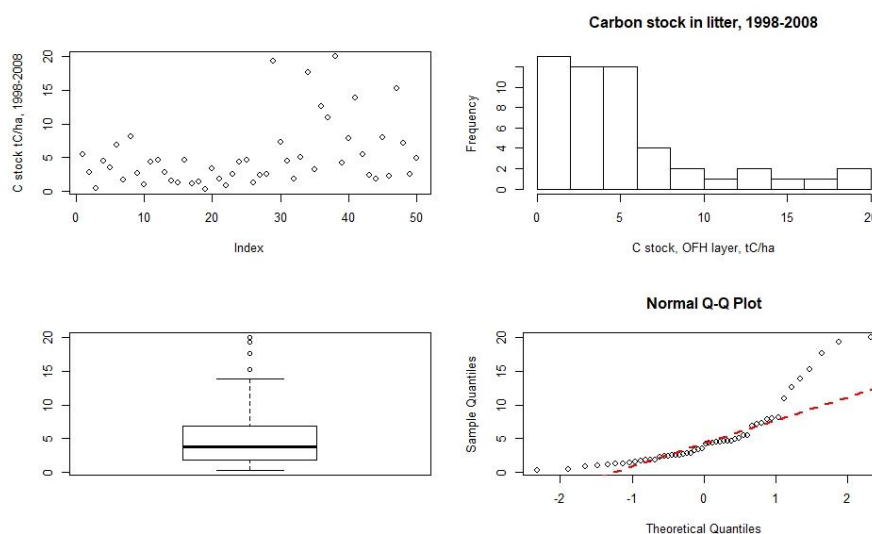


Figure 120 Distribution of the carbon stock in litter layer for the period 1998-2008, $n=50$

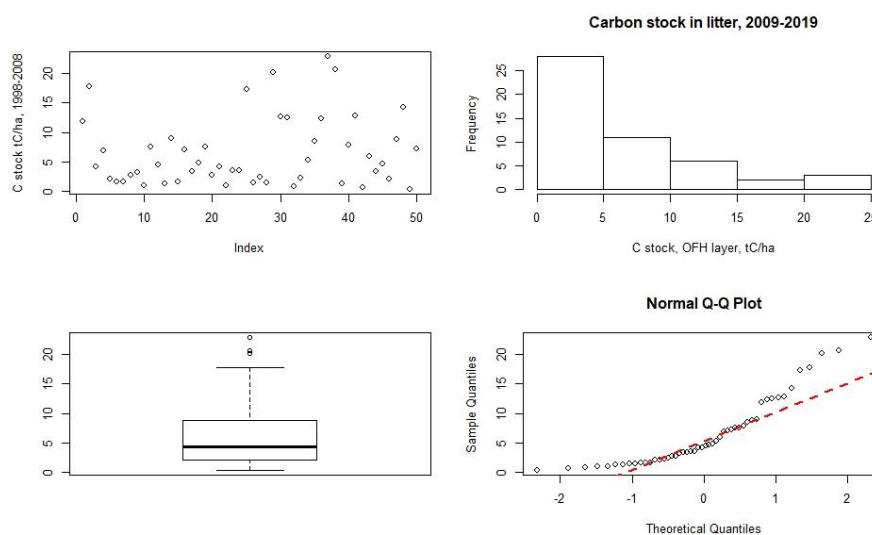


Figure 121 Distribution of the carbon stock in litter layer for the period 2009-2019, $n=50$

Table 227 Summary statistics of the carbon stock in forest litter and the carbon stock changes between the two periods

litter	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
P1, 1998-2008	0.37	1.95	3.84	5.21	6.54	19.90
P2, 2009-2019	0.37	2.03	4.32	6.47	8.66	22.86
CSC	-0.615	-0.051	0.009	0.063	0.166	0.751

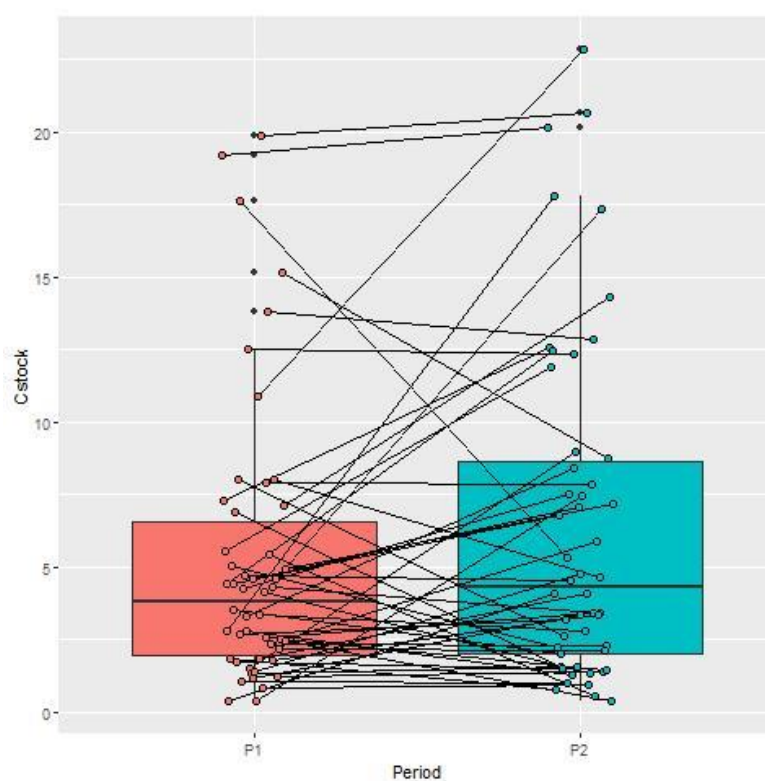


Figure 122 Distribution in the C stock in litter layer for the two periods and the change in the stock, $n=50$.

6.3.3.1.3 Changes in carbon stock in soils

Mineral soils

In Submission 2017 and 2018 Bulgaria reported emissions and removals from soil by using results from a study on application of CBM-CFS model at EU level (Pilli et al, 2016). Back in 2017, this was the only option to report CSC from these pools in response to the encouragements of several ERT's to apply higher tier in FL-FL for these pools, as BG does not have proper data to account for the changes in soil pool of the remaining lands. Subsequently, we acknowledged that by using the CBM results, there is a methodological inconsistency in the methods and tools in assessing the CSCs from forest carbon pools (e.g CBM for DOM and SOC, and own calculations from biomass). In addition, according to Pilli's study, the soils in FL-FL of Bulgaria are a source of emissions, which we assumed was not possible taking into consideration the development of forestry in Bulgaria in the past 20-30 years. The rationale behind our conclusion that the soil is not a source of emissions is that the standing biomass stock of the Bulgarian forests steadily increased in the last years by >50 %, which means that there is increasing C flux to the litter and soil pool accordingly from dead leaves and branches and dead fine and coarse roots. In addition, the harvest in the Bulgarian forests has also increased in the last years, which means that also the C flux from harvest residues (leaves, branches, roots, stumps, non-extracted stemwood) to the litter and soil pool increased accordingly. All these suggested that the use of the CBM results for soil was not appropriate as the simulation in that study was mostly designed for simulating the biomass development and there is a large uncertainty associated with the estimates in soils. The Pilli's results on CSC in soil and DOM have not been validated or verified and come from a non-adjusted model for the Bulgarian conditions.

As there were no proper data to accurately estimate the emissions and removals in that pools, there was not any other alternative than to apply again T1 approach in Submission 2020 assuming that the pools are not a source. Since the last ERT review in 2020 a lot of efforts and resources are dedicated

to collect and analyse appropriate data and to quantitatively provide evidence that the soil pool is not a source. For that the information from ICP Forest program at Level I since 1998 until recently was gathered, processed and analysed.

First, the soil data was collected from the ICP Forest yearly reports. Soil information for 171 sample plots have been gathered and stored in electronic format. The data encompasses the years since 1998 until 2020. It contains information on the carbon content per depth ranges of 0-10 cm, 10-20 cm, and 20-40 cm, information on bulk density, coarse fraction, pH etc. Information of bulk density for all layers is available for the sample plots, which have been analyzed since 2008. For the soils analyzed before 2011, the bulk density is available for certain plots and in most cases only for the 0-10 layer. Missing data on bulk density in that cases has been gap-filled by data from later observations for these plots. The bulk density for the deeper layers has been estimated using the Alexander B (1980) PTF function 4:

$$\rho_b = 1.72 - 0.294 * (\text{org.C}, \%0.5)$$

Data on the coarse fraction is also available for almost all layers and depths since 2011. For the years before that, the data is not available for all samples, thus a gap-filling approach has been implemented – for the paired plots, the data from later observations have been used, whereas for other plots – an average value.

The SOC content is obtained by summing the SOC contents of the constituent soil layers; the SOC content of each layer is calculated by multiplying the concentration of soil organic carbon in a sample (g C (kg soil)⁻¹), with the corresponding depth and bulk density (Mg m⁻³) and adjusting for the soil volume occupied by coarse fragments.

$$SOC = \sum_{\text{horizon}=1}^{\text{horizon}=n} SOC_{\text{horizon}} = \sum_{\text{horizon}=1}^{\text{horizon}=n} ([SOC] \cdot BulkDensity \cdot Depth \cdot (1 - frag) \cdot 10)_{\text{horizon}}$$

The total number of the soil carbon stock calculations for the 0-30 cm depth is 418 from 171 sample plots. In that dataset some of the plots have been measured more than twice, whereas others only once. This is because throughout the years of the forest monitoring programme in Bulgaria there are changes in the monitoring grid and sampling design (6.3.3). Thus, the dataset has been split into two periods 1998-2008 and 2009-2019 taking into consideration the change in the observation network of sample plots in connection with the FUTMON project. Further analysis has been done to extract only the paired sample plots, which have been observed at least once for both periods. In the end, data for 90 paired sample plots have been sorted and analyzed. It includes 305 calculated SOC stock in total for 0-30 cm depth. For each observation plot the average carbon stock in litter has been estimated as for some plots there is more than one measurement in a period. Then, the carbon stock change in each plot have been obtained as a difference in the mean value of carbon stock for each plot and divided by the number of years from the beginning of the observed period until the end of it – 23 years. The resulting CSCs have been checked for outliers via double standard deviation ($x \pm 2\sigma$) and removed (7 outliers in total). Like this the sample size of the paired plots has been reduced to 84. The remaining data have been further analysed with paired difference test to assess whether their population means differ. The soil organic carbon stock among the sample size of these 84 plots does not follow the normal distribution (Figure 122 and Figure 123), thus a paired t-test has been used to compare whether their population means differ. The outcome of the test confirms the null hypothesis (p-value = 0.064), that difference in means is not significant (Stoeva and Kirova, 2021)²⁷. Thus, Tier 1 approach assuming that the pool is at equilibrium has been used for reporting.

The summary statistics for the soil organic carbon stock and the carbon stock changes for the plots for the two periods are presented below.

²⁷ Stoeva, L., L. Kirova. 2021. [Assessing the carbon stock changes in forest soils in Bulgaria](https://doi.org/10.3897/silvabalcanica.22.e76252). Silva Balcanica 22(3): 69-78. <https://doi.org/10.3897/silvabalcanica.22.e76252>

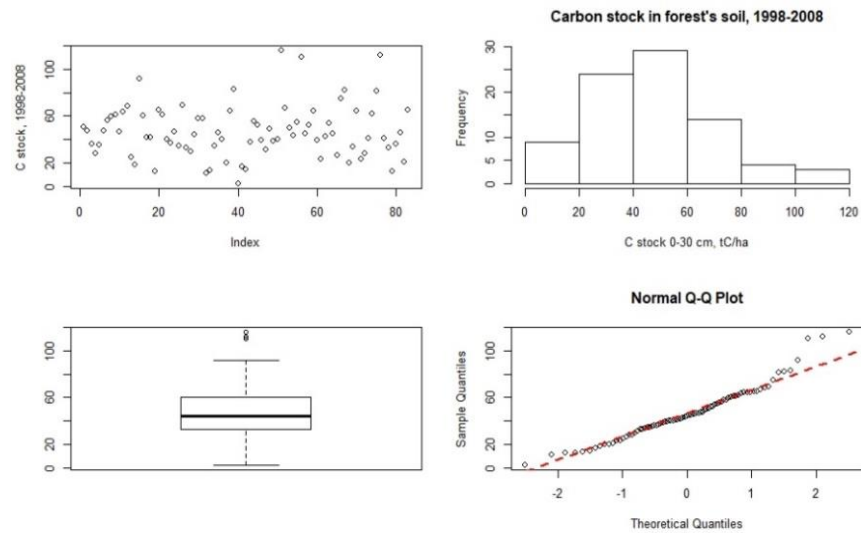


Figure 123 Distribution of the soil organic carbon stock for 0-30 cm for the period 1998-2008, n=84

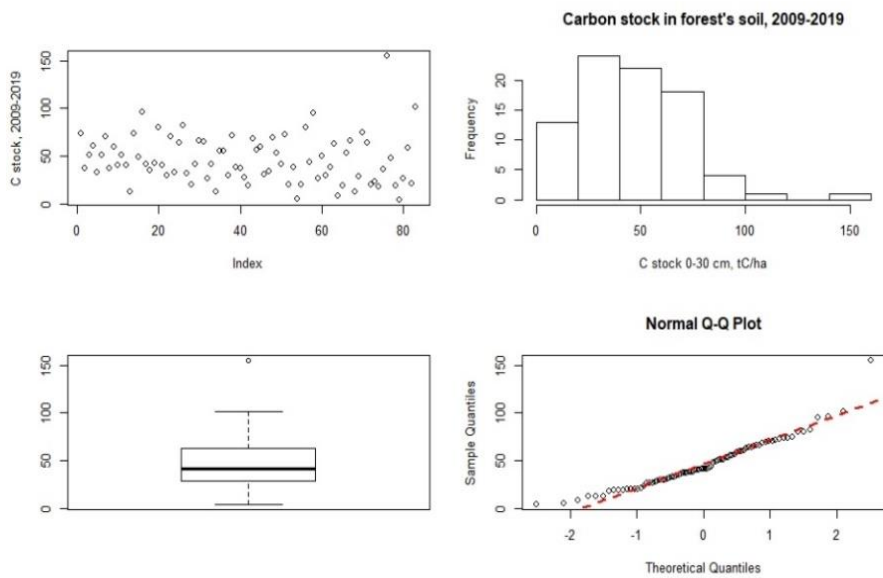


Figure 124 Distribution of the soil organic carbon stock for 0-30 cm for the period 2008-2019, n=84

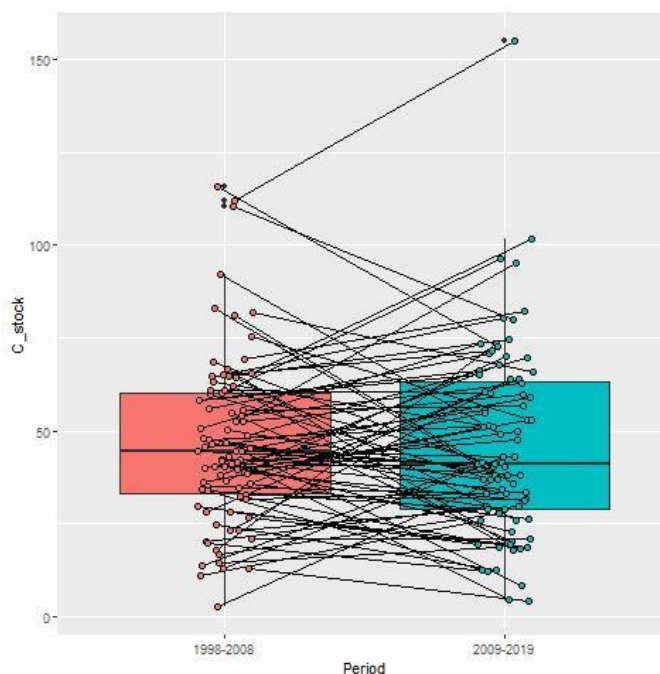


Figure 125 Distribution in the C stock in soil for the two periods and the change in the stock, $n=84$

Table 228 Summary statistics of the soil organic carbon stock and the carbon stock changes between the two periods

Soil	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
SOC, P1	3.244	38.757	49.765	50.753	62.855	115.683
SOC, P2	4.185	29.057	41.233	46.176	63.104	154.856
CSC	-2.245	-0.716	-0.269	-0.199	0.389	1.871

Organic soils

Histosols cover 0.05% of the total area of Bulgaria and are mostly 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 these reasons Histosols are not subject to evaluation.

6.3.3.1.4 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 CO_2 - 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 114

6.3.3.2 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 has the LUC from GL to FL, followed by annual CL, perennial CL and OL.

The total emissions from wildfires (e.g. 4.A.1 and 4.A.2) are presented in Figure 114

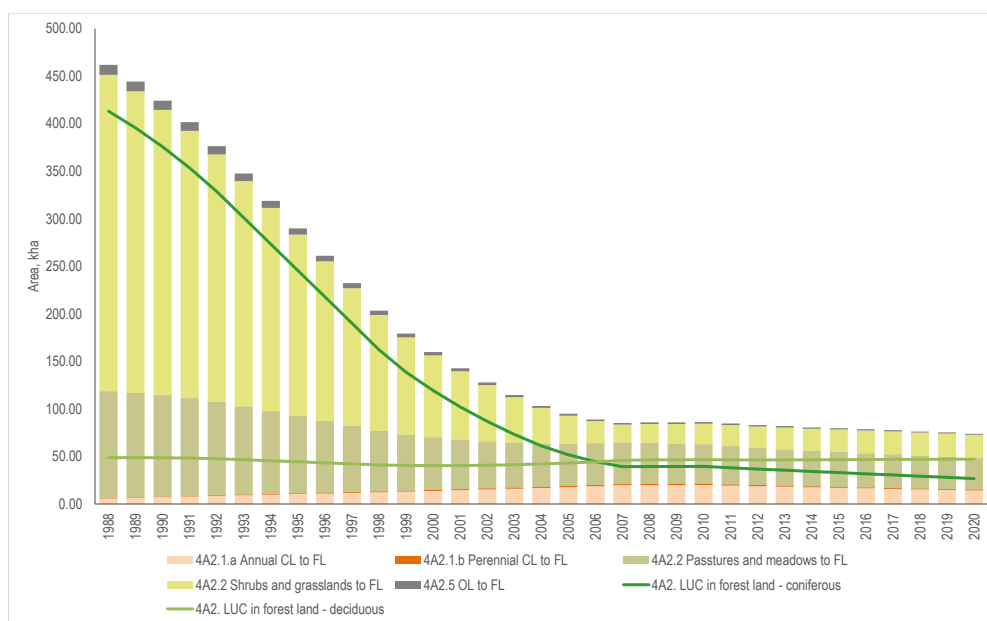


Figure 126 Area of LUCs to FL (20 years)

6.3.3.2.1 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 more precise estimates of changes in carbon stocks in biomass. The net annual CO₂ 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

$$\Delta C_{CONVERSION} = \sum \{(B_{AFTERi} - B_{BEFOREi}) \cdot \Delta A_{TO OTHERSi}\} \cdot CF$$

Where:

$\Delta C_{\text{CONVERSION}}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C yr⁻¹

$B_{\text{AFTER}i}$ = biomass stocks on land type i immediately after the conversion, tonnes d.m. ha⁻¹

$B_{\text{BEFORE}i}$ = biomass stocks on land type i before the conversion, tonnes d.m. ha⁻¹

$\Delta A_{\text{TO\_OTHERS}i}$ = 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 the 1st 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, 2020. Once we obtained the weighted 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 1st 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 229 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

BEF₂ coefficient adds the biomass of the leaves and needles. The values of BEF₂ for coniferous and deciduous forests are estimated as a weighted mean considering the volumes of different coniferous and deciduous species. To estimate the average BEF₂, data from literature sources on results from ecosystem studies for Spruce, Scots pine, Beech and Oaks for the 1st age class stands were used (compiled in Korner et al., 1993).

Basic wood density for the 1st 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 – 3.56 tC/ha
- Perennial cropland – 4.42 tC/ha
- Pastures and meadows – 6.58 tC/ha
- Shrubs and grasslands – 5.24 tC/ha
- Other land – 0 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 thinning start in older age classes, which is implicitly accounted for within the category Forest Land remaining Forest Land.

6.3.3.2.2 Changes in dead organic matter

6.3.3.2.2.1 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.

6.3.3.2.2.2 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), fomic and humic layers. As was explained in the chapter Forest remaining forest, the data on forest litter is from the ICP Forest Programme. According to the ICP Forests Manual samples are taken separately for the different depths OL, OH, and OF. OL data is not available in Bulgaria. Data for OH and OF is available. The estimation for the average carbon stock in the litter pool is based on a database for carbon content in OFH layers available for 116 sample plots, analysed in the period 2011-2016. According to the data available it was estimated that the carbon stock in the litter is 10.23 tC/ha.

6.3.3.2.3 Changes in the carbon stock in soils

The changes in the soil organic carbon pool following the land-use conversion from other land-use to forests have been estimated based on the calculated stock of the soil organic carbon from the soil under different land-use types using the equation:

$$\Delta C_{\text{mineral soil}} = [(SOC_{\text{ref}} - SOC_{\text{non forest land}}) \cdot A_{\text{Aff}}] / T_{\text{Aff}}$$

where:

$\Delta C_{\text{mineral soil}}$ - annual change in the carbon stock in mineral soils in the year of assessment, tonnes C/yr

SOC_{ref} – reference carbon stock in forests, tonnes C/ha

$SOC_{\text{non forest land}}$ - stable carbon stock in the soil in a previous type of land-use (croplands, grasslands and other lands), tonnes C/ha

A_{Aff} - total afforested area after the conversion, ha

T_{Aff} - duration of the transition from non-forest land to forest, yr

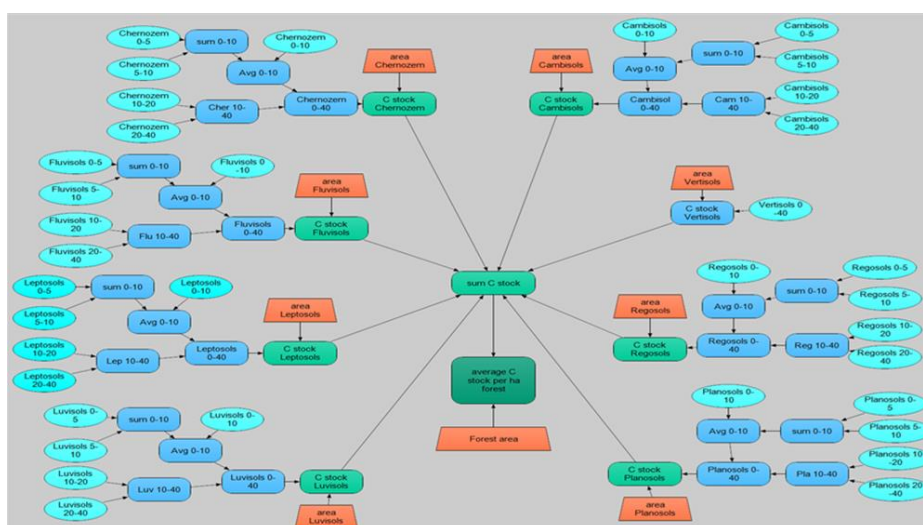
The used transition period is 20 years according to 2006 IPCC Guidelines.

the source of information for the contents of organic carbon in forest soil is the database of the ICP Forest. 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 soil chemistry and physical parameters. The measurements of the soil's parameters are made for layers (0-5 cm, 5-10 cm, 0-10 cm, 10-20 cm, and 20-40 cm). The content of organic matter is presented in percentages. 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:

$$\rho_b = 1.72 - (0.294 * (org.C, \%)^{0.5}))$$

Thus, the organic carbon stock has been calculated for all samples from the dataset. Then, the samples have been grouped by 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 SOC of every particular soil type which are presented in Bulgarian forests. The procedure to derive the reference carbon stock in forest soils, which has a value of 61.86 tC/ha (0-30 cm) is presented in the figure below.



Note: the procedure is applied for soil depth of 0-30 cm

Figure 127 Procedure to derive the organic carbon reference stock in forest's soils

For the stable stock of organic carbon in soils (0-30 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: 67.74 t C/ha
- Perennial crops: 67.49 t C/ha
- Pastures and meadows: 72.77 t C/ha
- Shrubs and grasslands: 86.96 t C/ha
- Other land: 51.8 (IPCC 2006)

Following the recommendation from the ERT Bulgaria 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 IPCC Guidelines. In order to choose the most appropriate default SOC reference level Bulgaria did the following:

According to the "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 the 2006 IPCC Guidelines) for the respective climate regions. The result for the 0-30 cm depth is 51.8 tC/ha.

A description of the methods of deriving these soil C stocks can be found in the respective chapters.

6.3.3.2.4 N₂O emissions from N mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soils

Emissions have been estimated for all situations where C losses in mineral soils occur (according to 2006 IPCC Guidelines), based on equations 11.1, 11.2, 11.8.

The ratio C/N in mineral soils of Forest lands is the default value from 2006 IPCC Guidelines – 15, whereas the C/N ratio of CL and GL is derived based on data from soil inventory in BG (since 2005). N₂O emissions from N mineralization associated with a loss of soil organic matter are presented in the table below.

Table 230 N₂O emissions associated with loss of soil organic carbon when lands are converted to FL

Year	4A (III) CL to FL, CO ₂ eq	4A (III) GL to FL, CO ₂ eq
1988	0,72	186,00
1990	0,90	168,92
1995	1,32	110,25
2000	1,74	53,76
2005	2,25	23,77
2010	2,51	19,35
2015	2,14	19,31
2016	2,07	19,31
2017	2,00	19,28
2018	1,92	19,16
2019	1,86	19,18
2020	1,78	19,05
2021	1,68	18,44

6.3.4 Uncertainty Assessment

The overall uncertainty in estimation of gas emissions and removals over a year for the category “Forests” is **236%**. The trend uncertainty due to activity data and emission factors amounts to **675%** (Table 225).

The combined uncertainty for the sub-category “Forest land remaining forest land” is **251%** and the uncertainty in the trend of the gas emissions is **43%**.

The uncertainties for the sources “Living biomass”, “Forest fires”, and “Dead wood” within the sub-category “Forest land remaining forest land” were determined. Annual change in carbon stocks in “Living biomass” was estimated using the stock-difference method. The overall uncertainty over a year for the “Living biomass” is **283%**. The trend uncertainty due to activity data and emission factors amounts to **30%**.

The combined uncertainty for „Forest fires“ is **73%** and the uncertainty in the trend of the gas emissions is **415%**. Annual change in carbon stocks in “Dead wood” was estimated using the stock-difference method. The overall uncertainty over a year for the “Dead wood” is **67%**. The trend uncertainty due to activity data and emission factors amounts to **120%**.

The combined uncertainty for the sub-category „Land use changed to forest land” is **41%**. The trend uncertainty in gas emissions is **3%**.

The uncertainties of gas emission estimations from “Living biomass”, “Litter” and “Soil” for the sources “Crop land (annuals and perennials) changed to forest land”, “Grassland (permanent pasture and meadows, PPM and shrubs and grasslands) 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 **35%**. The trend uncertainty due to activity data and emission factors amounts to **2%**. The overall uncertainty over a year for „Litter“ is **19%**. The trend uncertainty due to activity data and emission factors is **4 %**. The combined uncertainty for „Soil“ is **16 %**. The uncertainty in the estimated tendency for the gas emissions is **1%**.

The overall uncertainty over a year for “Forest fires under changed land use” is **74%**. The trend uncertainty due to activity data and emission factors amounts to **184%**.

Table 231 Uncertainties in the gas emissions from the IPCC category “Forests”

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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 introduced into the trend
Forest Land remaining Forest Land	Living biomass	conifers	CO2	-5948.24	-3896.31	3	264.91	264.92	14697.33	228.74	1.94	52323.87
		broadleaved	CO2	-6981.49	-3185.40	3	540.04	540.04	40820.65	633.94	1.59	401886.99
	Forest fires		CH4	1.06	139.53	3	102.89	102.93	2.85	1.66	0.07	2.77
			N2O	0.55	73.05	3	83.36	83.41	0.51	0.70	0.04	0.50
	Dead wood	conifers	CO2	-163.92	-572.92	3	97.26	97.30	42.87	2.99	0.29	9.00
		broadleaved	CO2	-143.21	-548.85	3	92.55	92.60	35.63	3.01	0.27	9.12
Land use changed to forest land	Living biomass	new forest biomass	CO2	-4049.68	-621.61	10	32.69	34.18	6.23	27.02	1.03	731.14
		conversion of cropland with annuals	CO2	6.85	1.67	10	23.03	25.11	0.00	0.03	0.00	0.00
		conversion of cropland with perennials	CO2	0.62	0.09	10	25.00	26.93	0.00	0.00	0.00	0.00
		conversion of grassland (PGM)	CO2	34.79	10.54	10	79.35	79.98	0.01	0.52	0.02	0.27
		conversion of grassland (MGL)	CO2	4.48	6.94	10	50.00	50.99	0.00	0.01	0.01	0.00
		conversion of other land	CO2	0.00	0.00	10	75.00	75.66	0.00	0.00	0.00	0.00
	Litter	conversion of cropland with annuals	CO2	-10.69	-25.35	10	29.84	31.47	0.01	0.02	0.04	0.00
		conversion of cropland with perennials	CO2	-0.73	-1.31	10	29.84	31.47	0.00	0.00	0.00	0.00

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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 introduced into the trend
		conversion of grassland (PPM)		-211.04	-59.44	10	29.84	31.47	0.05	1.20	0.10	1.44
		conversion of grassland (MGL)	CO2	-623.00	-45.04	10	29.84	31.47	0.03	3.99	0.07	15.90
		conversion of other land	CO2	-20.04	-1.71	10	29.84	31.47	0.00	0.13	0.00	0.02
	Soil	conversion of cropland with annuals	CO2	6.15	14.58	10	44.74	45.84	0.01	0.02	0.02	0.00
		conversion of cropland with annuals	N2O	0.72	1.68	10	116.92	117.35	0.00	0.00	0.00	0.00
		conversion of cropland with perennials	CO2	0.40	0.72	10	49.05	50.06	0.00	0.00	0.00	0.00
		conversion of grassland (PPM)	CO2	225.29	63.46	10	24.20	26.19	0.04	1.04	0.11	1.09
		conversion of grassland (PPM)	N2O	186.00	18.44	10	110.70	111.15	0.06	4.36	0.03	18.97
		conversion of grassland (MGL)	CO2	1530.37	110.64	10	10.49	14.49	0.04	3.45	0.18	11.94
		conversion of other land	CO2	-19.73	-1.68	10	386.92	387.05	0.01	1.63	0.00	2.65
	Forest fires		CH4	0.15	2.57	10	102.89	103.38	0.00	0.03	0.00	0.00
			N2O	0.08	1.35	10	83.36	83.96	0.00	0.01	0.00	0.00
		Total emissions		-16174.26	-8514.38	Overall uncertainty in the year (%)			236	Trend uncertainty (%)		675

6.3.5 Category-Specific Qa/Qc And Verification, If Applicable

More information on the QA/QC procedures are provided in Chapter 6.1.6 QA/QC

Referring to an ERT's recommendation from previous reviews to "Provide estimates of changes in carbon stock in living biomass by applying the gain–loss method in future annual submissions for verification purposes", Bulgaria conducted in 2019 a pilot assessment of the emissions and removals from forest biomass calculated by applying Gain-Loss method. The official statistics in Bulgaria do not include information on the net annual increment, so for the pilot assessment the increment has been determined based on a growth model according to growth tables and information on growing stock of the stands per tree species and age class. The growth model has been applied to the aggregated data – reporting forms (RF 1-7). In RF3 the growing stock is not differentiated by yield class, so the growth rate was calculated as a weighted average of its value for the various yield classes, assuming a normal distribution of the area of the tree species by yield class with a maximum for the average yield class III. To perform the calculations on the increment, the growth tables were modelled with the Chapman-Richards equation

$$y = a(1 - e^{-kx})^{-n}$$

where y is the stock of 1 ha, x is the age of the stand, and a , k , and n are regression constants. When modeling the stock with this equation, the growth rate has the form

$$p = \frac{kn}{e^{kx} - 1}$$

Although the model used provides estimates of the increment at a level of tree species the emissions and removals from forest biomass by using the gain-loss method have been performed at aggregated level – by forest type (coniferous and deciduous) and not by tree species. The model used to derive the current increment provides information from 1995-2015 per five-year period. For 1990 the value for 1995 has been applied. The increment has been converted to biomass by applying the conversion factors from the table below. The BCEFs are lower than the IPCC defaults because the current increment is derived from the standing growing stock which includes branches and stem tops, so we do not expand for branches and tops.

	BCEF (D*BEF)	R	CF
Coniferous	0.464	0.29	0.51
Deciduous	0.621	0.24	0.48

Losses have been calculated based on the information from reporting form 5 (RF5), which provides the annual harvesting amount for coniferous and deciduous species. The form contains information on harvested amounts from different types of loggings including also harvesting from salvage logging. Thus, losses associated with disturbances have been accounted for under losses associated with harvesting. The harvested amounts have been converted to biomass by applying the respective conversion factors as indicated in IPCC 2006 Guidelines.

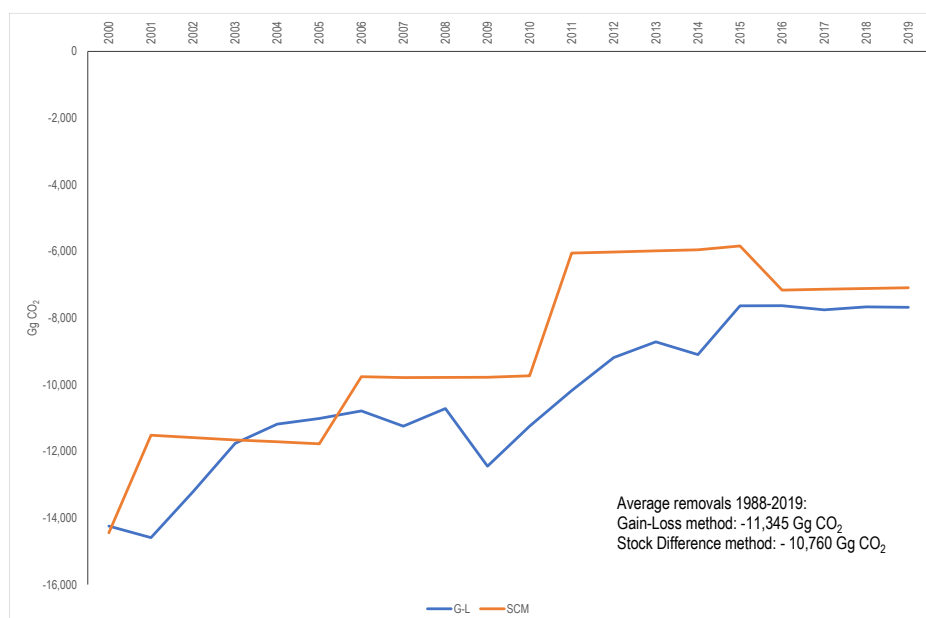


Figure 128 Comparison between the emissions and removals estimates – gain-loss method vs. stock difference method

When comparing the results from both methods – stock difference and gain-loss, it shows that both estimates have a decreasing trend in removals. It should be noted that estimates differ at the level of stratification which could explain some of the differences in the trend. Although there is not a good match between the estimates during the time series, the average emissions are similar because the large discrepancy at the beginning of the time series between the two estimates levels out the difference between the methods after the year 2000. Uncertainty assessment of the gain-loss estimates shows that it is much lower (35% for biomass in FLrFL) than the uncertainty of the estimates based on the SD

method (>200%). This shows that a change in the method would reduce the uncertainty for the category. However, there are some technical issues that should be resolved before this step as follow:

1. To carefully revise and consider any specifics of the official forestry statistics which could affect the estimation of increment data as the calculation are based on the aggregated data on the growing stock.
2. To analyse other possibilities to calculate increment which could be more accurate.
3. To apply the gain-loss method at more disaggregated level.

6.3.6 Category-Specific Recalculations

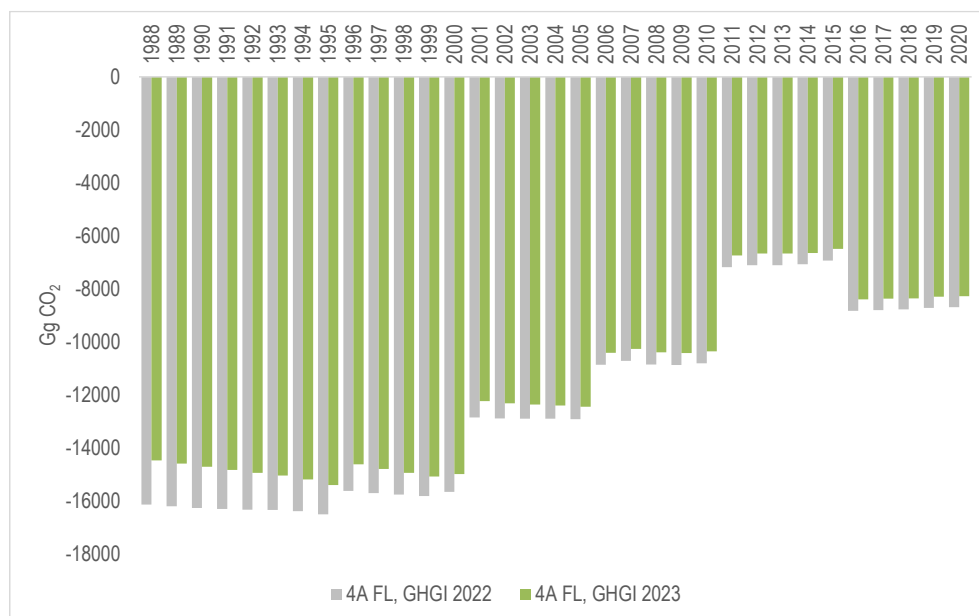


Figure 129 Recalculations in Forest Land category

The recalculations in FL are due to the following:

1. Small changes in the time series of lands converted to FL are explained in more details in Chapter 6.3.2 The changes in area affected the emission estimates throughout the whole time series.
2. Improvement in estimation of the biomass growth after conversion to FL by disaggregated between conversion to conifers or broadleaves.
3. Update of the GWP of the N₂O and CH₄ emissions

6.3.7 Category-Specific Planned Improvements Including Those In Response To The Review Process

See Chapter 6.1.8 PLANNED IMPROVEMENTS

6.4 Cropland (4.B)

6.4.1 Description Of The Category

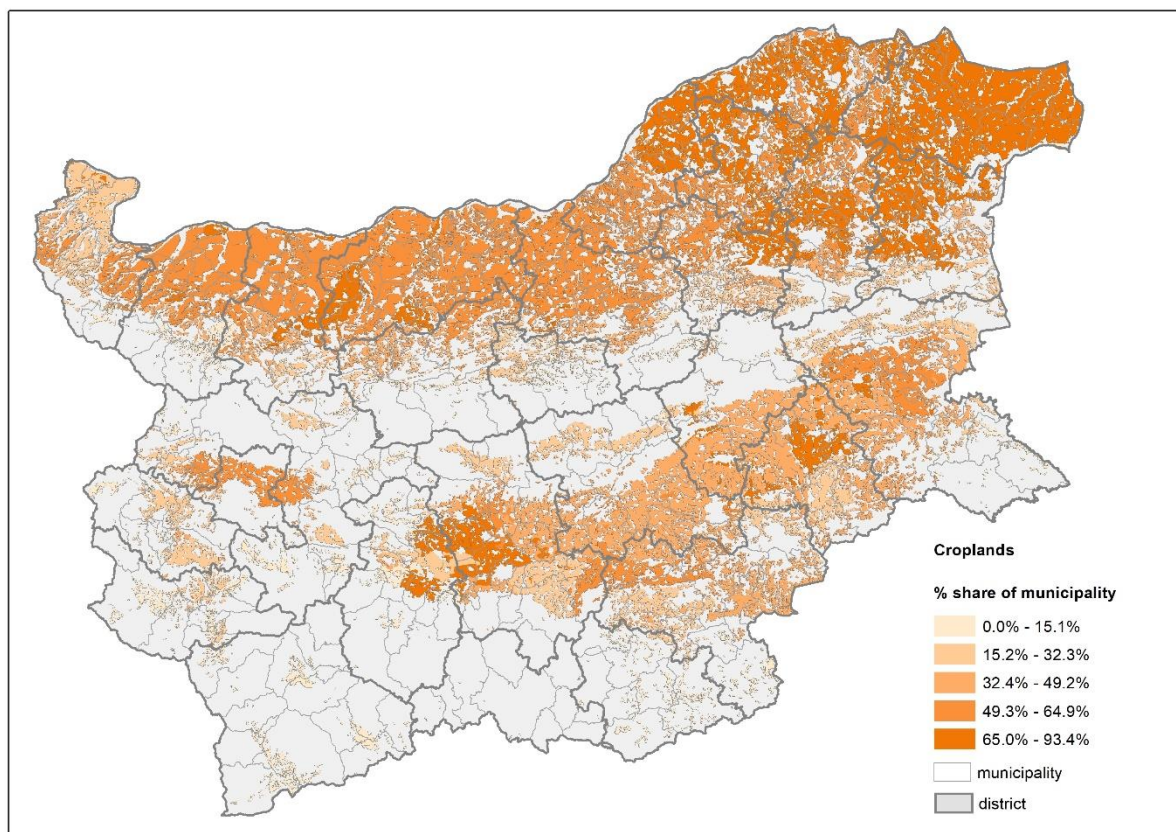


Figure 130 Share of municipality area occupied by Cropland. The map is elaborated based on CLC, 2018

In 2021, croplands in Bulgaria cover an area of 3691 kha which represents 33.25 % of the country's territory. The figure below presents data on the area of Cropland for the reporting period.

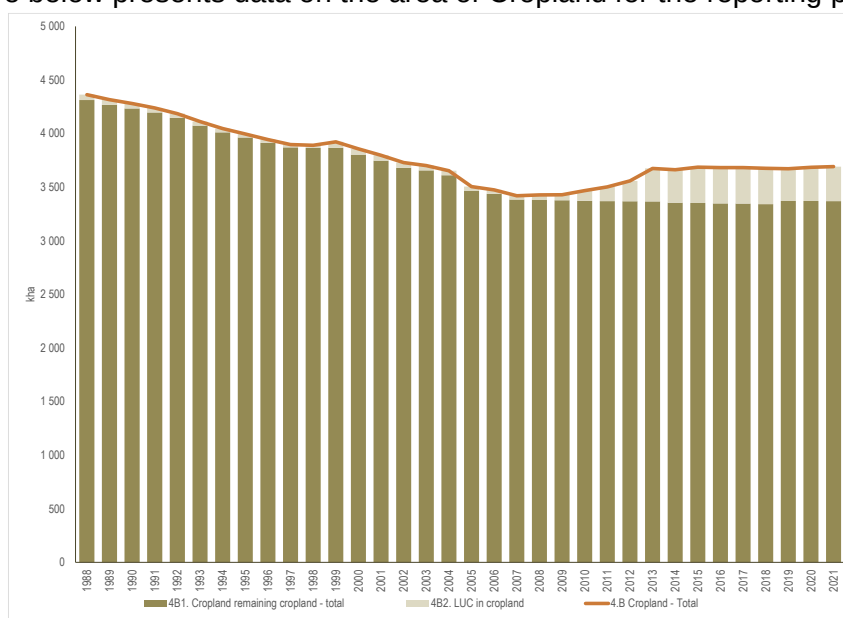


Figure 131 Trends in Cropland category 1988-2021

There is a constant decrease in cropland since the base year, nevertheless the trend of LUC to CL has increased in the past 10 years. The total cropland area is 15.40 % lower, compared to the base year, and varies from 4363 kha in 1988 to 3691 kha in 2021.

Annual crops have a share of 95% of the total cropland's territory and the rest 5% are referred to perennial crops. Since the recalculations in the land representation for Submission 2020 there is a change in the whole time series as some of the issues related to methodological changes in the agricultural statistics (between, before and after 2000) and some differences in definitions have been addressed by interpolation between the data in 1988 (before the land reform which started since 1991) and the year 1998 (which is the first year of the new statistics BANCİK). The present representation of the Croplands includes only the utilized (managed) croplands as all secondary lawns and marginal croplands are reported under GL category as a subcategory. The trend in the areas of cropland category is presented in the figure below.

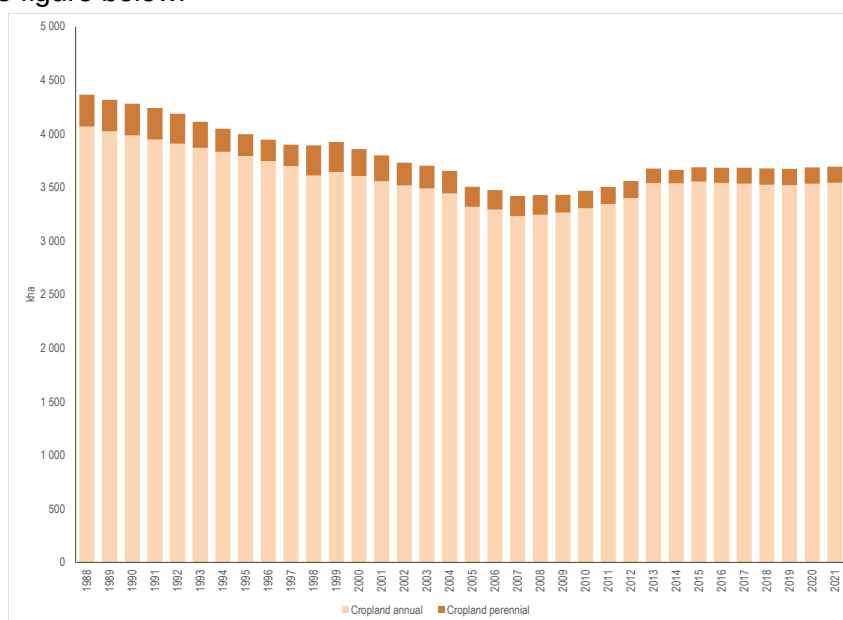


Figure 132 Annual and perennial cropland's distribution under CL category

A steady decrease in croplands is observed due to the abandonment of agricultural lands after the socioeconomic and political changes in the 90's in the country and the subsequent land reform related to restitution processes which led to inefficient land use in agricultural lands (e.g. CL and GL). Since the accession of Bulgaria to the EU, there is a slight increase in CL areas which due to the implementation of the Common Agricultural Policy (CAP). The use of the mechanisms of the CAP and the increase in access to finance are driving new operator in the agricultural business and to more efficient land use.

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, an increase in biomass stocks in a single year is assumed to equal to biomass losses from harvest and mortality in that same year - thus there is no net accumulation of biomass carbon stocks.

The immature perennial crop area accumulates carbon at a rate of approximately 0.43 t C/ha/yr for orchards and 0.28 t C/ha/yr for vineyards. For Bulgaria's conditions the default accumulation rate purposed in 2019 Refinement to the 2006 IPCC GNGGI was applied (Ch. 5.2.1.2., table 5.3).

The assumption in Tier 1 (according to 2006 IPCC 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-CO₂ emissions associated with the management of permanent agricultural lands are estimated as part of the Agriculture Chapter from this report. N₂O emissions from land-use conversions to cropland as a result of soil oxidation are reported under LULUCF sector.

The cropland's emissions over the reporting period range from -784.77 Gg CO₂ eq. in 1988 to 268.06.15 Gg CO₂ eq. in the last reporting year. As it can be seen from the table below, emissions from subcategory Cropland remaining cropland have 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.

Table 232 Emissions and removals from Cropland category, Gg CO₂ eq

Year	4 B Total cropland	4.B.1 Cropland remaining cropland	4.B.2 Land converted to Cropland	4.B.2.a Grassland Pastures and meadows converted to Cropland	4.B.2.b Grassland Shrubs and grasslands converted to cropland	4.B.2.5 Other land converted to cropland	4.B.2.2 Grassland converted to cropland (N ₂ O converted into CO ₂ equivalents)
1988	-784.77	-878.12	83.97	29.07	54.89	NO	9.39
1989	-791.93	-880.37	79.55	27.54	52.00	NO	8.89
1990	-767.79	-851.31	75.13	26.01	49.11	NO	8.40
1991	-773.81	-852.42	70.71	24.48	46.23	NO	7.91
1992	-773.15	-846.85	66.29	22.95	43.34	NO	7.41
1993	-745.84	-814.63	61.87	21.42	40.45	NO	6.92
1994	-676.14	-740.01	57.45	19.89	37.56	NO	6.42
1995	-612.57	-671.53	53.03	18.36	34.67	NO	5.93
1996	-617.62	-671.67	48.61	16.83	31.78	NO	5.44
1997	-619.92	-669.06	44.19	15.30	28.89	NO	4.94
1998	-680.90	-725.12	39.77	13.77	26.00	NO	4.45
1999	-251.94	-719.35	457.04	318.82	138.22	NO	10.38
2000	-732.10	-830.37	88.38	30.60	57.78	NO	9.88
2001	-681.30	-774.65	83.97	29.07	54.89	NO	9.39
2002	-652.71	-741.15	79.55	27.54	52.00	NO	8.89
2003	-552.06	-635.58	75.13	26.01	49.11	NO	8.40
2004	-601.72	-680.33	70.71	24.48	46.23	NO	7.91
2005	-735.04	-808.74	66.29	22.95	43.34	NO	7.41
2006	-544.03	-612.82	61.87	21.42	40.45	NO	6.92
2007	-630.94	-694.81	57.45	19.89	37.56	NO	6.42
2008	-354.59	-570.58	206.85	114.28	92.57	NO	9.15
2009	-352.30	-498.84	136.34	58.53	77.81	NO	10.19
2010	70.50	-539.25	589.95	327.21	262.74	NO	19.79
2011	139.22	-505.17	616.16	310.54	305.63	NO	28.22
2012	434.17	-517.20	910.52	459.01	451.51	NO	40.85
2013	1285.91	-489.44	1708.00	878.43	829.57	NO	67.34
2014	175.68	-509.40	617.73	149.48	468.25	NO	67.34
2015	467.18	-521.22	915.14	323.87	591.27	NO	73.26
2016	218.26	-527.38	672.38	161.79	510.59	NO	73.26
2017	325.27	-435.82	687.54	170.81	516.73	NO	73.56
2018	290.68	-457.98	675.11	162.42	512.69	NO	73.56
2019	181.18	-503.61	617.66	142.53	475.13	NO	67.13

Year	4 B Total cropland	4.B.1 Cropland remaining cropland	4.B.2 Land converted to Cropland	4.B.2.a Grassland Pastures and meadows converted to Cropland	4.B.2.2.b Grassland Shrubs and grasslands converted to cropland	4.B.2.5 Other land converted to cropland	4.B.2.2 Grassland converted to cropland (N ₂ O converted into CO ₂ equivalents)
2020	352.72	-496.29	778.74	238.97	539.77	NO	70.26
2021	268.06	-532.60	728.79	198.45	530.34	NO	71.87

6.4.2 Information On The Approaches Used To Present The Data On The Areas And The Database On The Land-Use Used For The Inventory

Information on total Cropland and Grassland area is available from different data sources during the years (Chapter 6.1.4.1). 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 since 1992, when the land reform since the collapse of planned economy has actually started. No unambiguous, reliable and consistent information was found on the allocation and reallocation of land resources shares during in the period 1991 – 1997 (Yarlovskaya N., 2018), when the land reform has started. So, it was assumed that the annual variability in the totals of CL and GL according to the national statistics for the years 1992-1999 could be as a result of the restitution of lands and relocation between these categories based on the information on old real boundaries of lands or parcels and past management of these lands. Thus, it was decided to smooth this unrealistic trend by interpolation method between 1988-1998. The year 1998 is the first year of the BANCIAK statistics which is still operating today, so the data directly from BANCIAK was used to construct the time series since 1998. Like this, consistent information is used to represent the area of CL.

The balance of the territory of Bulgaria based on orthophoto images (under LPIS) has been available since 2010. This information was used to check and verify the information regarding the lands reported under Shrubs and grassland categories since the balance of the territory under LPIS has separate land cover class on shrubs and secondary lawns.

As regards reporting of LUCs, there are no LUCs from forests to CL or GL. Any conversions and re-conversions from, other lands, wetlands and settlements to CL are considered as unlikely since settlements according to the applied definition in the country encompass the artificial surfaces and other lands constitutes of bare lands and rocks. Thus, it has been considered that the only possible gain in the area of cropland, observed in the official statistic is due to change from grassland. The annual LUCs between CL and GL have been calculated based on the changes in the totals of these categories. The variations in the net changes in the area of CL and GL follow the opposite directions throughout the time series.

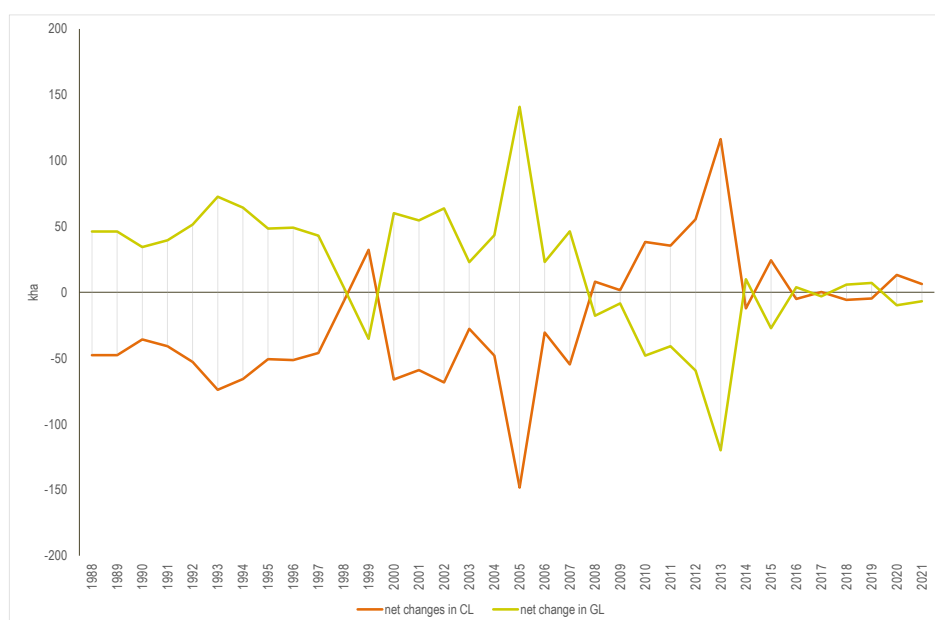


Figure 133 Net change in area of CL and GL

The LUCs within CL category – between annual and perennial is reported according to data from BANCİK statistics since 2000. The same annual change is applied for the years before 2000.

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 recognized 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 2019 IPCC Refinement the perennials accumulate biomass through the first 20 years. Emissions from perennials occur in the year of their clearing, assuming that annually 5% of the area of perennials are being replanted.

The area of the perennials over the time series ranges from 293 kha to 148 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:

Annual change in the biomass carbon stock

$$= (\text{area of the perennials remaining perennials} \cdot \text{coefficient of accumulation of carbon}) - (\text{area of the perennials 20 year earlier}^1 \cdot 0.05 \cdot \text{coefficient of accumulation of biomass});$$

¹ excluding area lost through land – use change

For the aboveground biomass stock at maturity the value 6.91 tonnes C.ha⁻¹ has been adopted, and for the annual accumulation – 0.35 tonnes C.ha⁻¹.y⁻¹ (2019 IPCC Refinement).

Table 233 Accumulation and loss of carbon in the aboveground biomass and period of clearing of perennials (calculated based on the 2019 IPCC Refinement)

Climatic zone	ABG C stock at maturity - MAX (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)
Temperate (all humidity regimes)	6.91	20	0.35	4.49

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 ($A_{\text{Conversion}}$), multiplied by the carbon stock in the biomass of the perennials ($L_{\text{Conversion}}$) plus the changes in the carbon stock in the biomass during the first year after the conversion (ΔC_{Growth}).

$$\text{The annual change of carbon stock in biomass} = A_{\text{conversion}}(L_{\text{conversion}} + \Delta C_{\text{growth}})$$

where,

$$L_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$A_{\text{conversion}}$ – area of the lands converted to annual crops, ha yr⁻¹

$L_{\text{conversion}}$ – 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 based on the NSI's yield data for annual crops (cereals, industrial crops, vegetables, fodder crops) for 1995, 2000 and 2005, 2010, 2015. 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 coefficients²⁸ have been used (Table 234). 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 234 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
field peas	100	-	NE
Rape	210	-	NE
sunflower	250	-	0.06
sugar beet	80	-	0.43
fodder beet	30	-	NE

²⁸ The expansion factors according to Bodenfruchtbarkeitsbeirat 2001 (pers. comm.)
Root-to-shoot ratios are published by West, T.O., 2008

Crop	Rest of aboveground biomass (in % of yield biomass)	Aboveground/belowground ratio	Root-to-shoot ratio
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
Tobacco		0.6	0.8

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 weighted mean of the cropland biomass was calculated then on basis of the yields of the individual crops in Bulgaria for single years - $\Delta C_{\text{Growth}} = 3.56 \text{ tonnes C ha}^{-1}$.

The calculations are based on the following steps:

$$Ba_{total_x} = B_{yield_x} \cdot C_{drm_x} + B_{yield_x} \cdot C_{drm_x} \cdot F_{rab_x}$$

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

$$Bb_{total_x} = Ba_{total_x} \cdot R_x$$

Where,

Bb total – total belowground biomass

R – root to shoot ratio

x – any particular annual crop for which data is gathered for single year

$$B_{total_x} = Ba_x + Bb_x$$

Where,

B total – total biomass (above and belowground)

Ba total - Total aboveground biomass

Bb total – total belowground biomass

$$\frac{B}{ha}_{t,1995,2000,2005,2010,2015} = \sum B_{total_x} / \sum area_x$$

Where,

B – biomass in t/ha

B total – total biomass (above and belowground)

Area – ha

Average of B t/ha for 1995, 2000, 2005, 2010, 2015 = 3.56 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 4.42 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 0.35 tonnes C ha⁻¹y⁻¹ is used (for each year of the transition period) given in the 2019 IPCC Refinement. The value 3.56 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 ($\Delta C_{Growth} = 0.35$ tonnes C ha⁻¹). For the biomass losses the actual annual land use change area from annual to perennial is multiplied by the biomass carbon stock of annual crops.

$$\text{Annual change in carbon stock in biomass} = (\text{area of the converted lands for 20 years} \cdot \Delta C_{growth}) + (\text{actual annual area of conversion} \cdot L_{conversion})$$

where,

$$L_{conversion} = C_{after} - C_{before}$$

$L_{conversion}$ – carbon stock in the biomass of lands which were converted to perennial crops, tonnes C ha⁻¹

$$C_{Before} = 3.56 \text{ tC/ha/y}$$

ΔC_{growth} – change of the carbon stock in the biomass in the first year after the conversion, tonnes C ha⁻¹

C_{After} = Change of the carbon stock immediately after the conversion is considered to be 0.

6.4.3.1.4 Changes in the carbon stock in soils of croplands remaining croplands

Mineral soils

The assessment of the carbon stock in the soil is performed at 0-30 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 Histosols in Bulgaria cover 0.05 % (5664 ha) of the total area of the country. In the sector Agriculture there are emissions reported from organic soils. For consistency reasons, we report here the area of agricultural lands (croplands and grasslands) with organic soils. The emissions of organic soils in croplands are not assessed. They are assumed to be insignificant taking into consideration the small area - 0.05 % is the total area of the Histosols in Bulgaria. Based on data from IACS we identified that less than 50 % of their total area is connected with anthropogenic impacts. In addition, there is no transition from CL or to CL of lands with organic soils. We assume that in more than 50 % of the total area including organic soils (Histosols) there is no peat extraction or other type of impact on Histosols under annual crops and perennials.

The 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 a dataset from a full soil inventory carried out in 2010. 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 approximated using the Alexander B (1980) PTF function²⁹:

$$\rho_b = 1.72 - (0.294 * (org.C, \%)^{0.5})$$

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 SOC_s of every particular soil type under cropland and grassland categories. The average soil organic carbon stocks in cropland (0-30 cm) are 67.74 tC/ha for annual crops and 67.49 tC/ha for perennial crops.

6.4.3.1.4.1 Changes in the carbon stock in the soils of annual remaining annual and perennials remaining perennials

For estimating the CSC in annual remaining annual and perennial remaining perennial, Equation 2.25 Formulation A (Chapter 2, IPCC 2006) is used to estimate changes in soil organic C stocks in mineral soils by subtracting the C stock in the last year of an inventory period (SOC₀) from the C stock at the beginning of the inventory time period (SOC_(0-T)) and dividing by the time dependence of the stock change factors (D - 20 years). Default management factors have been applied but they were adjusted according to the Bulgarian climate conditions. The input factors have been assigned to 1. Land use factors have been incorporated when the average SOC content in soils of perennial and annual crops has been estimated.

MG f	Non-till	Reduced till	Full till
Annual	1.06	1.01	1
Perennial	1.06		

6.4.3.1.4.2 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:

$$\Delta SOC_{20} = \frac{[(SOC_0 - SOC_{0-T})]}{20} = 0.0125 \text{ tC/ha}$$

where,

SOC₀ – carbon stocks in the soils after 20 years of transition = 67.74 t C/ha,

²⁹G.TAULYA et al., 2005 Validation of pedotrasfer functions for soil bulk density estimation on a Lake Victoria Basin soilscape

SOC_{0-T} – carbon stock in the soils before the conversion = 67.49 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.

6.4.3.1.4.3 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:

$$\Delta SOC_{20} = \frac{[(SOC_0 - SOC_{0-T})]}{20} = -0.0125 \text{ tC/ha}$$

where,

SOC_0 – carbon stocks in the soils after 20 years of transition = 67.49 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 67.74 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.

Organic soils

Histosols cover less than 0.05 % of the country's territory. Most of the area with Histosols are in protected areas. However, some of the territories with organic soils follow under agricultural use. To get information on the extent of that, an intersection of the Histosols soil map with IACS data on physical blocks has been done. The area of Histosols within the CL category is 1.367 kha and stays constant throughout the reporting period. The CO₂ emissions from managed organic soils are estimated to 39.60 Gg CO₂ and are calculated according to Tier 1 of the Wetlands Supplement (2013). The emission factors used follow those provided in table 2.1 in Wetlands Supplement. Considering the negligible size of the area no LUC has been assessed and reported. CO₂ emissions from organic soils are reported in LULUCF in the remaining category, while the associated direct and indirect N₂O emissions are reported in Agricultural sector, CRF table 3.D.

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:

$$\text{The annual change of carbon stock in biomass} = A_{\text{conversion}}(L_{\text{conversion}} + \Delta C_{\text{growth}})$$

where,

$$L_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$A_{\text{conversion}}$ – area of the lands converted to annual crops, ha yr⁻¹

$L_{\text{conversion}}$ – 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 carbon stock in the living biomass after the conversion (C_{After}) is equal to 0. The biomass stock before the conversion is 6.58 t/ha for GL. 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 (1995-2015). 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 a scientific paper based on a 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 = 3.56 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 (2006 IPCC).

6.4.3.2.1.1 Changes of the carbon stock in the living biomass in 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.

$$\text{Annual change in carbon stock in biomass} = (\text{area of the converted lands for 20 years} \cdot \Delta C_{\text{growth}}) + (\text{actual annual area of conversion} \cdot L_{\text{conversion}})$$

where,

$$L_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$L_{\text{conversion}}$ – 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

To calculate the changes in the carbon stocks in the biomass the following values were used:

$$\Delta C_{\text{growth}} = 0.35 \text{ tC/ha y (calculated based on IPCC 2019)}$$

$$C_{\text{after}} = 0$$

$$C_{\text{before}} = 6.58 \text{ t C/ha calculated for for subcategory Pastures and meadows}$$

$$C_{\text{before}} = 5.24 \text{ t C/ha for subcategory Shrubs and grasslands (IPCC 2019)}$$

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 average carbon stock in grassland soils (72.77 t C/ha for Pastures and meadows and 86.96 tC/ha for Shrubs and grassland) has been calculated as described in 6.4.3.1.4.

The average annual change in the carbon stock in the soils of lands converted to annual crops ($\Delta C_{\text{LGsoils}}$), is calculated using the following equation:

$$\Delta C_{\text{LGsoil}} = \frac{[(SOC_0 - SOC_{0-T})]}{20}$$

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 = 67.74 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 86.96 t C/ha and 72.77 t C/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 ($\Delta CLG_{\text{Soils}}$), converted to perennials is calculated using the following equation:

$$\Delta C_{LG\text{soil}} = \frac{[(SOC_0 - SOC_{0-T})]}{20} =$$

Where,

$\Delta C_{LG\text{soil}}$ - annual change in carbon stock in soils in land converted to CL

SOC_0 – carbon stocks in the soils after 20 years of transition = 67.49 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 86.96 and 72.77 tC/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 N₂O emissions in grasslands converted to croplands

N₂O emissions from land-use conversions to cropland as a result of soil oxidation has been estimated based on the tier 1 approach and equations 11.1, 11.2, 11.8. (2006 IPCC Guidelines).

The ratio C/N in the mineral soils is derived based on data gathered under the soil inventory in BG (since 2005).

6.4.4 Uncertainty Assessment

The overall uncertainty in estimation of gas emissions and removals over a year for the category “Cropland” is **664%**. The trend uncertainty owed to activity data and emission factors is **169%** (Table 229).

The combined uncertainty for the sub-category “Cropland remaining cropland” is **195%** and the uncertainty in the trend of the gas emissions is **27%**.

The uncertainties for the sources “Living biomass” and “Soil” within the sub-category “Cropland remaining cropland” were determined.

The overall uncertainty over a year for the “Living biomass” is **64%**. The trend uncertainty for the same sub-category exceeded more than 100 times the estimated tendency in emissions, which was due primarily to the high uncertainty introduced by the emission factors.

The combined uncertainty for „Soils“ is **172%** and the uncertainty in the trend of the gas emissions is **15%**.

The combined uncertainty for the sub-category „Land use changed to cropland” is **12%**. The trend uncertainty in gas emissions is **79%**.

The uncertainties of gas emission estimations from the pools “Living biomass” and “Soil” for the sources “Forest land changed to cropland (annuals and perennials)”, “Grassland (permanent pasture and meadows, PPM and shrubs and grasslands, MGL) changed to cropland (annuals and perennials)” and “Other land changed to cropland (annuals and perennials)” were estimated.

The combined uncertainty for “Living biomass” is **21%**. The trend uncertainty due to activity data and emission factors is **42%**.

The combined uncertainty for „Soil“ is **17%**. The uncertainty in the estimated tendency for the gas emissions is **73%**.

Table 235 Uncertainties in the gas emissions from the IPCC category “Cropland”

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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 introduced into the trend
Cropland remaining cropland	Living biomass	growth perennial biomass	CO2	-289.69	-92.15	3	28.13	28.28	240.11	5.15	0.47	26.77
		loss perennial biomass	CO2	284.77	169.88	3	13.26	13.60	188.60	3.69	0.88	14.36
		biomass growth annuals	CO2	-83.11	-80.91	3	23.03	23.23	124.86	2.74	0.42	7.66
		conversion of cropland with perennials	CO2	72.06	79.23	3	25.00	25.18	140.70	2.86	0.41	8.32
		biomass growth perennial	CO2	-37.43	-41.15	3	28.13	28.28	47.90	1.67	0.21	2.82
		conversion of cropland with annuals	CO2	42.51	38.02	3	23.03	23.23	27.57	1.31	0.20	1.75
	Soil	C increment in annuals	CO2	-738.70	-591.76	3	187.92	187.94	437235.75	168.03	3.05	28244.55
		C increment in perennials	CO2	-168.50	-53.57	3	58.70	58.78	350.52	6.26	0.28	39.30
		conversion of perennials to annuals	CO2	-2.63	-2.69	3	329.41	329.43	27.83	1.29	0.01	1.67
		conversion of annuals to perennials	CO2	2.99	2.91	3	329.41	329.43	32.40	1.41	0.01	1.98
Land use changed to cropland	Living biomass	growth annual biomass	CO2	0.00	0.00	10	23.03	25.11	0.00	0.00	0.00	0.00
		conversion of forest land	CO2	0.00	0.00	10	32.41	33.92	0.00	0.00	0.00	0.00
		conversion of grassland (PPM)	CO2	0.00	0.00	10	79.35	79.98	0.00	0.00	0.00	0.00
		conversion of grassland (MGL)	CO2	0.00	0.00	10	50.00	50.99	0.00	0.00	0.00	0.00
		conversion of other land	CO2	0.00	0.00	10	75.00	75.66	0.00	0.00	0.00	0.00
		new biomass of perennials	CO2	-3.19	-9.35	10	28.13	29.85	2.75	0.34	0.16	0.14
		conversion of forest land	CO2	-1.46	-7.77	10	28.13	29.85	1.90	0.28	0.13	0.09
		conversion of grassland (PPM)	CO2	0.00	0.00	10	32.41	33.92	0.00	0.00	0.00	0.00
		conversion of grassland (MGL)	CO2	0.00	0.00	10	79.35	79.98	0.00	0.00	0.00	0.00
		conversion of other land	CO2	0.00	0.00	10	50.00	50.99	0.00	0.00	0.00	0.00
	Soil	conversion of forest land to annuals	CO2	0.00	0.00	10	75.00	75.66	0.00	0.00	0.00	0.00
		conversion of grassland (PPM) to annuals	CO2	0.00	0.00	10	44.74	45.84	0.00	0.00	0.00	0.00
		conversion of grassland (MGL) to annuals	CO2	29.84	154.95	10	4.00	10.77	98.45	0.78	2.66	7.70
		conversion of other land to annuals	CO2	52.27	494.56	10	0.49	10.01	866.64	0.30	8.50	72.28
		conversion of forest land to perennials	CO2	0.00	0.00	10	243.64	243.85	0.00	0.00	0.00	0.00
		conversion of grassland (PPM) to perennials	CO2	0.00	0.00	10	49.05	50.06	0.00	0.00	0.00	0.00
		conversion of grassland (MGL) to perennials	CO2	2.42	7.09	10	16.28	19.11	0.65	0.15	0.12	0.04
		conversion of other land to perennials	CO2	4.09	21.74	10	4.31	10.89	1.98	0.12	0.37	0.15

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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 introduced into the trend
		conversion of grasslands to croplands	N ₂ O	0.00	0.00	10	247.64	247.84	0.00	0.00	0.00	0.00
		Total emissions		-823.21	168.20	Overall uncertainty in the year (%)			664.29	Trend uncertainty (%)		169

6.4.5 Data Verification Category-Specific Qa/Qc And Verification, If Applicable

See 6.1.6. QA/QC VERIFICATION

6.4.6 Category-Specific Recalculations

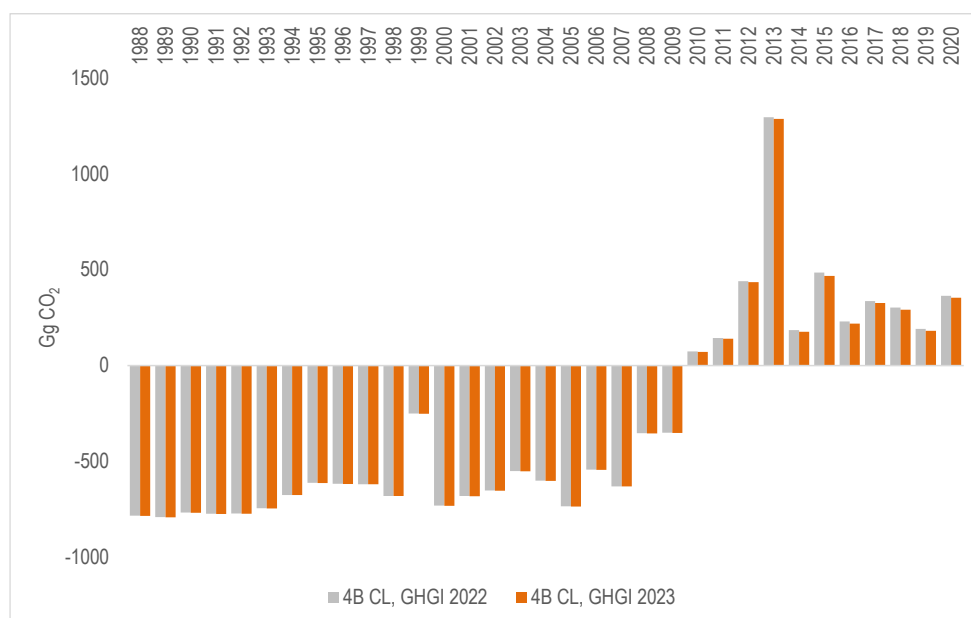


Figure 134 Recalculations in Cropland category

The recalculations in CL category are related mainly to the update of the GWP of the N₂O emissions. (See 6.1.7 RECALCULATIONS).

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. In addition, we plan to update the information on carbon stock in agricultural soils in order to increase the accuracy in reporting emissions and removals associated with LUC to and from agricultural lands (e.g Grasslands).

6.5 Grassland (4.C)

6.5.1 Description Of The Category

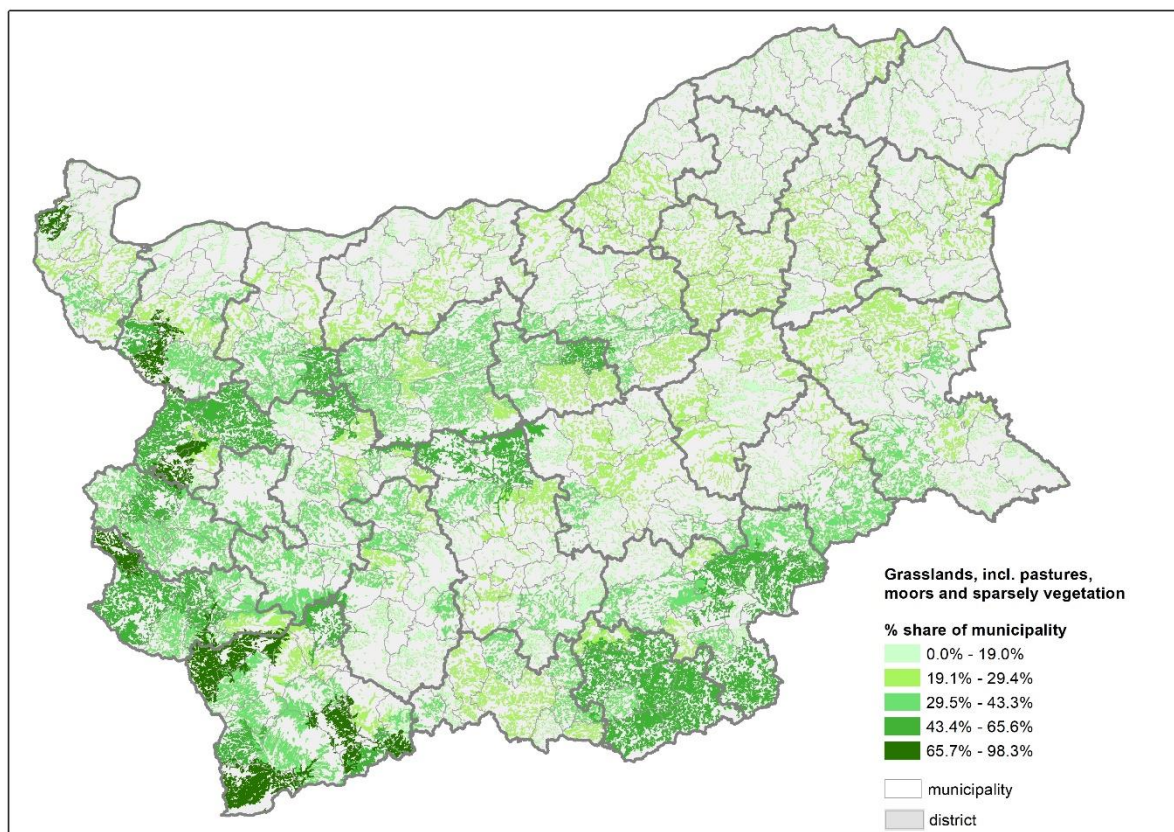


Figure 135 Share of municipality area occupied by Grasslands. The map is elaborated based on CLC, 2018.

Grassland in Bulgaria cover an area of 2553 kha in 2021, which represents 23% of the country's territory. The total grassland area is 28% higher, comparing to the base year, and varies from 1995 kha in 1988 to 2553 kha in 2021. The figure below presents data on the area of Grasslands for the reporting period.

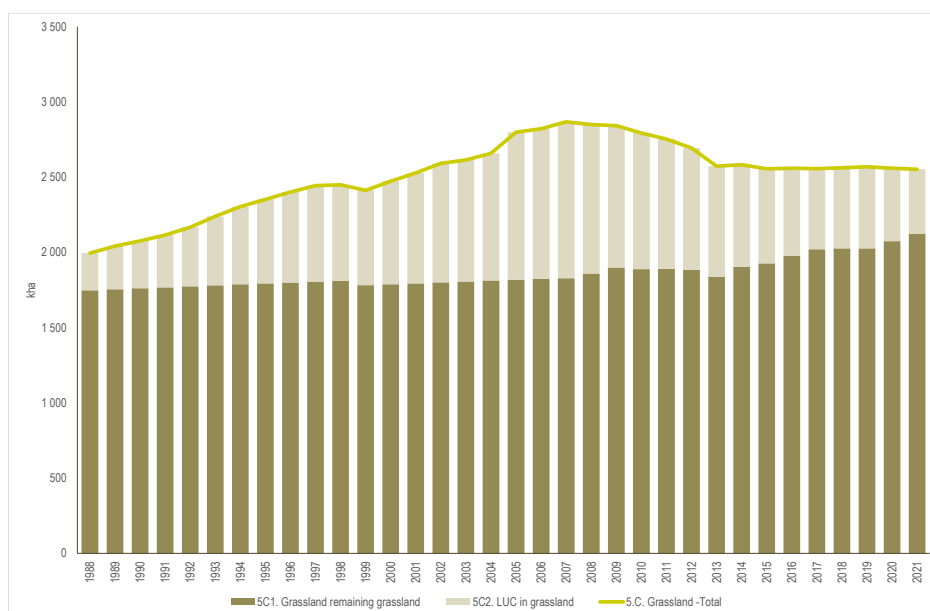


Figure 136 Trends in Grassland category 1988-2021

The Grassland category includes 1397kha of pastures and meadows, which represent 54.72% of these lands, and the other 45.28% of the category or 1156 kha represent shrubs and grasslands. Over the reporting period there are fluctuations in the area of GL, presented in the figure below, which are in the opposite direction of the changes observed in the CL area.

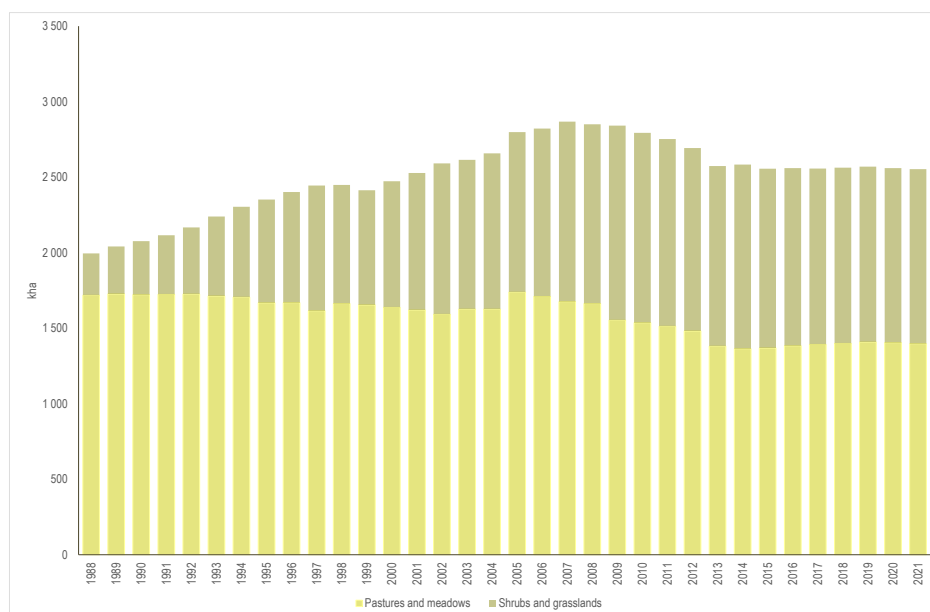


Figure 137 Pastures and meadows, and shrubs and grasslands distribution under GL category

The evaluation of the emissions/removals from the Grassland category is based on estimates of the changes in the carbon stocks in living biomass and soil.

The assumption in Tier 1 (according to 2006 IPCC 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 236 Emissions (+)/removals of CO₂ in Grassland Remaining Grassland and Lands Converted to Grassland (Gg CO₂ equivalent) (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. Cropland in Grassland	4.C.2.5 OL converted to GL	N ₂ O emissions
1988	-934.59	195.41	-1158.11	-709.48	-448.63	28.10
1989	-990.22	198.20	-1216.55	-756.60	-459.95	28.13
1990	-913.12	200.87	-1142.15	-670.89	-471.27	28.16
1991	-1015.54	203.14	-1246.87	-764.21	-482.66	28.19
1992	-1202.59	205.21	-1436.03	-941.96	-494.07	28.22
1993	-1507.17	207.26	-1742.67	-1237.34	-505.33	28.24
1994	-1522.53	208.42	-1759.21	-1242.51	-516.71	28.26
1995	-1450.92	209.26	-1688.42	-1164.24	-524.18	28.24

year	4.C Grassland Total	4.C.1 Grassland remaining Grassland	4.C.2 LUC in Grassland	4.C.2.2. Cropland in Grassland	4.C.2.5 OL converted to GL	N ₂ O emissions
1996	-1539.95	208.62	-1776.79	-1241.81	-534.98	28.23
1997	-1555.89	208.32	-1792.37	-1250.44	-541.93	28.17
1998	-1213.38	205.17	-1446.70	-895.08	-551.62	28.14
1999	-1171.61	203.24	-1402.97	-841.62	-561.35	28.12
2000	-1775.94	202.24	-2006.26	-1527.18	-479.08	28.08
2001	-1802.76	200.48	-2031.26	-1561.37	-469.89	28.02
2002	-1989.05	198.23	-2215.22	-1754.45	-460.77	27.94
2003	-1662.90	193.88	-1884.67	-1433.34	-451.33	27.89
2004	-1916.94	190.50	-2135.28	-1693.18	-442.10	27.84
2005	-3057.31	185.90	-3271.09	-2838.31	-432.78	27.88
2006	-2043.31	183.08	-2254.29	-1830.65	-423.64	27.90
2007	-2332.14	179.91	-2539.93	-2125.41	-414.52	27.89
2008	-1817.82	172.51	-2018.17	-1624.58	-393.59	27.84
2009	-1743.43	166.67	-1937.81	-1564.09	-373.71	27.70
2010	-1685.48	157.97	-1871.00	-1517.97	-353.03	27.54
2011	-1620.92	149.79	-1798.08	-1463.26	-334.82	27.37
2012	-1534.16	141.92	-1703.25	-1389.18	-314.06	27.17
2013	-1414.25	135.31	-1576.45	-1278.52	-297.94	26.89
2014	-1420.13	128.45	-1575.19	-1296.55	-278.64	26.61
2015	-1269.31	121.65	-1417.31	-1118.91	-298.40	26.36
2016	-1237.58	115.56	-1379.27	-1075.64	-303.62	26.12
2017	-1073.33	110.91	-1210.18	-963.43	-246.75	25.93
2018	-1187.86	105.79	-1319.36	-1002.85	-316.51	25.71
2019	-1283.82	100.54	-1409.87	-999.18	-410.69	25.51
2020	-1179.51	96.21	-1301.04	-856.28	-444.75	25.31
2021	-957.86	92.63	-1075.62	-749.23	-326.38	25.13

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 data sources and the approach used for deriving the area information for sub-categories 4.C.1 and 4.C.2 are described in 6.4.2. The total of the strata Pastures and meadows (PM) comes from NSI and BANCİK and covers the whole time series. The information for the Shrubs and grasslands (ShG) is derived from BANCİK (since 1998), where activity data for low productive lands (secondary lawns) is reported. These lands constitute around 47 % of the total Shrubs and grasslands subcategory. The other 53% represent Shrublands. The information on Shrublands is checked with CLC data and orthophoto images to confirm this share.

As regards reporting of LUCs, there are no LUCs from forests to GL. Any conversions and re-conversions from wetlands and settlements to CL are considered as unlikely since settlements according to the applied definition in the country encompass the artificial surfaces. Other lands constitute from bare lands and rocks and it was assumed that a possible conversion is between OL and Shrubs and grasslands. The annual LUCs between CL and GL have been calculated based on the changes in the totals of these categories. The variations in the net changes in the area of CL and GL follow the opposite directions throughout the time series (Figure 133)

LUC between the Pastures and meadows and Shrubs and grasslands is calculated. It was defined that 3% of the territory covered by each subcategory under GL (e.g. PM, ShG) is the annual change between these two subcategories. This assumption has been confirmed by data from BANCİK statistics but it should be further discussed with the data providers.

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

Mineral soils

Pastures and meadows converted to Shrubs and grasslands

The average SOC of lands under category GL has been estimated based on empirical data and followed the approach described in 6.4.3.1.4.

The average annual change in the carbon stock in mineral soils of Pastures and meadows converted to Shrubs and grasslands (ΔSOC_{20}) has been calculated using the equation:

$$\Delta SOC_{20} = \frac{[(SOC_0 - SOC_{0-T})]}{20} = -1.409 \text{ tC/ha}$$

$$\Delta SOC_{20} = [(SOC_0 - SOC_{0-T})]/20 = -0.7095$$

where,

SOC_0 – carbon stocks in the soils after 20 years of transition = 72.77 t C/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 86.96 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.

Shrubs and grasslands converted to Pastures and meadows

The average annual change in the carbon stock in mineral soils of Pastures and meadows converted to Shrubs and grasslands (ΔSOC_{20}) has been calculated using the equation:

$$\Delta SOC_{20} = \frac{[(SOC_0 - SOC_{0-T})]}{20} = 1.409 \text{ tC/ha}$$

$$\Delta SOC_{20} = [(SOC_0 - SOC_{0-T})]/20 = 0.7095$$

where,

SOC_0 – carbon stocks in the soils after 20 years of transition = 86.96 tC/ha,

SOC_{0-T} – carbon stock in the soils before the conversion = 72.77 tC/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.

Organic soils

Histosols covers less than 0.05 % of the country's territory. Most of the area with Histosols are in protected areas. However, some of the territories with organic soils follow under agricultural use. To get information on the extent of that, an intersection of the Histosols soil map with IACS data on physical blocks have been done. The area of Histosols within the GL category is 1.745 kha and stays constant throughout the reporting period. The CO₂ emissions from managed organic soils in GL are estimated

to 41.02 Gg CO₂ and are calculated according to Tier 1 of the Wetlands Supplement (2013). The emission factors used follow those provided in table 2.1 in Wetlands Supplement. Considering the negligible size of the area no LUC has been assessed and reported. CO₂ emissions from organic soils are reported in LULUCF in remaining category, while the associated direct and indirect N₂O emissions are reported in Agricultural sector, CRF table 3.D.

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 3.56 tC/ha (Section 6.4.3.2).

The average value for the growth rate in the living biomass of subcategory Pastures and meadows has been estimated by using the equation below.

$$B_{total} = [(B_{cut} \cdot 0.47) + (B_{peak\ aboveground} \cdot 0.47)] \cdot (1 + R)$$

where:

B_{total} – total biomass (aboveground and belowground), tonnes d.m.

B_{cut} – yield biomass, tonnes d.m = 2.09

$B_{peak\ aboveground}$ – 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 Guidelines)

The source of information for B_{cut} for subcategory Pastures and meadows is the National Statistical Yearbook and Agrostistics, where the information for the hay yield is published.

Like this, the B_{total} for Pastures and meadows has a value of 6.58 tC/ha.

The average value of growth rate in biomass of subcategory Shrubs and grassland is estimated to 5.24 tC/ha based on data from MediNet project.

To calculate the annual carbon stock changes in the living biomass of lands converted to grassland the following equation has been used (IPCC 2006):

$$\text{The annual change of carbon stock in biomass} = A_{conversion}(L_{conversion} + \Delta C_{growth})$$

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} = 6.58 tC/ha for subcategory Pastures and meadows (applied only for annual LUC)

$\Delta C_{growth} = 5.24$ tC/ha for subcategory Shrubs and grasslands

$C_{after} = 0$

$C_{before} = 3.56$ tC/ha, for annual crops (calculated for Bulgaria)

$C_{before} = 4.42$ tC/ha for perennials (2006 IPCC Guidelines)

$C_{before} = 0$ tC/ha for Other lands (calculated based on research data on case study area)

6.5.3.2.2 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 ($\Delta C_{LGsoils}$), 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 = 72.77 tC/ha for Pastures and meadows and 86.96 t C/ha for Shrubs and grasslands,

SOC_{0-T} – carbon stock in the soils before the conversion = 67.74 tC/ha for annual crops, 67.49 tC/ha for perennials and 51.8 t C/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 the annual change in carbon stock in soils by the area of the converted territory.

6.5.4 Uncertainty Assessment

The overall uncertainty in estimation of gas emissions and removals of over a year for the category “Grassland” is **64%**. The trend uncertainty due to activity data and emission factors amounts to **53%** (Table 233).

A larger portion of this uncertainty is accounted for by the sub-category “Grassland remaining grassland”. Its combined uncertainty is estimated to be **157%** and the uncertainty in the trend of the gas emissions is **46%**.

The uncertainties for the two principal pools “Living biomass” and “Soil” within the sub-category “Grassland remaining grassland” were determined.

The overall uncertainty over a year for the “Living biomass” is **3279%**. The trend uncertainty due to activity data and emission factors amounts to **471%**.

The combined uncertainty for „Soil“ is **35%** and the uncertainty in the trend of the gas emissions is **12 %**.

The combined uncertainty for the sub-category „Land use changed to grassland” is **28%**. The trend uncertainty in gas emissions is **36%**.

The uncertainties of gas emission estimations from “Living biomass” and “Soil” for the sources “Forest land changed to grassland (permanent pasture and meadows, PPM and shrubs and grasslands, MGL)”, “Cropland (annuals and perennials) changed to grassland”, “Other land changed to grassland” were estimated.

The combined uncertainty for “Living biomass” is **51%**. The trend uncertainty due to activity data and emission factors amounts to **12%**.

The combined uncertainty for „Soil“ is **58%**. The uncertainty in the estimated tendency for the gas emissions is **12%**.

Table 237 Uncertainties in the gas emissions from the IPCC category “Grassland”

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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
Grassland remaining Grassland	Living biomass	growth PPM biomass	CO2	-124.37	-101.17	5	79.35	79.51	160.08	1.63	0.73	3.21
		loss MGL biomass	CO2	99.00	80.53	5	50.00	50.25	40.51	0.82	0.58	1.02
		growth MGL biomass	CO2	-16.01	-66.62	5	50.00	50.25	27.73	2.88	0.48	8.52
		loss PPM biomass	CO2	20.12	83.70	5	79.35	79.51	109.56	5.74	0.61	33.34
	Soil	conversion of MGL to PPM	CO2	263.76	235.87	5	1.54	5.23	3.77	0.10	1.71	2.93
		conversion of PPM to MGL	CO2	-88.09	-180.69	5	1.54	5.23	2.21	0.19	1.31	1.75
		conversion of PPM to MGL	N2O	28.10	25.13	5	91.94	92.07	13.24	0.64	0.18	0.45
Land use changed to grassland	Living biomass	new biomass of PPM	CO2	-945.76	0.00	10	79.35	79.98	0.00	49.65	0.00	2465.10
		conversion of forest land	CO2	0.00	0.00	10	32.41	33.92	0.00	0.00	0.00	0.00
		conversion of annual cropland	CO2	460.31	0.00	10	23.03	25.11	0.00	7.12	0.00	50.63
		conversion of perennial cropland	CO2	63.50	0.00	10	25.00	26.93	0.00	1.06	0.00	1.13
		conversion of other land	CO2	0.00	0.00	10	75.00	75.66	0.00	0.00	0.00	0.00
		new biomass of MGL	CO2	-226.35	-48.00	10	50.00	50.99	14.82	5.09	0.70	26.37
		conversion of forest land	CO2	0.00	0.00	10	32.41	33.92	0.00	0.00	0.00	0.00
		conversion of annual cropland	CO2	74.46	0.00	10	23.03	25.11	0.00	1.15	0.00	1.31
		conversion of perennial cropland	CO2	10.27	0.00	10	25.00	26.93	0.00	0.17	0.00	0.03
		conversion of other land	CO2	0.00	0.00	10	75.00	75.66	0.00	0.00	0.00	0.00
	Soil	conversion of forest land to PPM	CO2	0.00	0.00	10	29.84					
		conversion of annual cropland to PPM	CO2	0.00	0.00	10	24.20	26.19	0.00	0.00	0.00	0.00
		conversion of perennial cropland to PPM	CO2	-138.81	-194.11	10	4.00	10.77	10.81	0.42	2.81	8.10
		conversion of other land to PPM	CO2	-16.19	-19.86	10	16.28	19.11	0.36	0.16	0.29	0.11
		conversion of forest land to MGL	CO2	0.00	0.00	10	185.30	185.57	0.00	0.00	0.00	0.00
		conversion of annual cropland to MGL	CO2	0.00	0.00	10	10.49	14.49	0.00	0.00	0.00	0.00
		conversion of perennial cropland to MGL	CO2	-85.82	-89.49	10	0.49	10.01	1.99	0.02	1.30	1.68
		conversion of other land to MGL	CO2	-9.66	-13.33	10	4.31	10.89	0.05	0.03	0.19	0.04
		Total emissions		-975.61	-635.78	Overall uncertainty in the year (%)			63.77	Trend uncertainty (%)		53

6.5.5 Data Verification Category-Specific Qa/Qc And Verification, If Applicable

See 6.1.6 QA/QC VERIFICATION

6.5.6 Category-Specific Recalculations

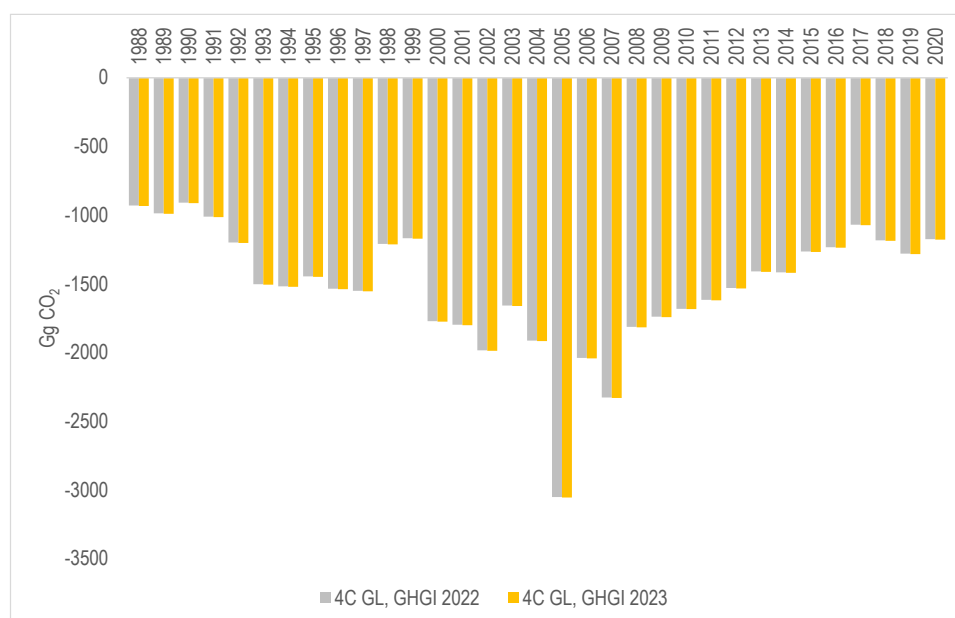


Figure 138 Recalculations in the Grassland category

The recalculations in CL category are related to the update of the GWP potential of the N₂O emissions (See 6.1.7 RECALCULATIONS).

6.5.7 Category-Specific Planned Improvements Including Those In Response To The Review Process

For the Grassland category it is planned to continue working on the land-use classification and representation across the time series. In addition, we plan to update the information on carbon stock in agricultural soils in order to increase the accuracy in reporting emissions and removals associated with LUC to and from agricultural lands (e.g Grasslands).

6.6 Wetlands (4.D)

6.6.1 Description Of The Category

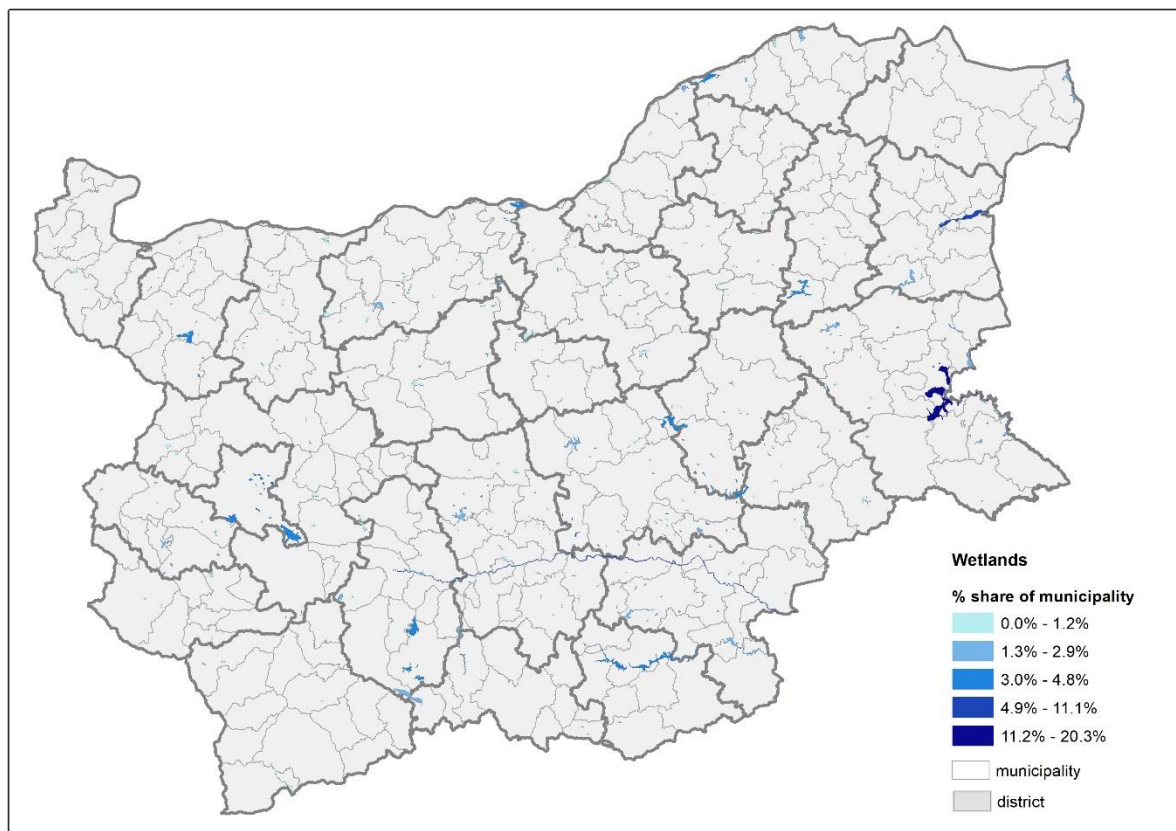


Figure 139 Share of municipality area occupied by Wetlands. The map is elaborated based on CLC, 2020.

In 2021, Wetlands in Bulgaria cover an area of 232 kha which represents 2.09 % of the country's territory. The total wetland area is 8.85 % higher, comparing to the base year, and varies from 213.50 kha in 1988 to 232 kha in 2021. The figure below presents data on the area of Wetlands for the reporting period.

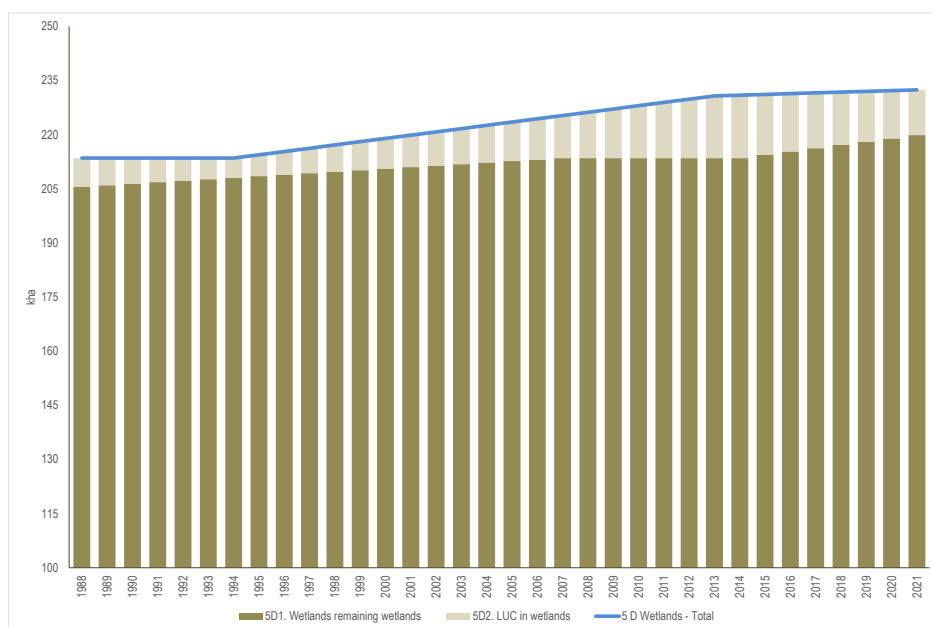


Figure 140 Trends in Wetland category 1988-2021

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 are equal to 0.

It was assumed that during the period of inventory the conversion to wetlands comes out from shrubs and grasslands and other lands. The emissions of carbon dioxide from the wetlands are presented in the table below.

Table 238 Emissions (+)/removals of CO₂ in Wetlands Remaining Wetlands and Lands Converted to Wetlands (Gg CO₂ equivalent)

year	5.D Wetlands Total	5.D.2.2 Grassland converted to Wetlands	5.D.2.5 Other land in wetlands	5.D.2.2 GL in WL 2 (N ₂ O converted into CO ₂ eq)	5.D.2.5 OL in WL 2 (N ₂ O converted into CO ₂ eq)
1988	116.34	100.98	15.36	10.76	1.16
1989	110.22	95.67	14.55	10.19	1.10
1990	104.10	90.35	13.74	9.63	1.04
1991	97.97	85.04	12.93	9.06	0.98
1992	91.85	79.72	12.13	8.49	0.92
1993	85.73	74.41	11.32	7.93	0.86
1994	79.60	69.09	10.51	7.36	0.80
1995	102.13	91.23	10.90	8.12	0.83
1996	109.85	98.64	11.21	8.89	0.85
1997	114.96	102.53	12.43	9.51	0.94
1998	121.77	108.06	13.71	10.11	1.04
1999	128.56	113.53	15.03	10.70	1.14
2000	135.95	119.79	16.17	11.33	1.22
2001	143.33	126.16	17.17	11.98	1.30
2002	150.83	132.81	18.02	12.65	1.36
2003	158.02	139.14	18.88	13.33	1.43
2004	165.40	145.73	19.68	14.01	1.49
2005	172.77	152.35	20.42	14.71	1.55
2006	180.23	159.13	21.10	15.42	1.60

year	5.D Wetlands Total	5.D.2.2 Grassland converted to Wetlands	5.D.2.5 Other land in wetlands	5.D.2.2 GL in WL 2 (N ₂ O converted into CO ₂ eq)	5.D.2.5 OL in WL 2 (N ₂ O converted into CO ₂ eq)
2007	187.81	166.12	21.69	16.14	1.64
2008	201.29	178.20	23.09	17.43	1.75
2009	215.08	190.69	24.39	18.74	1.85
2010	228.60	202.90	25.71	20.04	1.95
2011	242.17	215.15	27.02	21.35	2.05
2012	255.69	227.33	28.36	22.65	2.15
2013	272.07	243.43	28.64	24.14	2.17
2014	261.89	232.97	28.92	24.45	2.19
2015	251.40	223.40	28.00	23.43	2.12
2016	240.88	213.73	27.16	22.40	2.06
2017	230.97	205.57	25.40	21.53	1.92
2018	221.12	197.53	23.59	20.67	1.79
2019	211.31	189.59	21.72	19.82	1.64
2020	201.37	181.34	20.03	18.94	1.52
2021	191.34	172.87	18.47	18.04	1.40

Note: The reporting of the subcategory "wetland remaining wetland" follows Tier 1 – no changes in carbon stocks.

6.6.2 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 obtained 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 orthophoto images for the years 2010 - 2020. 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 orthophoto images. 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 orthophoto images has been considered 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 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 grassland 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). 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 the designation of the 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 in 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.

6.6.3 Methodology

6.6.3.1 Lands converted to wetlands (4.D.2)

6.6.3.1.1 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.

$$\text{The annual change in the carbon stock} = \text{annual area of lands converted to wetlands} \cdot (B_{\text{after}} - B_{\text{before}}) \cdot CF$$

where,

B_{before} – living biomass stock in lands before the conversion – 5.24 tC/ha for Shrubs and grasslands and 0 tC/ha for other land.

B_{after} – living biomass immediately after the conversion, t d.m./ha (for Tier 1 = 0),

CF – carbon fraction in the dry matter (d.m.) (under Tier 1 = 0.5 t C/t d.m.).

6.6.3.1.2 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:

$$\Delta C_{wl} = A \cdot \frac{SOC_{\text{after}} - SOC_{\text{before}}}{20}$$

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, 86.96 tC/ha; for soils of shrubs and grasslands and 51.8 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.

6.6.3.1.3 N₂O 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 IPCC Guidelines), based on equations 11.1, 11.2, 11.8.

The ratio C/N in the mineral soils in OL is default from 2006 IPCC Guidelines – 15, whereas for shrubs and grasslands is derived based on data from soil survey in BG.

6.6.4 Uncertainty Assessment

The overall uncertainty in estimation of gas emissions and removals over a year for the category “Wetlands”, which is equivalent to the sub-category “Land use changed to wetlands”, is **90 %**. The trend uncertainty due to activity data and emission factors is **44%** (Table 236).

The uncertainties of gas emission estimations from the pools “Living biomass” and “Soil” for the sources “Cropland changed to wetlands”, “Grassland changed to wetlands” and “Other land changed to wetlands” were estimated. The combined uncertainty for “Living biomass” is **51 %**. The combined uncertainty for „Soil“, which is the primary gas emission and uncertainty source, is **78 %**. The trend uncertainty due to activity data and emission factors amounts to **38 %**.

Table 239 Uncertainties in the gas emissions from the IPCC category “Wetlands”

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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
Land use changed to wetlands	Living biomass	conversion of annual cropland	CO2	0.00	0.00	10.00	23.03	25.11	0.00	0.00	0.00	0.00
		conversion of perennial cropland	CO2	0.00	0.00	10.00	25.00	26.93	0.00	0.00	0.00	0.00
		conversion of PPM	CO2	0.00	0.00	10.00	79.35	79.98	0.00	0.00	0.00	0.00
		conversion of MGL	CO2	0.00	3.53	10.00	50.00	50.99	60.86	10.25	2.90	113.56
		conversion of other land	CO2	0.00	0.00	10.00	75.00	75.66	0.00	0.00	0.00	0.00
	Soil	conversion of annual cropland	CO2	0.00	0.00	10.00	0.04	10.00	0.00	0.00	0.00	0.00
		conversion of perennial cropland	CO2	0.00	0.00	10.00	1.24	10.08	0.00	0.00	0.00	0.00
		conversion of PPM	CO2	0.00	0.00	10.00	0.27	10.00	0.00	0.00	0.00	0.00
		conversion of MGL	CO2	10.76	18.04	10.00	108.03	108.49	7178.32	22.82	14.81	740.16
		conversion of MGL	N2O	-23.22	-38.94	10.00	0.10	10.00	284.22	0.05	31.96	1021.35
		conversion of other land	CO2	1.16	1.40	10.00	131.51	131.89	63.74	1.23	1.15	2.82
		conversion of other land	N2O	-5.93	-7.13	10.00	75.00	75.66	545.54	3.55	5.85	46.85
	Total emissions			-17.23	-23.10	Overall uncertainty in the year (%)			90.18	Trend uncertainty (%)		43.87

6.6.5 Data Verification

See 6.1.6 QA/QC VERIFICATION

6.6.6 Category-Specific Recalculations

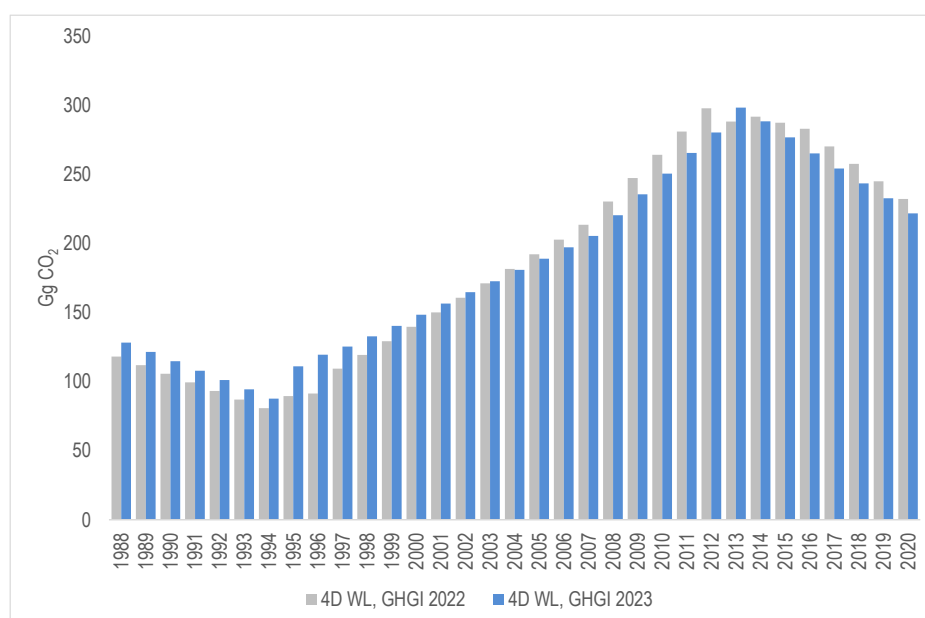


Figure 141 Recalculations in Wetlands category

The changes in WL category are as a result of the refinement in the area representation – the WL area between 1994 and 2013 has been interpolated which resulted in a change in WL total as well as LUC to WL. Previously the interpolation was made between 1996 and 2012. This change has resulted in small changes in lands converted to WL and more specifically to GL converted to WL. In addition N₂O emissions from soils have been recalculated in relation to the update of the GWP of N₂O (AR5).

6.6.7 Category-Specific Planned Improvements Including Those In Response To The Review Process

There are no planned improvements.

6.7 Settlements (4.E)

6.7.1 Description Of The Category

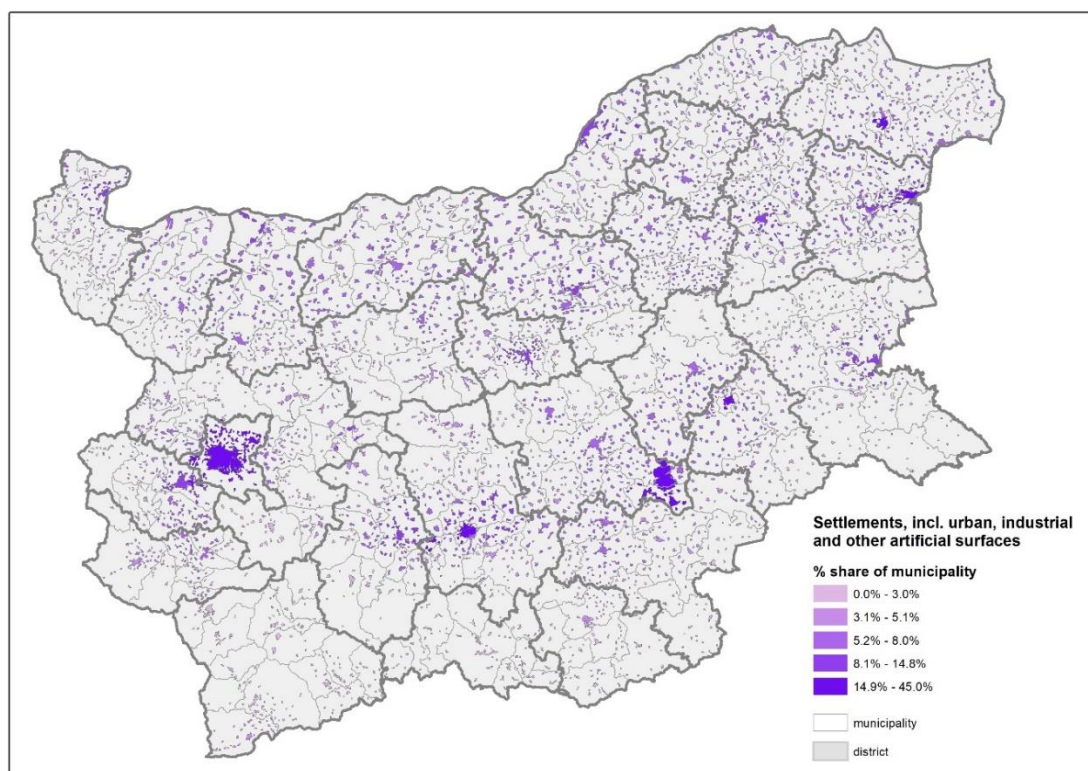


Figure 142 Share of municipality area occupied by Settlements. The map is elaborated based on CLC, 2018.

Settlements cover an area of 538 kha in 2021, which represents 4.84 % of the total territory of the country. The total settlements area is 16.58 % higher, comparing to the base year, and varies from 462 kha in 1988 to 538 kha in 2021. The area of settlements has increased gradually over the years. The figure below presents data on the area of Settlements for the reporting period.

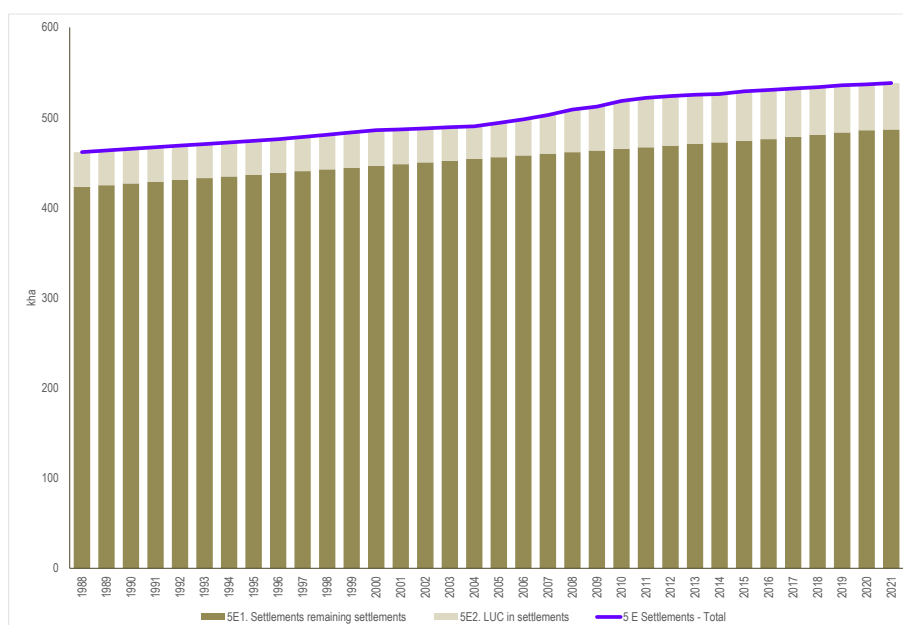


Figure 143 Trends in Settlements category 1988-2020

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 240 Emissions (+)/removals of CO₂ in Settlements remaining settlements and Lands converted to settlements (Gg CO₂ 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	433.43	NE	433.43	27.60	243.88	161.50	0.45
1989	431.55	NE	431.55	27.60	243.05	159.99	0.90
1990	425.41	NE	425.41	22.79	242.49	158.77	1.36
1991	442.91	NE	442.91	44.40	240.23	156.51	1.78
1992	460.99	NE	460.99	67.60	237.17	154.06	2.17
1993	419.80	NE	419.80	24.76	237.51	154.94	2.60
1994	424.59	NE	424.59	31.78	235.64	154.15	3.01
1995	406.75	NE	406.75	13.52	235.11	154.68	3.44
1996	405.35	NE	405.35	12.88	233.80	154.81	3.86
1997	422.50	NE	422.50	12.47	241.80	163.80	4.43
1998	430.53	NE	430.53	14.21	244.49	166.84	4.99
1999	457.59	NE	457.59	37.73	246.15	168.19	5.52
2000	460.22	NE	460.22	34.44	248.15	171.59	6.04
2001	403.69	NE	403.69	15.20	229.62	152.28	6.58
2002	425.61	NE	425.61	42.02	226.35	150.12	7.12
2003	408.38	NE	408.38	30.89	222.50	147.34	7.65
2004	399.64	NE	399.64	32.89	216.03	142.53	8.19
2005	486.81	NE	486.81	62.46	248.74	166.88	8.73
2006	500.21	NE	500.21	53.87	262.30	174.77	9.26
2007	578.26	NE	578.26	92.20	286.13	190.12	9.80
2008	773.18	NE	773.18	238.39	314.96	209.95	9.87
2009	565.75	NE	565.75	48.54	306.23	201.03	9.96
2010	714.49	NE	714.49	111.11	356.10	237.25	10.04
2011	636.55	NE	636.55	56.54	344.60	225.25	10.16
2012	645.52	NE	645.52	89.04	331.82	214.23	10.43
2013	697.38	NE	697.38	158.97	321.49	206.25	10.67
2014	595.53	NE	595.53	72.36	312.63	199.61	10.93
2015	760.25	NE	760.25	207.98	329.23	211.88	11.17
2016	702.39	NE	702.39	174.68	315.94	200.34	11.42
2017	697.86	NE	697.86	186.01	307.34	192.99	11.52
2018	586.99	NE	586.99	83.02	303.28	189.06	11.63
2019	736.82	NE	736.82	239.53	299.87	185.64	11.78
2020	586.45	NE	586.45	115.80	285.37	173.37	11.92
2021	564.36	NE	564.36	83.56	291.11	177.64	12.05

Table 241 Total N₂O emissions from N mineralization associated with loss of soil organic matter in Gg CO₂ 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	42.23	0.93	25.32	15.94	0.04
1989	42.00	0.93	25.24	15.75	0.07
1990	41.78	0.92	25.17	15.59	0.10
1991	41.53	0.97	25.03	15.40	0.14
1992	41.24	1.08	24.80	15.19	0.17
1993	41.04	1.07	24.69	15.09	0.20
1994	40.84	1.08	24.53	15.00	0.23
1995	40.68	1.03	24.42	14.96	0.26
1996	40.52	0.98	24.30	14.95	0.30
1997	41.15	0.94	24.60	15.27	0.34
1998	41.76	0.90	24.90	15.59	0.38
1999	42.33	0.92	25.15	15.84	0.42
2000	42.92	0.93	25.38	16.14	0.46
2001	41.70	0.89	24.65	15.65	0.51
2002	40.80	0.93	24.08	15.25	0.55
2003	39.96	0.93	23.57	14.88	0.59
2004	38.99	0.93	22.97	14.46	0.63
2005	40.93	1.01	24.16	15.09	0.67
2006	43.05	1.06	25.49	15.79	0.71
2007	46.14	1.21	27.37	16.81	0.75
2008	50.65	1.70	29.85	18.34	0.76
2009	52.35	1.72	30.86	19.01	0.76
2010	57.21	1.89	33.79	20.76	0.77
2011	59.10	1.86	34.97	21.48	0.78
2012	59.31	1.85	35.10	21.56	0.80
2013	58.81	2.12	34.62	21.25	0.82
2014	57.75	2.17	33.95	20.79	0.84
2015	58.64	2.56	34.32	20.91	0.86
2016	58.20	2.86	33.92	20.55	0.88
2017	56.92	3.18	33.04	19.82	0.88
2018	55.49	3.06	32.34	19.20	0.89
2019	54.61	3.19	31.81	18.71	0.90
2020	52.74	3.09	30.83	17.91	0.91
2021	53.06	2.98	31.09	18.06	0.92

6.7.2 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 orthophoto images for the year 2014 - 2020. In order to ensure the time series consistency interpolation and extrapolation have been applied. The total settlements area according to the balance from the orthophoto images 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 territory of the settlements is because of using different methodologies 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 or GL. 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 2020. 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 2020. 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 2020, 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.

6.7.3 Methodology

6.7.3.1 Land use change to settlements (4.E.2.)

6.7.3.1.1 Forests converted to settlements

The methodology and the data for the forests are presented in Chapter 6.2.3. 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 fomic layers) and soil C stock (including the losses in litter). The converted forest area to settlements ranges between 1-2 kha.

6.7.3.1.1.1 Changes in the carbon stock in living biomass of forests converted to settlements

For estimating biomass loss associated with deforestation, data from the forest inventory 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 tC/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 242 Living biomass stocks which are used to calculate the emissions associated with forest loss to settlements

		1990	1995	2000	2005	2010	2015-2019
Weighted mean tree biomass stocks	tC/ha	45.47	50.89	55.19	57.10	62.71	65.86

Estimates for living biomass in settlements are based on the results of a scientific study ³⁰ carried out in Bulgaria on mapping and assessment of ecosystem services in urban areas (Project TunesinUrb,

³⁰ 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

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, and urban green areas. Based on the biomass data of trees (Zhiyanski et al.(2015a))³¹, shrubs (Nowak et al. (2002))³² and ground vegetation ((Zhiyanski et al. 2013))³³ in this study an average biomass per ha settlement area was calculated (see table below) using the relative share of each urban subsystem. The average share of green spaces in the SM areas is estimated to be 3% (based on CLC data classes 1.4.1, 1.4.2). Thus, the change in carbon stock of biomass is estimated only for 3% of the observed LUC.

Table 243 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
scattered 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
trees and shrubs				0.68
ground veg.	2.0	Zhiyanski et al. (2013)	1	2.00

6.7.3.1.1.2 Changes in carbon stock in dead organic matter of forests converted to settlements

The calculation of the emissions from the litter pool (humic and fomic 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 fomic) in forests (10.22 t C/ha). The estimation of changes in the litter pool is done based on annual change from FL to WL, because 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 tC/ha.

For estimating changes in DW stock due to deforestation activity average carbon stock in DW has been used. It has been estimated based on the approach described in 6.3.3.1.2.

Table 244 Dead wood stocks used for estimating the changes in DW pool after deforestation

		1990	1995	2000	2005	2010	2015 - 2021
DW stock	tC/ha	3.24	3.24	3.60	4.01	4.31	4.58

6.7.3.1.1.3 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 (61.86 tC/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 30 cm depth.

³¹ 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

³² Nowak, D.J., Crane, D.E., 2002. Carbon storage and sequestration by urban trees in the USA. Environmental Pollution 116 (3), 381-389.

³³ 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

6.7.3.1.2 Cropland converted to settlements

6.7.3.1.2.1 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 (3.56 tC/ha) and perennials (4.42 tC/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 238

6.7.3.1.2.2 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 (67.74 tC/ha) and perennials (67.49 tC/ha), and values of the carbon stock in the soil of the settlements – 19.70 tC/ha.

6.7.3.1.3 Grassland converted to settlements

6.7.3.1.3.1 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 grasslands determined for Bulgaria (6.58 tC/ha for Pastures and meadows and 5.2 tC/ha for Shrubs and grasslands) and the annual growth rates of the carbon stock in the biomass of the settlements.

6.7.3.1.3.2 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 (72.77 for pastures and meadows and 86.96 tC/ha for shrubs and grasslands).

6.7.3.1.4 Other land converted to settlements

6.7.3.1.4.1 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 (0 tC/ha) and the annual growth rates of the carbon stock in the biomass of the settlements.

6.7.3.1.4.2 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 (51.8 tC/ha).

6.7.3.1.5 N₂O 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 IPCC Guidelines), based on equations 11.1, 11.2, 11.8.

The ratio C/N used in the estimation for the mineral soils of FL and OL is the default value from 2006 IPCC Guidelines – 15. The C/N ratio for CL and GL is calculated based on data from soil survey in BG (since 2005).

6.7.4 Uncertainty Assessment

The category “Settlements” is represented only by the sub-category “Land use changed to settlements”. Its overall uncertainty in estimation of gas emissions and removals over a year is **10%**. The trend uncertainty due to activity data and emission factors is **10%** (Table 243).

The uncertainties of gas emission estimations from the pools “Living biomass”, “Dead wood”, “Litter” and “Soil” for the sources “Forest land changed to settlements”, “Cropland changed to settlements”, “Grassland changed to settlements” and “Other land changed to settlements” were estimated.

The combined uncertainty for “Living biomass” is **20%**, while trend uncertainty amounts to **22%**. The overall uncertainty over a year for „Dead wood“ is **13%**. The trend uncertainty due to activity data and emission factors is **32%**.

The combined uncertainty for „Litter“ is **31%**. The uncertainty in the estimated tendency for the gas emissions is **23%**.

The overall uncertainty over a year for “Soil” is **11%**. The trend uncertainty due to activity data and emission factors amounts to **10%**.

Table 245 Uncertainties in the gas emissions from the IPCC category “Settlements”

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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
Land use changed to settlements	Living biomass	growth biomass in settlements	CO2	-3.28	-4.14	10	35.00	36.40	0.06	0.01	0.12	0.02
		conversion of forest land	CO2	11.89	27.92	10	20.46	22.78	1.06	0.54	0.83	0.98
		conversion of annual cropland	CO2	13.79	9.33	10	23.03	25.11	0.14	0.41	0.28	0.25
		conversion of perennial cropland	CO2	1.24	0.61	10	25.00	26.93	0.00	0.05	0.02	0.00
		conversion of PPM	CO2	10.77	5.45	10	79.35	79.98	0.50	1.42	0.16	2.05
		conversion of MGL	CO2	1.39	2.89	10	50.00	50.99	0.06	0.11	0.09	0.02
		conversion of other land	CO2	0.00	0.00	10	75.00	75.66	0.00	0.00	0.00	0.00
	Dead wood	conversion of forest land	CO2	0.85	1.94	10	8.99	13.45	0.00	0.02	0.06	0.00
	Litter	conversion of forest land	CO2	2.67	4.33	10	29.84	31.47	0.05	0.05	0.13	0.02
	Soil	conversion of forest land	CO2	12.31	49.82	10	17.14	19.84	2.56	1.22	1.48	3.68
		conversion of annual cropland	CO2	216.36	269.40	10	14.40	17.53	58.52	0.34	8.01	64.28
		conversion of perennial cropland	CO2	14.52	14.11	10	14.56	17.66	0.16	0.14	0.42	0.20
		conversion of PPM	CO2	104.60	93.16	10	13.16	16.53	6.22	1.18	2.77	9.05
		conversion of MGL	CO2	45.86	77.31	10	10.57	14.55	3.32	0.39	2.30	5.44
		conversion of other land	CO2	0.47	12.21	10	107.01	107.48	4.52	2.61	0.36	6.94

IPCC sub-category	Pool	Level of estimation	Gas	Base year 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
		conversion of forest land	N2O	0.93	2.98	10	109.38	109.83	0.28	0.41	0.09	0.17
		conversion of annual cropland	N2O	25.32	31.09	10	93.04	93.58	22.21	0.35	0.92	0.97
		conversion of grassland	N2O	15.94	18.06	10	91.93	92.47	7.32	0.51	0.54	0.55
		conversion of other land	N2O	0.04	0.92	10	152.05	152.38	0.05	0.28	0.03	0.08
		Total emissions		475.66	617.41	Overall uncertainty in the year (%)			10.35	Trend uncertainty (%)		10

6.7.5 Data Verification Category-Specific Qa/Qc And Verification, If Applicable

See 6.10. QA/QC VERIFICATION.

6.7.6 Category-Specific Recalculations

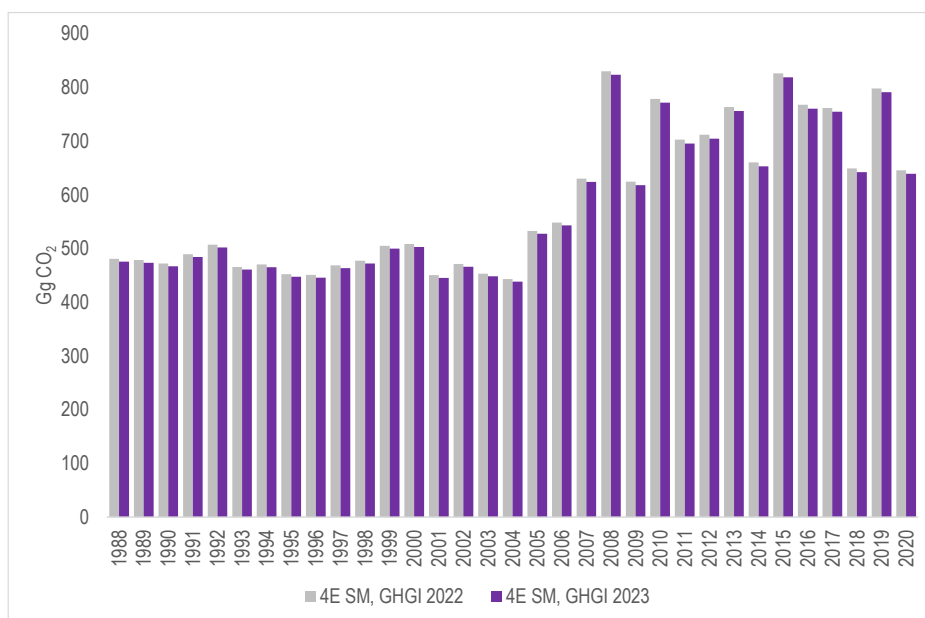


Figure 144 Recalculations in Settlements category

The changes in SM category are due to the update of the GWP of the N₂O emissions.

6.7.7 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 the area of other land is gathered from Executive Forest Agency. 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 <2%.

6.9 Harvested Wood Products

The contribution of 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=1990. Default conversion factors have 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.

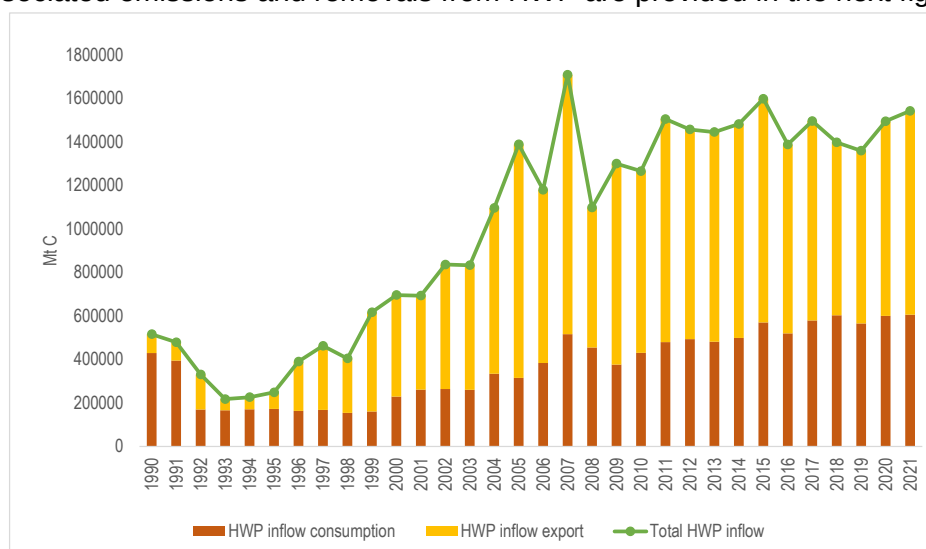


Figure 145 Annual HWP Inflow

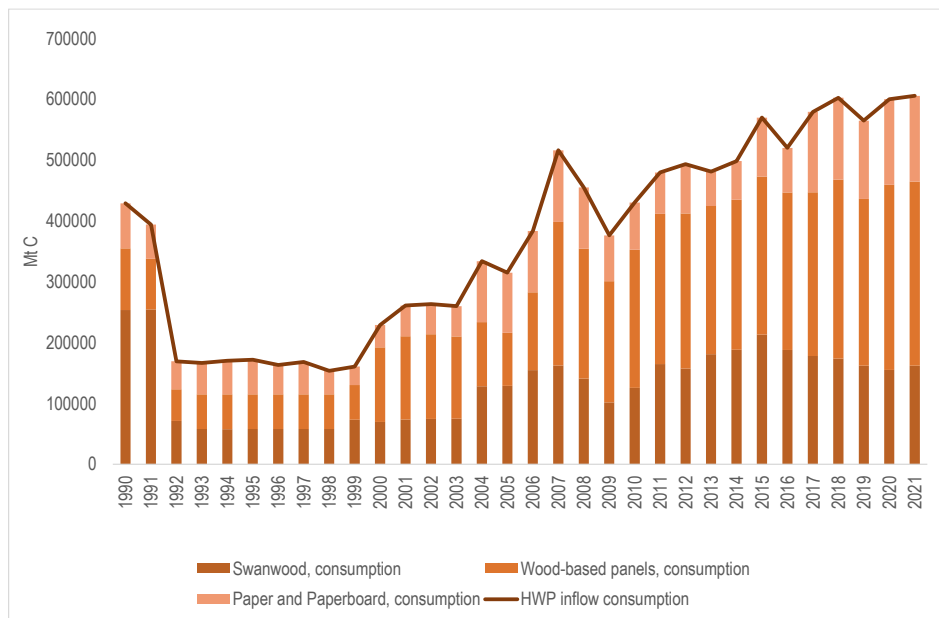


Figure 146 Annual Inflow of HWP in consumption by semi-finished products, Mt C

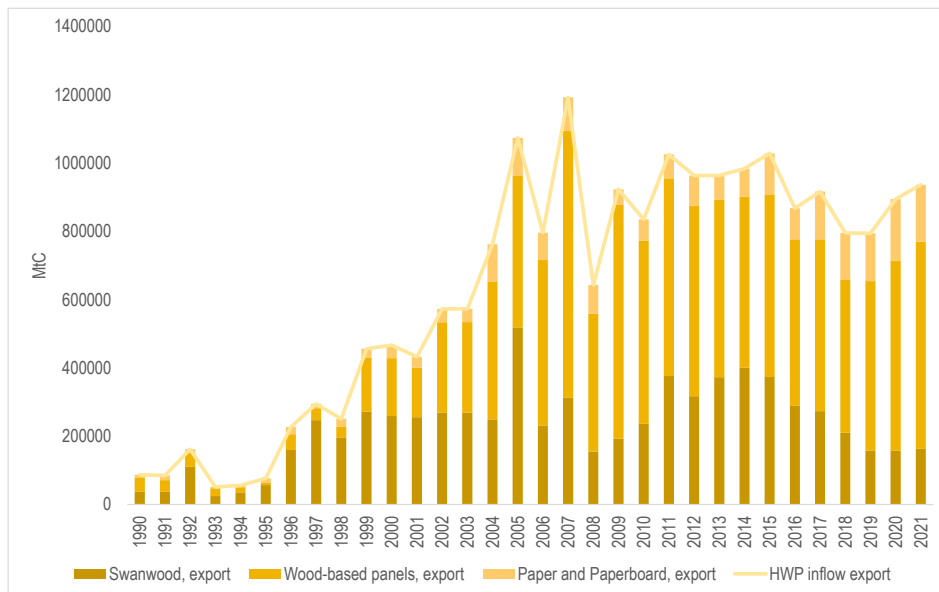


Figure 147 Annual Inflow of exported HWP by semi-finished products, Mt C

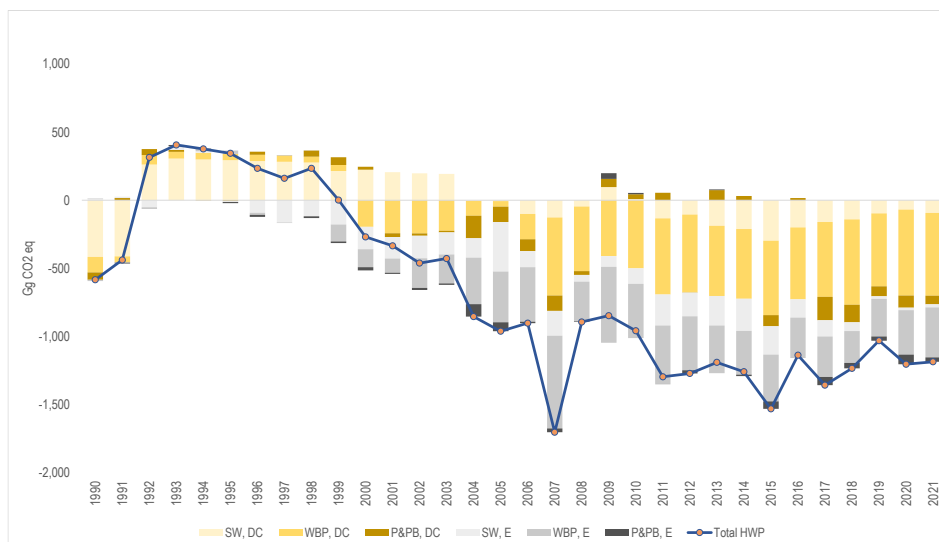


Figure 148 Emissions and removals from HWP, Gg CO₂ eq

The overall uncertainty over a year for the „Harvested wood products“ is **15%**. The trend uncertainty due to activity data and emission factors amounts to **43%**.

Table 246 Uncertainties in gas emissions from HWP

IPCC sub-category	Pool	Gas	Base year emissions	Current year emissions	Activity data	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total in the	Uncertainty in trend introduced by emission	Uncertainty in trend introduced by activity data	Uncertainty introduced into the trend
HWP	Sawnwood	CO2	-406.14	-204.19	0	30.59	30.59	21.78	37.91	0.00	1437.53
	Wood-based panel	CO2	-123.69	-860.49	0	18.24	18.24	137.45	17.99	0.00	323.72
	Paper and paperboard	CO2	-53.44	-273.93	0	35.51	35.51	52.80	9.20	0.00	84.67
	Total emissions		-583.27	-1338.61	Overall uncertainty in the year (%)			15	Trend uncertainty (%)		43

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 (CO₂), methane (CH₄) and nitrous oxide (N₂O) 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 CH₄, CO₂ and N₂O. The GHG emissions trends in this sector are presented in Table 247 and following figures.

Table 247 Trend in GHG emissions from Waste by sub-sectors for 1988-2021

GHG gases	CH ₄				N ₂ O			CO ₂
Category	5 A	5 B	5 C	5 D	5 B	5 C	5 D	5 C
1988	71.46	NO	7.01E-05	108.96	NO	4.86E-03	0.80	18.51
1990	74.98	NO	7.49E-05	105.75	NO	5,22E-03	0.67	19.84
1995	88.36	NO	7.90E-05	63.98	NO	5,50E-03	0.59	20.91
2000	98.23	NO	2.31 E-04	43.86	NO	1,69E-02	0.56	62.58
2005	102.59	NO	2.06 E-04	29.41	NO	1,45E-02	0.48	54.83
2010	105.78	NO	5.25E-05	22.42	NO	3,43E-03	0.48	13.45
2011	106.50	0.33	3.88E-05	21.50	0.02	2,41E-03	0.47	9.71
2012	104.61	0.37	7.68E-05	20.48	0.02	5,22E-03	0.48	20.09
2013	102.46	0.43	0.00014	24.49	0.03	1,04E-02	0.48	38.90
2014	98.66	0.24	4.30E-05	25.30	0.01	2,93E-03	0.49	11.26
2015	97.12	1.25	3.88E-05	22.97	0.07	2,61E-03	0.47	10.10
2016	94.60	1.06	4.66E-05	23.28	0.06	3,21E-03	0.49	12.27
2017	90.80	0.96	5.57E-05	18.70	0.06	3,86E-03	0.48	14.72
2018	87.88	0.38	2.64E-05	17.93	0.02	1,73E-03	0.47	6.77
2019	85.03	0.75	4.73E-05	16.02	0.04	3,33E-03	0.46	12.60
2020	82.29	0.22	0,00045	15.89	0.01	0.03	0.46	123.29
2021	79.95	0.12	2.97E-05	16.55	0.01	9,54E-04	0.45	5.71

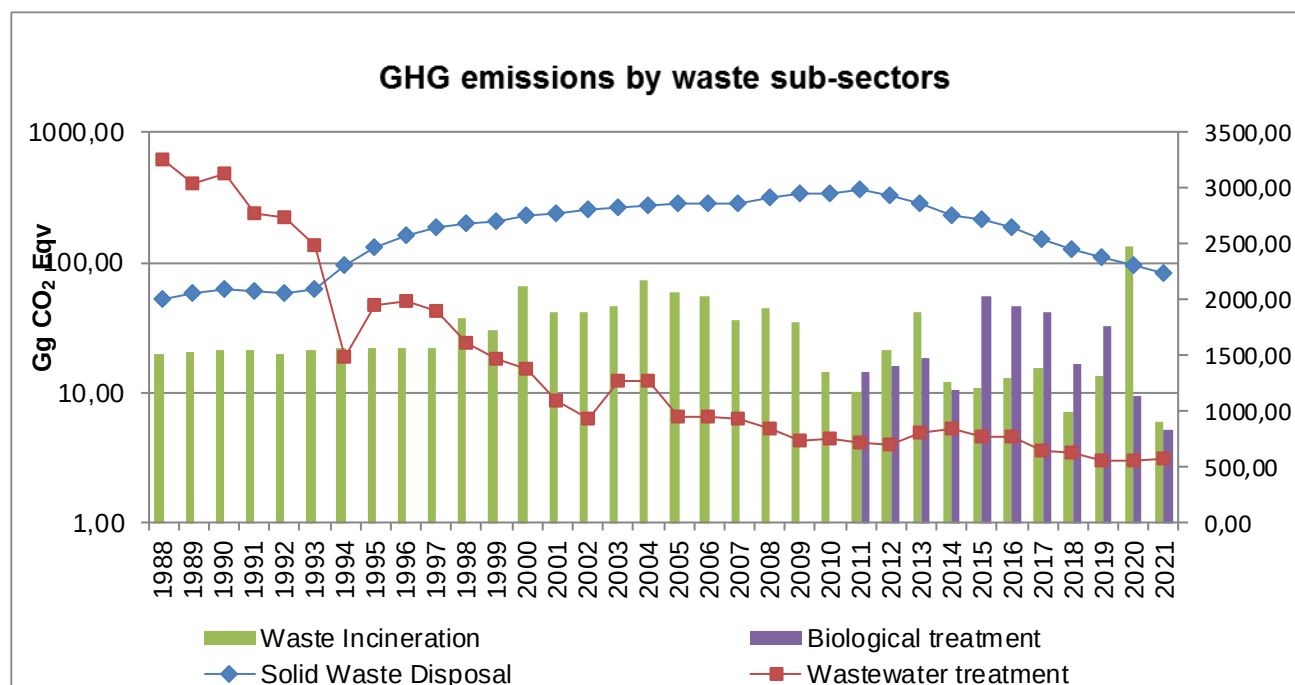


Figure 149 Emissions by waste sub-sectors

Emissions from the waste sector in 2021 decreased by 46.39% (2832.94Gg CO₂-eq in 2021 compared to 5284.33Gg CO₂-eq in 1988) compared to the base year.

Figure below presents the total CO₂ eqv from the whole waste sector.

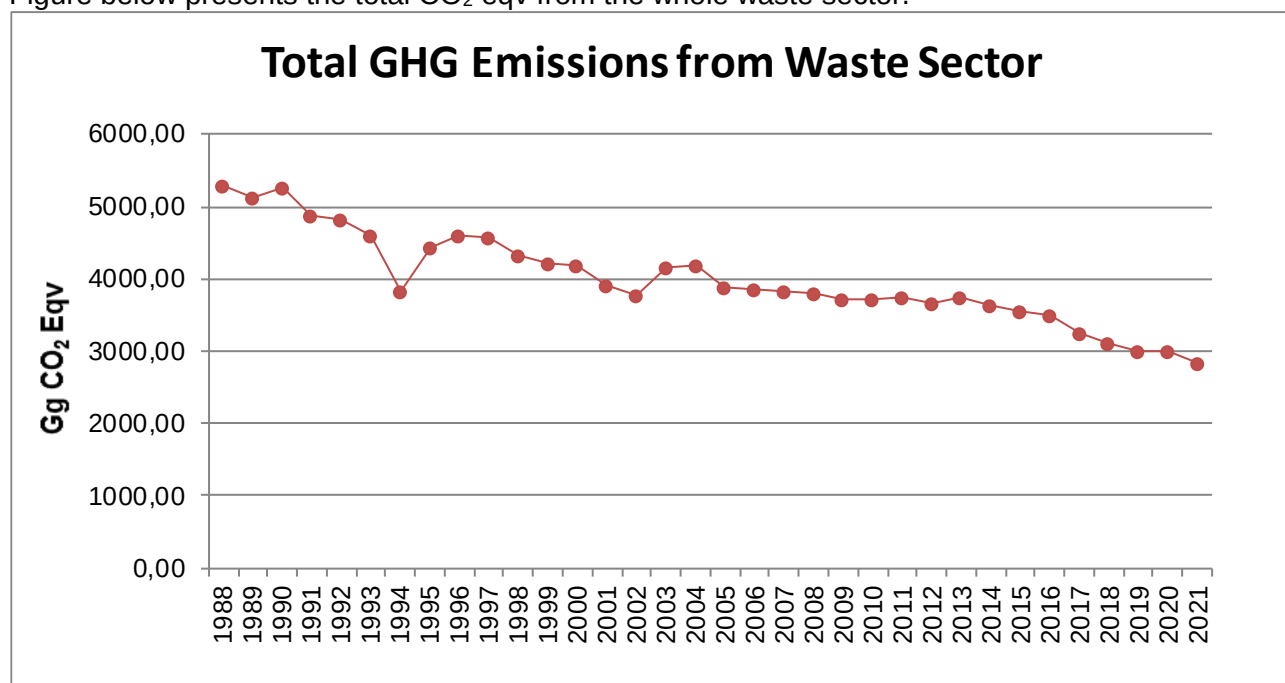


Figure 150 GHG emissions from Waste sector

7.1.2 KEY CATEGORIES

Table 248 describes the key categories of the waste sector and type of emitted greenhouse emissions.

Table 248 Key categories, Waste sector (Tier 1)

CRF categories	Category		GHG	Assessment of Key Source	Assessment of Key Source

		Key category Y/N		excluding LULUCF	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 249 Description of the completeness

Waste IPCC Category	Waste IPCC Category	CO ₂	CH ₄	N ₂ O
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	5B1 Composting 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 (CH₄). CH₄ produced at SWDS contributes approximately 3 to 4 percent to the annual global anthropogenic greenhouse gas emissions (IPCC 2001). In this report CH₄ 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. Efforts were 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:

The end of global economic, political and regime change of government in our country started to lay the groundwork for approval of plans and strategies outlining guidelines on sustainable management. At the beginning of the 1990s 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 CH₄ 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 (2014-2020)

Ordinance for the treatment of bio-waste and separate bio-waste collection (2017, last amendment 2021)

Third National Action Plan on Climate Change (2013-2020)

National Waste Management Plan (2021-2028)

Bulgarian legislation introduced 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 the amount of biodegradable municipal waste should have decreased to 35 percent, compared to the total waste in the Republic of Bulgaria from 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 being observed, concerning SWD on the managed and unmanaged disposal sites.

Since 2000 the share of population, land filling on unmanaged sites has decreased and the share of population, which disposes of wastes on managed sites is increasing.

The landfills are classified as managed and unmanaged (see below: Activity data).

The main criteria governing whether landfills are managed or unmanaged are justified by the fact if the landfills meet the requirements laid down in EU Directive 1999/31/EC on the landfill of waste.

Under regulation 1 of 9 February 2015 on the requirements for activities involving the collection and treatment of waste on the premises of medical and health institutions, clinical waste is identified as hazardous and therefore incinerated - all clinical waste is considered hazardous waste by law and is therefore incinerated.

7.2.2 EMISSION TREND

Methane emissions are shown in the Table 247, Table 255 and Figure 152 CH₄ Emissions from SWDS from managed and unmanaged sites.

Total CO₂ eq. from Solid waste disposal for 2021 are 2 832.94Gg CO₂ eqv. In 2021 emissions decrease with 5.93% 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 77.01%% in 2009 to 53.09%% in 2021). Recyclable waste collection, which was a scarce practice at the beginning of the 1990s, 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 2021 is 2808 kt which is in average 1.12 kg/capita/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 MemberStates 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 (the following figure).

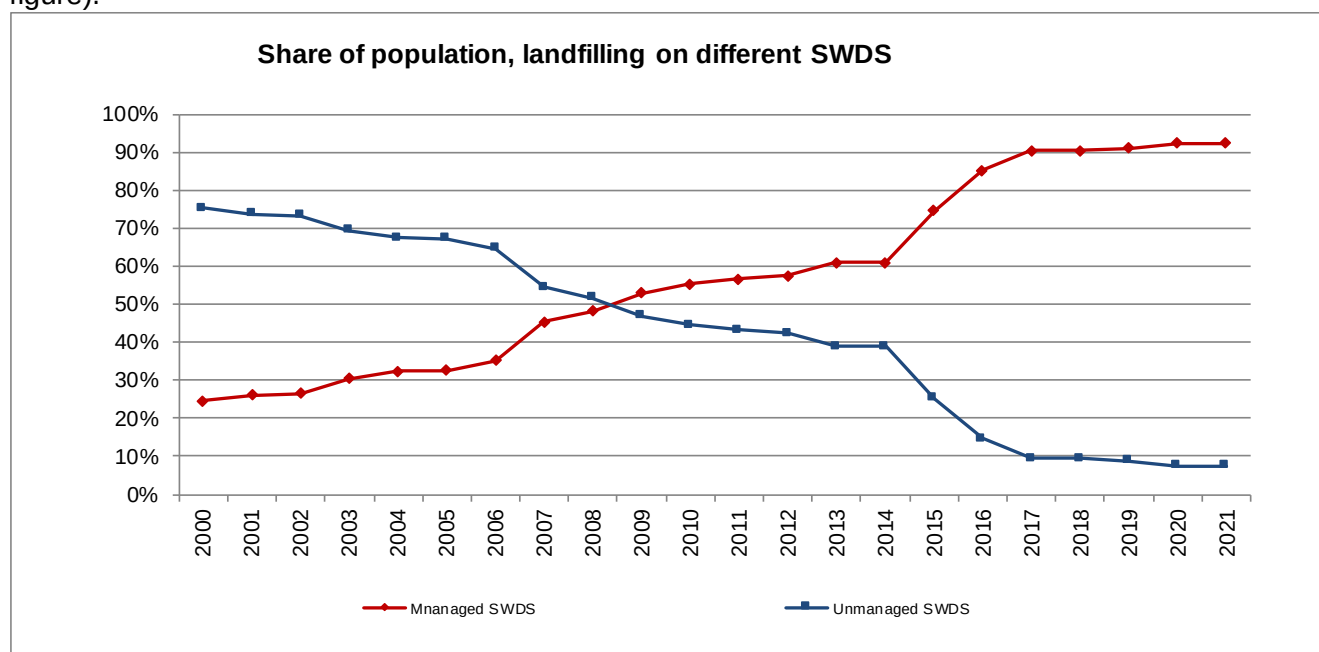


Figure 151 Share of population, landfilling on different SWDS

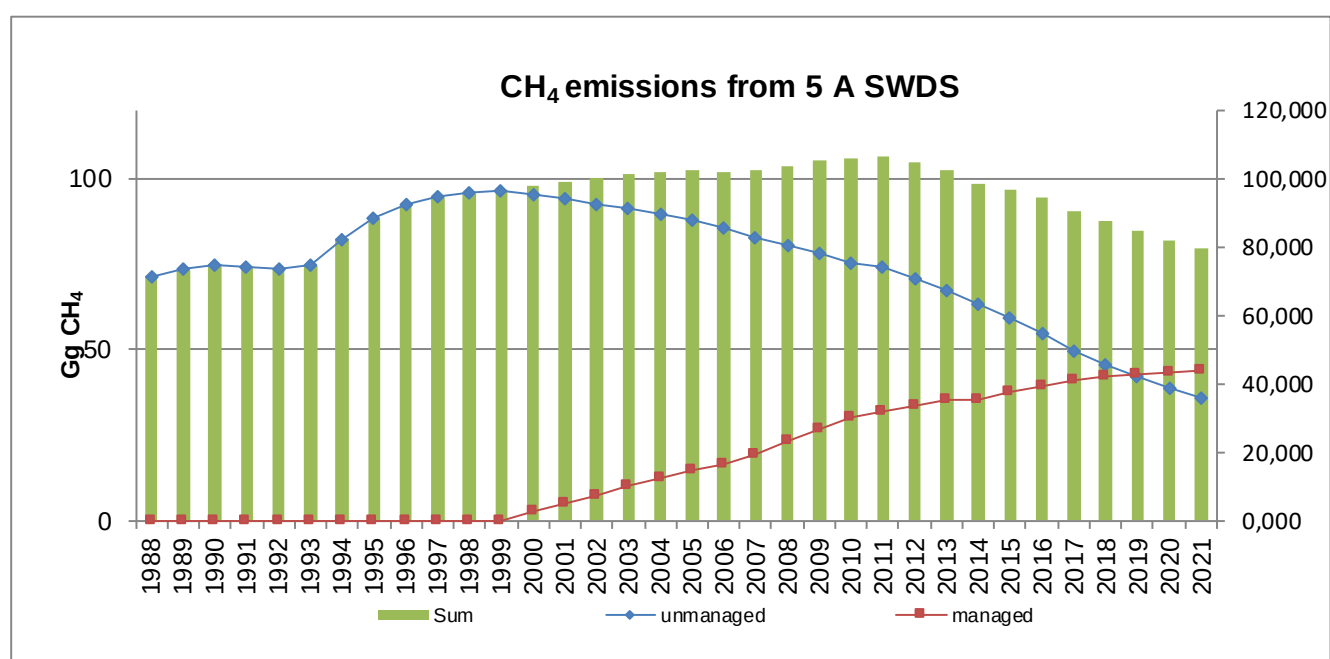


Figure 152 CH₄ Emissions from SWDS

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.

As there are not available good quality country-specific activity data on historical waste disposal and the SWD is a key category, the current waste disposal data were collected and the historical data were estimated through a regression analysis.

The preparation of a new regression analysis was necessary due to the revision in time of part of the data on the generated, collected and disposed waste for the period 1995-2012, reported to EUROSTAT. The new regression model repeats the steps of the old one and the assessment was made for the same period 1950-2008. The use of the same period is due to the fact that not very remote data (more than 20 years) from the transition of the country from centralized to market base economy are used.

For the regression model, natural / actual data on the generated and deposited waste in the country for the period 1979-2008 were used and natural /activity data on the collected waste for the period 1994-2008.

For the period 1950-1978 the generated waste is considered as a function of the total population of the country on the basis of the generated waste for the period 1979-2008.

The collected waste for the period 1950-1993 are considered as a function of the relative share of the collected to the generated waste and the relative share of the urban population to the total population of the country for the period 1994-2008.

The deposited waste for the period 1950-1978 are considered as a function of the relative share (%) of the deposited waste from the collected waste, as the latter are a function of the urban population.

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.

Sludge from wastewater treatment plants

Sludge from wastewater treatment plants has also been considered, 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 landfill sites has been estimated to be 22.53 Gg in 1988 (extrapolated value) decreasing to 1.58 Gg in 2021 (decreased by 92.99%). In current submission (2023) the amount of sludge have been extrapolated for the years from 1988 to 2003 (Table 250).

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).

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 250 Time series of sewage sludge production and landfilling

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Sewage sludge production Gg	47,48	46,32	45,80	45,41	44,83	44,69	44,52	44,30	44,07
Sewage sludge landfilled Gg	22,53	21,98	21,73	21,55	21,27	21,21	21,12	21,02	20,91

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
Sewage sludge production Gg	43,76	43,48	43,27	43,06	41,69	41,45	41,22	40,38	41,70
Sewage sludge landfilled Gg	20,76	20,63	20,53	20,43	19,78	19,67	19,55	17,90	23,40

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sewage sludge production Gg	38,00	39,90	42,90	39,40	49,80	51,40	59,30	60,30	54,94
Sewage sludge landfilled Gg	16,40	20,80	17,80	11,10	13,97	7,05	6,64	10,49	8,47

Year	2015	2016	2017	2018	2019	2020	2021		
Sewage sludge production Gg	57,36	65,79	68,72	53,08	44,43	33,47	45,38		
Sewage sludge landfilled Gg	8,54	6,18	6,91	3,74	1,88	1,60	1,58		

Industrial waste

Industrial waste assimilated to municipal solid waste (AMSW) could be disposed of to the same landfills as MSW. It originates 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). The share industrial waste disposed in landfill is very small and it is mostly composed of inert substances.

✓ 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. Hazardous 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 251 Represents the trend in AMSW, disposed of to landfills.

Year	2015	2016	2017	2018	2019	2020	2021

Assimilated municipal solid waste disposed in landfills (Gg)	320.75	337.88	374.26	420.38	435.18	439.51	437.41

The table below presents the summarized sources of initial activity data.

Table 252 Source of Activity data by year

Year	Parameters										
	generat ed waste	Source of informat ion	waste generati on rate	Source of informat ion	land fillin g waste	Source of informat ion	waste compo sition	Source of informat ion	type of landfill		Source of informat ion
									manag ed	unmanage d	
1950-1998	CS	NSI	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
2002-2021	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 1950-2021, and the plan for calculation depending on the time of reallocated activity data. The quantity of CH₄ 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 253 shows the morphological composition of the waste allocated according to distribution of population.

Table 253 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):

$$DOC = \sum_i (DOC_i \bullet W_i)$$

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 2020 as a whole:

$$DOC = 12.47 \%$$

DOC was estimated by using country-specific data on waste composition and quantities based on compiled data from 2002 to 2021 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 1950-1988: Paper/paperboard-**21.80%**; Food waste-**31.10%**; Wood waste-**7.50%**; Textile-**4.70%**; Rubber/leather-**1.40%**. The default value for DOC-**0.18134**, is used for 1950-1988 for all waste composition.

Table 254 Components of waste composition 1989-2021

Year	Waste composition, %							Degradable waste, %	DOC
	Paper/paperboard	Garden and park waste	Food waste	Wood waste	Textile	Rubber and leather	Sludge		
1989	12,94%	10,22%	18,05%	1,76%	3,58%	1,90%	0,78%	49,22%	0,1267
1990	12,94%	10,22%	18,05%	1,76%	3,58%	1,90%	0,82%	49,26%	0,1269
1995	12,94%	10,22%	18,05%	1,76%	3,58%	1,90%	0,47%	48,91%	0,1252
2000	12,94%	10,22%	18,05%	1,76%	3,58%	1,90%	0,63%	49,07%	0,1260
2001	12,94%	10,22%	18,05%	1,76%	3,58%	1,90%	0,62%	49,07%	0,1259
2002	12,94%	10,22%	18,05%	1,76%	3,58%	1,90%	0,62%	49,06%	0,1259
2003	12,95%	10,22%	18,05%	1,75%	3,58%	1,90%	0,62%	49,07%	0,1229
2004	12,96%	10,23%	18,07%	1,76%	3,58%	1,89%	0,58%	49,08%	0,1259
2005	13,00%	10,21%	18,11%	1,75%	3,58%	1,89%	0,75%	49,29%	0,1268
2006	13,04%	10,19%	18,18%	1,75%	3,58%	1,89%	0,60%	49,23%	0,1263

2007	13,04%	10,21%	18,17%	1,75%	3,58%	1,88%	0,70%	49,35%	0,1268
2008	13,05%	10,17%	18,21%	1,75%	3,58%	1,89%	0,53%	49,19%	0,1260
2009	13,03%	10,15%	18,23%	1,75%	3,58%	1,90%	0,33%	48,97%	0,1249
2010	13,08%	10,13%	18,28%	1,75%	3,58%	1,90%	0,46%	49,17%	0,1258
2011	13,26%	10,04%	18,55%	1,74%	3,57%	1,88%	0,28%	49,32%	0,1257
2012	13,30%	10,02%	18,60%	1,73%	3,57%	1,88%	0,29%	49,39%	0,1259
2013	13,34%	10,01%	18,64%	1,73%	3,57%	1,88%	0,49%	49,64%	0,1271
2014	13,30%	9,99%	18,61%	1,73%	3,56%	1,89%	0,53%	43,63%	0,1271
2015	13,31%	9,99%	18,60%	1,73%	3,56%	1,89%	0,39%	49,47%	0,1264
2016	13,35%	9,97%	18,66%	1,73%	3,56%	1,89%	0,34%	49,49%	0,1264
2017	13,38%	9,98%	18,69%	1,73%	3,56%	1,88%	0,40%	49,61%	0,1268
2018	13,42%	9,96%	18,75%	1,73%	3,56%	1,88%	0,25%	49,54%	0,1262
2019	13,42%	9,98%	18,74%	1,73%	3,56%	1,87%	0,13%	49,43%	0,1257
2020	13,22%	10,07%	18,47%	1,74%	3,57%	1,89%	0,11%	49,06%	0,1247
2021	13,26%	10,05%	18,52%	1,74%	3,57%	1,88%	0,11%	49,13%	0,1248

The Methane Correction Factor (MCF) reflects the way in which MSW is managed and the effect of management practices on CH₄ generation.

MCF accounts for the fact that unmanaged SWDS produce less CH₄ 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 CH₄ generation potential (Lo). (Gg CH₄ generated) depends upon the composition of waste. on waste disposal practices and on the physical characteristics of the SWDS. For calculation of CH₄ generation potential Equations 3.2 and 3.3 (2006 IPCC Vol.5: Waste p. 3.9) are used.

For 2020 inventory year the values are:

$$Lo_{\text{managed landfills}} = 0.041890 \text{ Gg CH}_4$$

$$Lo_{\text{unmanaged landfills}} = 0.033512 \text{ Gg CH}_4$$

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 $t_{1/2}$) 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 CH₄ 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 2011 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.

There is a recalculation of methane recovery due to updated AD and methodology. For 2020 the recovered methane is 0.0531 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 255.

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 255 Parameters in Tier 2 for Solid waste Disposal Sites

Year	Total population	Waste generation rate	Fraction of MSW disposed	Fraction DOC_f 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		
1988	8986.64	2.36	0.355	0.1269	0.01	0.5	0.090	38	71.464	NO
1989	8767.30	2.63	0.339	0.1267	0.01	0.5	0.090	39	73.575	NO
1990	8669.27	2.53	0.334	0.1269	0.01	0.5	0.090	40	74.983	NO
1991	8595.47	2.71	0.240	0.1281	0.01	0.5	0.090	41	74.441	NO
1992	8484.86	2.60	0.246	0.1282	0.01	0.5	0.090	42	73.780	NO
1993	8459.76	2.38	0.340	0.1271	0.01	0.5	0.090	43	74.661	NO
1994	8427.42	2.21	0.725	0.1250	0.01	0.5	0.090	44	82.544	NO
1995	8384.72	1.90	0.765	0.1252	0.01	0.5	0.090	45	88.358	NO
1996	8340.94	1.69	0.774	0.1254	0.01	0.5	0.090	46	92.309	NO
1997	8283.20	1.59	0.752	0.1257	0.01	0.5	0.090	47	94.815	NO
1998	8230.37	1.62	0.649	0.1261	0.01	0.5	0.090	48	95.813	NO
1999	8190.88	1.64	0.651	0.1261	0.01	0.5	0.090	49	96.812	NO
2000	8149.47	1.68	0.654	0.1260	0.01	0.5	0.090	50	98.230	NO
2001	7891.10	1.65	0.670	0.1259	0.01	0.5	0.090	51	99.326	NO
2002	7845.84	1.64	0.676	0.1259	0.01	0.5	0.090	52	100.264	NO
2003	7801.27	1.64	0.681	0.1229	0.01	0.5	0.090	53	101.219	NO
2004	7761.05	1.63	0.669	0.1259	0.01	0.5	0.090	54	101.829	NO
2005	7718.75	1.60	0.698	0.1268	0.01	0.5	0.090	55	102.590	NO
2006	7679.29	1.57	0.627	0.1263	0.01	0.5	0.090	56	102.088	NO
2007	7640.24	1.50	0.714	0.1268	0.01	0.5	0.090	57	102.469	NO
2008	7606.55	1.62	0.749	0.1260	0.01	0.5	0.090	58	103.951	NO
2009	7563.71	1.61	0.770	0.1249	0.01	0.5	0.090	59	105.465	NO
2010	7504.87	1.48	0.748	0.1258	0.01	0.5	0.090	60	105.777	NO
2011	7327.22	1.34	0.719	0.1257	0.01	0.5	0.090	61	106.504	0.239

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
2012	7284.55	1.22	0.715	0.1259	0.01	0.5	0.090	62	104.607	0.138
2013	7245.68	1.19	0.693	0.1271	0.01	0.5	0.090	63	102.458	0.084
2014	7202.20	1.21	0.501	0.1271	0.01	0.5	0.090	64	98.661	0.079
2015	7153.78	1.15	0.729	0.1264	0.01	0.5	0.090	65	97.115	0.097
2016	7101.86	1.11	0.633	0.1264	0.01	0.5	0.090	66	94.604	0.092
2017	7050.03	1.19	0.557	0.1268	0.01	0.5	0.090	67	90.803	0.070
2018	7000.04	1.12	0.531	0.1262	0.01	0.5	0.090	68	87.882	0.070
2019	6951.48	1.12	0.516	0.1257	0.01	0.5	0.090	69	85.028	0.059
2020	6916.55	1.12	0.507	0.1247	0.01	0.5	0.090	70	82.287	0.053
2021	6838.94	1.12	0.531	0.1248	0.01	0.5	0.090	71	79.954	0.066

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 256 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. CH₄ 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

For the years 2019 and 2020 were made recalculations due to revised AD provided by 1) NSI, which present the amounts of the direct landfilled municipal waste and

2) Executive Environment Agency's annual reports, which provide the data for Waste from the installations for in advance treatment, submitted for disposal. The quantities are summarized based on the data received from the submitted annual reports by the obligated persons on the procedure and templates for providing information on waste activities, as well as the procedure for conducting public registers.

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 CH₄ and N₂O emissions in the atmosphere from biological treatment of solid waste (composting) and Anaerobic Digestion at Biogas Facilities. Calculation of the emissions depends on the quality of collected data, amount and type of solid waste, treated biologically and Anaerobic digested at biogas facilities and the choice of emission factors respectively.

Composting is a waste management practice for reducing the volume of land filled organic waste and reducing CH₄ 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.

CH₄ and N₂O 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.

During the UNFCCC Centralized review of the 2022 submission of Bulgaria, ERT noted that Bulgaria reported CH₄ emissions from category 5.B.2 anaerobic digestion at biogas facilities as not estimated (NE) emissions in 2014-2020. Bulgaria has provided an excel spreadsheet containing activity data for anaerobic digestion at biogas facilities for the period of 2014-2020 and CH₄ emissions calculations for this category using Tier 1 method from the 2006 IPCC Guidelines (vol. 5; chap. 4.1.3.1, table 4.1, p.4.6). The source of activity data is the annual report according to IPPC permits of Installation for biological treatment at the site "Khan Bogrov"

7.3.1.1 Methodological issues

Methodology for calculation of CH₄ and N₂O 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.

Table 257 Default emission factors for CH₄ and N₂O emissions from biological treatment of waste

Type of biological treatment	CH ₄ Emission Factors (g CH ₄ /kg waste treated)		N ₂ O Emission Factors (g N ₂ O/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)

Table 258 Default emission factors for CH₄ and N₂O emissions from anaerobic digestion at biogas facilities

Type of biological treatment	CH ₄ Emission Factors (g CH ₄ /kg waste treated)		N ₂ O Emission Factors (g N ₂ O/kg waste treated)	
	on a dry weight basis	on a wet weight basis	on a dry weight basis	on a wet weight basis
Anaerobic digestion at biogas facilities	2 (0-20)	1 (0-8)	assumed negligible	assumed negligible

7.3.1.2 Activity data

The source of activity data is National statistical institute and Executive environment agency. The emissions from composting and anaerobic digestion at biogas facilities are given in the tables below.

Table 259 CH₄ and N₂O emissions from composting

Year	Total annual amount (dry matter) treated by composing (Gg)	CH ₄ emissions (kt)	N ₂ O emissions (kt)
2011	33,474	0,335	0,020
2012	36,800	0,368	0,022
2013	42,597	0,426	0,026
2014	23,451	0,235	0,014
2015	124,400	1,244	0,075
2016	105,200	1,052	0,063
2017	95,200	0,952	0,057
2018	38,215	0,382	0,023
2019	74,611	0,746	0,045
2020	21,014	0,210	0,0126
2021	11,493	0,115	0,007

Table 260 CH₄ emissions from anaerobic digestion at biogas facilities

Year	Total annual amount (dry matter) treated at biological treatment facilities (Gg)	CH ₄ emissions (kt)	N ₂ O emissions (kt)
2014	1,999	0,004	NE
2015	2,937	0,006	NE
2016	3,624	0,007	NE
2017	3,423	0,007	NE
2018	1,316	0,003	NE
2019	3,686	0,007	NE
2020	3,541	0,007	NE
2021	2,020	0,004	NE

During the 2020 review TERT noted that there is an important reduction of the amount of waste composted between 2017 and 2018. The reduction was in accordance with the implementation of an ordinance for the separate collection of biowaste and treatment of biodegradable waste, which introduced more stringent requirements for the fraction of separated waste to be composted.

7.3.1.3 Emission factors

Default emission factors (on wet weight basis) are used for emission estimation of CH₄ and N₂O from composting. Country specific emission factors or plant specific emission factors are not available at the moment.

Default emission factors (on a dry weight basis) are used for emission estimation of CH₄ from anaerobic digestion at biogas facilities. 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 CH₄ emissions from compost production is estimated to be about 30% concerning activity data. EF used for N₂O is 30% and for CH₄ - 400%.

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

A recalculation was made in sector 5B1 due to revised activity data for total annual amount treated by composting for 2020.

7.3.5 SOURCE-SPECIFIC IMPROVEMENT PLAN

There are no planned source specific improvements.

7.4 WASTE INCINERATION (CRF CATEGORY 5C)

7.4.1 OVERVIEW OF THE SECTOR

Emissions from waste incineration without energy recovery are reported in Waste sector, while emissions from incineration with energy recovery are reported in Energy sector. According to the 2006 IPCC Guidelines incineration of waste produces emissions of CO₂, CH₄ and N₂O. Normally emissions of CO₂ from waste incineration are significantly greater than CH₄ and N₂O emissions. Except this type of emissions in the atmosphere are released non-greenhouse gasses like NO_x, NH₃, NMVOCs and etc. Emissions of CH₄ 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 CO₂ from waste incineration (significantly greater than N₂O emissions) N₂O and CH₄ emissions.

Incineration of waste is not a key category in the country. For estimation of CO₂, N₂O and CH₄ emissions is applied TIER 1 method. This report includes emissions from incinerated in the country clinical and hazardous waste.

7.4.1.1 Emission trend

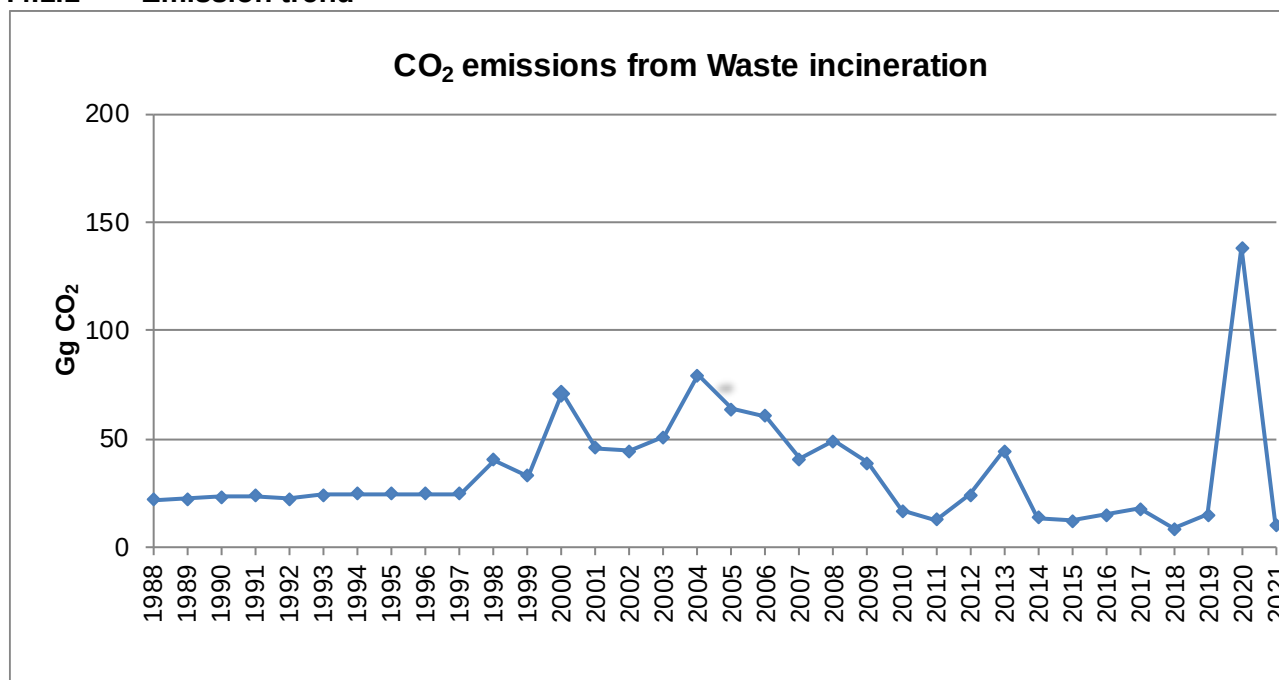


Figure 153 CO₂ Eqv emissions from Waste incineration

Table 261 CO₂, CH₄ and N₂O emissions from incineration of clinical and hazardous waste

Year	Clinical waste				Hazardous waste			
	Clinical waste Gg/yr	CO ₂ emissions	CH ₄ emissions	N ₂ O emissions	Hazardous waste Gg/yr	CO ₂ emissions	CH ₄ emissions	N ₂ O emissions
1988	0,976	0,859	5,854E-06	4,878E-05	10,70	17,66	0,0000642	0,005
1990	0,977	0,860	5,86E-06	4,884E-05	11,50	18,98	0,0000690	0,005
1995	1,070	0,941	6,419E-06	5,349E-05	12,10	19,97	0,0000726	0,005
2000	1,124	0,989	6,742E-06	5,618E-05	37,33	61,59	0,000224	0,017

2005	2,353	2,071	1,412E-05	0,0001177	31,97	52,76	0,0001918	0,014
2006	2,579	2,269	1,547E-05	0,0001289	29,88	49,30	0,0001793	0,013
2007	2,035	1,791	1,221E-05	0,0001018	19,66	32,43	0,0001179	0,009
2008	1,440	1,267	8,64E-06	7,2E-05	24,93	41,13	0,0001496	0,011
2009	1,301	1,145	7,805E-06	6,504E-05	19,48	32,13	0,0001169	0,009
2010	1,285	1,131	7,71E-06	6,425E-05	7,47	12,32	4,481E-05	0,003
2011	1,244	1,095	7,466E-06	6,222E-05	5,22	8,61	3,132E-05	0,002
2012	1,355	1,193	8,133E-06	6,777E-05	11,45	18,90	6,871E-05	0,005
2013	0,892	0,785	5,353E-06	4,461E-05	23,10	38,12	0,0001386	0,010
2014	0,744	0,655	4,466E-06	3,722E-05	6,43	10,61	3,858E-05	0,003
2015	0,751	0,661	4,504E-06	3,753E-05	5,72	9,44	3,433E-05	0,003
2016	0,715	0,629	4,29E-06	3,575E-05	7,06	11,64	4,234E-05	0,003
2017	0,788	0,693	4,728E-06	3,94E-05	8,50	14,02	5,099E-05	0,004
2018	0,626	0,551	3,757E-06	3,131E-05	3,77	6,22	2,261E-05	0,002
2019	0,542	0,477	3,254E-06	2,711E-05	7,35	12,12	4,408E-05	0,003
2020	1,171	1,030	2,810E-06	2,342E-05	74,10	122,26	4,446E-05	0,030
2021	3,181	2,800	7,635E-06	6,363E-05	1,77	2,91	1,060E-06	0,001

Reduced incineration of hazardous waste in the installation of LukOil Neftochim for 2010 is due to the reduced quantity of processed sludge which is connected with decrease in 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 LukOil 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 2010/75/EU 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. Now all clinical waste are considered hazardous waste by law and therefore are incinerated.

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 CO₂, N₂O and CH₄ 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 CO₂ emissions from clinical waste incineration

TIER 1 method is used for estimation of CO₂ emissions from incineration of clinical waste. because it is not a key category. CO₂ 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 CO₂ emissions.

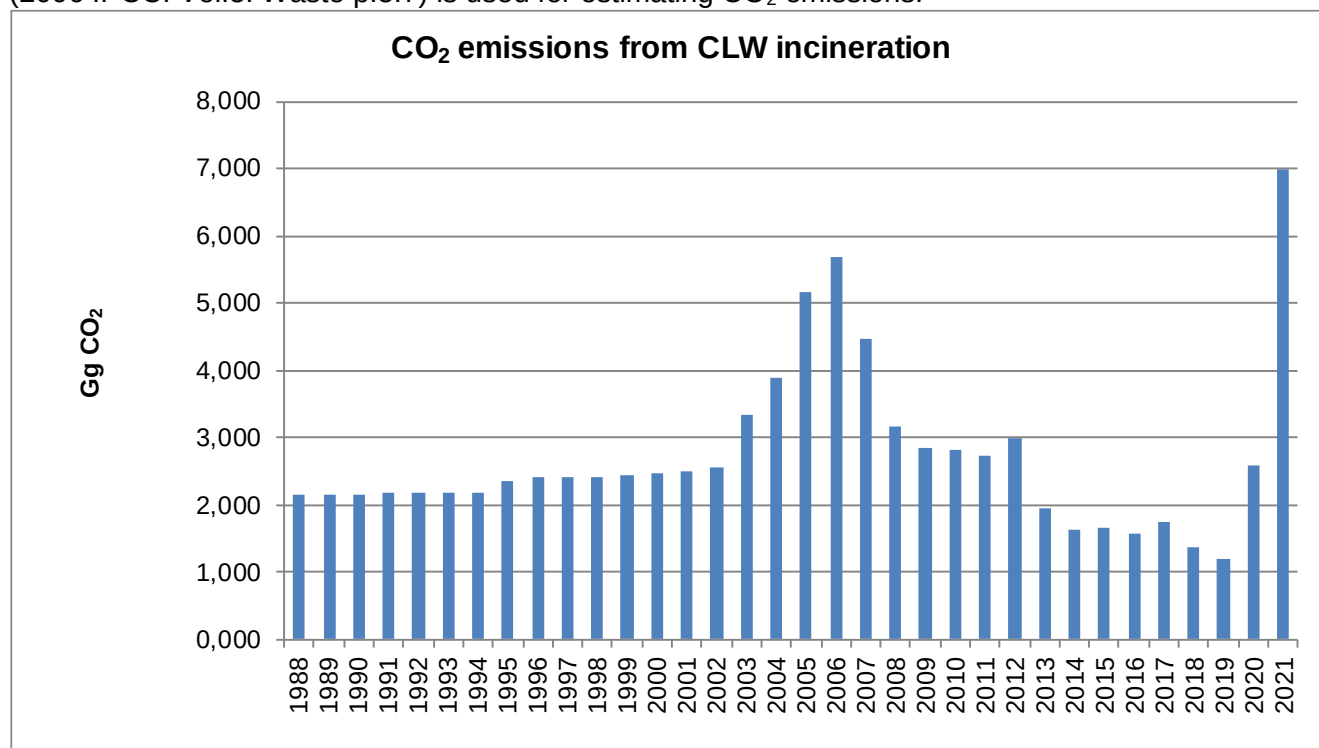


Figure 154 CO₂ emissions from clinical waste incineration

7.4.3.2 Choice of method for estimating N₂O emissions from clinical waste incineration

For N₂O emission calculations equation 5.5 is used (2006 IPCC. Vol.5: Waste p.5.14. TIER 1. non key category)

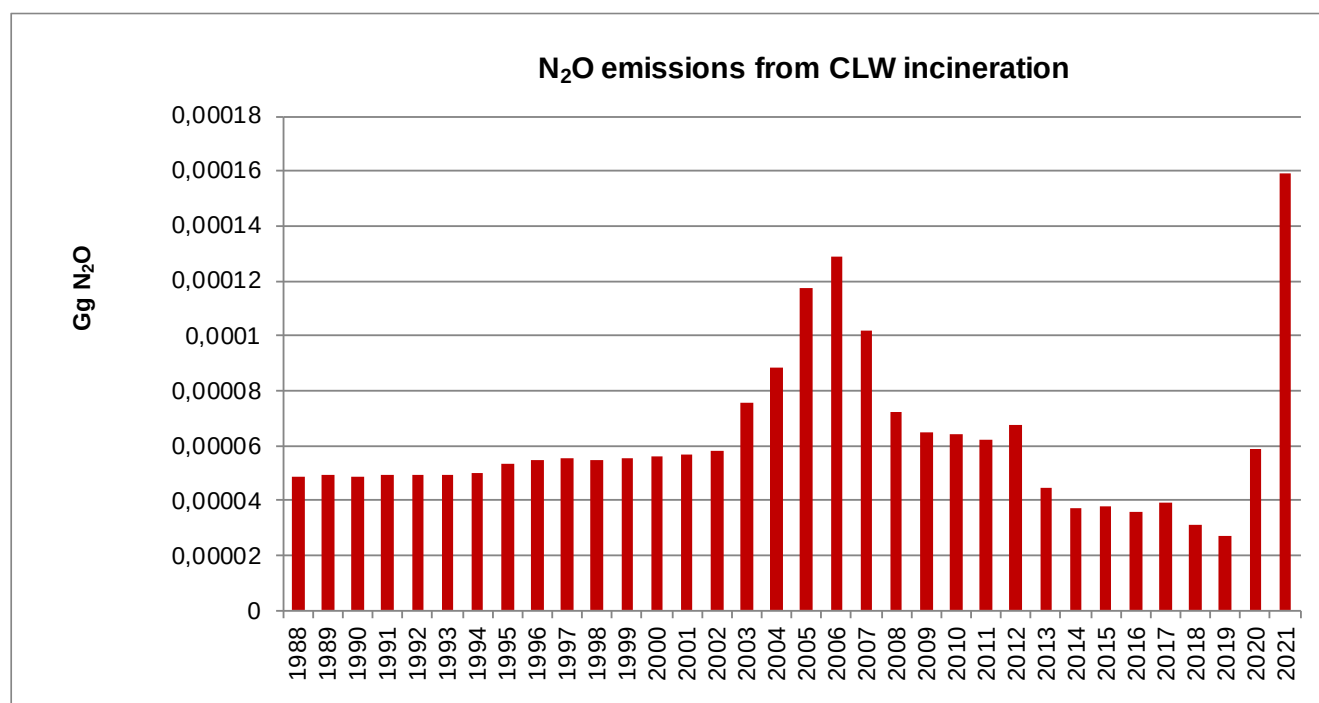
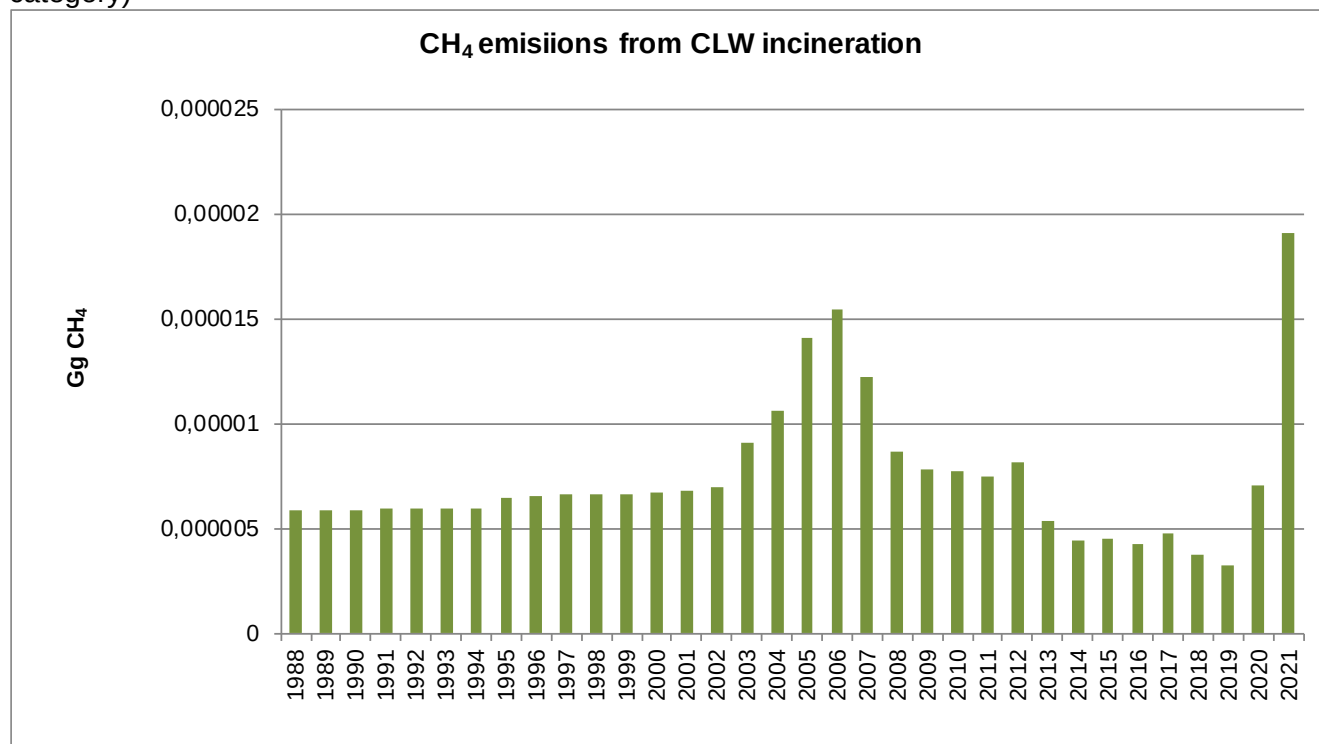


Figure 155 N₂O emissions from clinical waste incineration**7.4.3.3 Choice of method for estimating CH₄ emissions from clinical waste incineration**

For CH₄ emission calculations equation 5.4 is used (2006 IPCC. Vol.5: Waste p.5.12. TIER 1. non key category)

Figure 156 CH₄ emissions from clinical waste incineration**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. If site-specific emissions factors are not available, default factors can be used.

For estimation of CO₂ 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)

In country incineration plants are type heart or grate. There is no a default EF N₂O for such type of installation. For estimation of N₂O emissions from incineration of clinical waste we choose EF N₂O 50g N₂O/t waste for continuous and semi-continuous incinerators (2006 IPCC. Vol.5: Waste. p.5.22. Table 5.6)

For calculation of CH₄ 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 LukOil 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 CO₂ emissions from hazardous waste incineration

TIER 1 method is used for estimation of CO₂ 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 CO₂ emissions.

In 2020 CO₂ emissions from 5C1 “Waste incineration and open burning of waste” increase due to burning 74 096,22 t dry substance of waste with code 190811*(sludge containing hazardous substances from biological treatment of industrial wastewater) from Lukoil Neftohim Burgas at an industrial unit for incineration of oil and biological sludge and solid technological waste.

This was reported by Lukoil Neftohim Burgas in an Annual report on the implementation of the activities for which it has a Complex Permit for 2020.

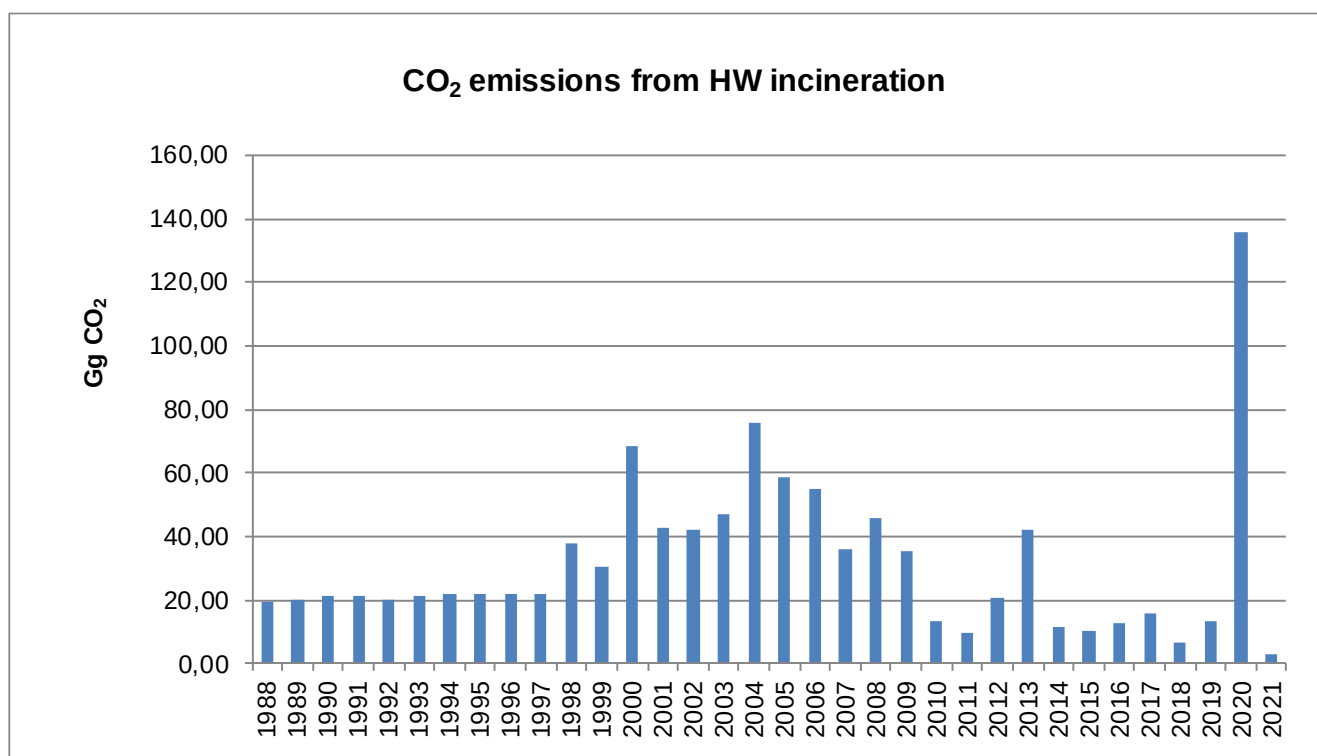


Figure 157 CO₂ emissions from hazardous waste incineration

7.4.5.3 Choice of method for estimating N₂O emissions from hazardous waste incineration

TIER 1 method is used for estimation of N₂O emissions from hazardous waste incineration. The calculation of N₂O emissions is based on the waste input to the incinerators and default emission factor. For N₂O emission calculations equation 5.5 is used (2006 IPCC. Vol.5: Waste p.5.14)

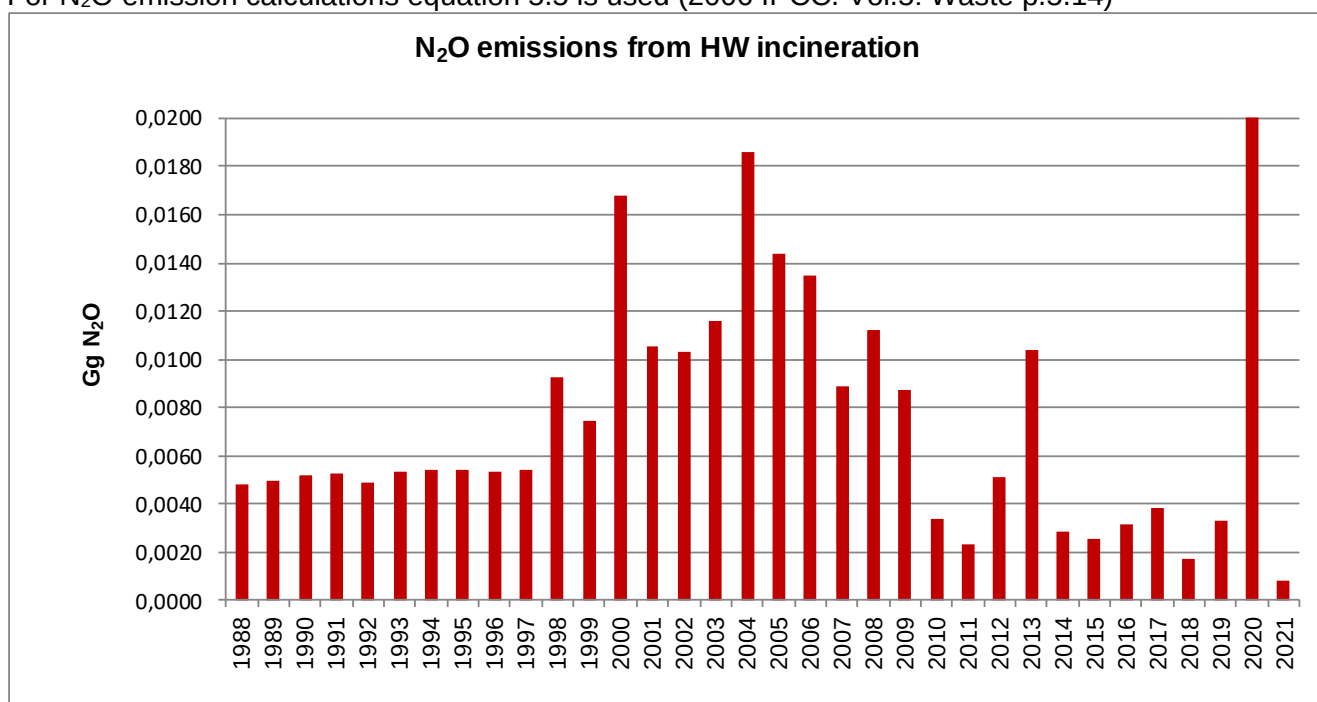


Figure 158 N₂O emissions from hazardous waste incineration

7.4.5.4 Choice of method for estimating CH₄ emissions from hazardous waste incineration

The calculation of CH₄ 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).

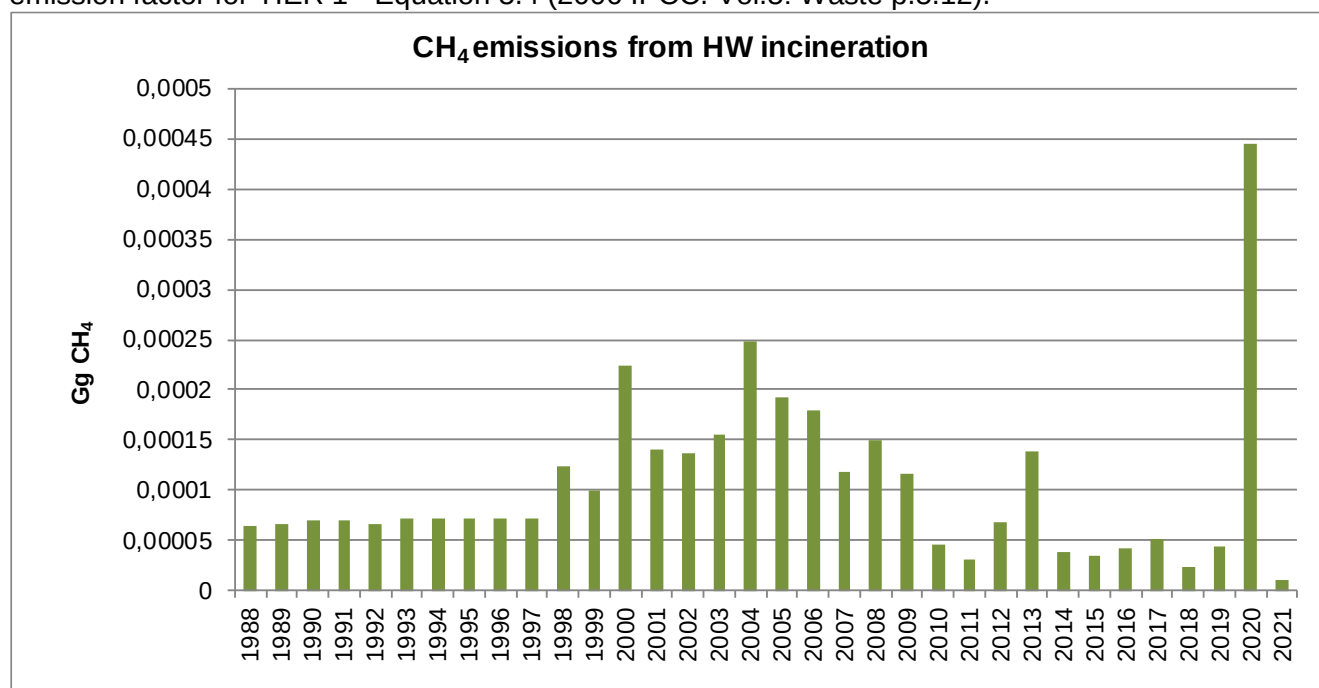


Figure 159 CH₄ emissions from hazardous waste incineration

7.4.6 CHOICE OF EMISSION FACTORS

For calculation of CO₂ 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 CO₂ 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.

For calculation of N₂O emissions from hazardous waste incineration we used EF N₂O of 450 g N₂O/t waste (2006 IPCC. Vol.5: Waste. p.5.21. Table 5.5)

For calculation of CH₄ emissions from hazardous waste incineration we used EF CH₄ 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

The activity data for this sector are revised for 2020.

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 CH₄ emissions from wastewater when treated or disposed anaerobically and indirect N₂O emissions for the period 1988-2021. CO₂ 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 CO₂ equivalents from wastewater handling for 2021 are 583.10 Gg CO₂ eq. In 2021 emissions increase with 3.02% in comparison with 2020.

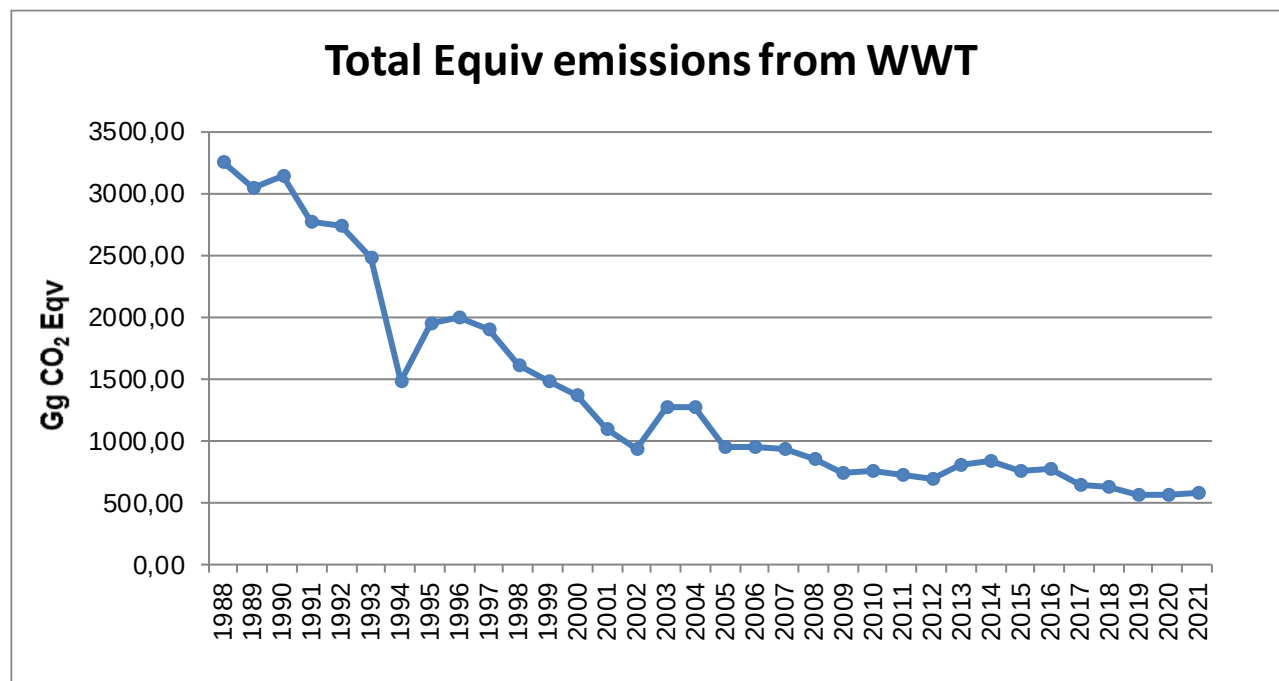


Figure 160 CO₂ eqv emissions from Wastewater treatment

TIER 2 is applied in the calculation of the CH₄ 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.

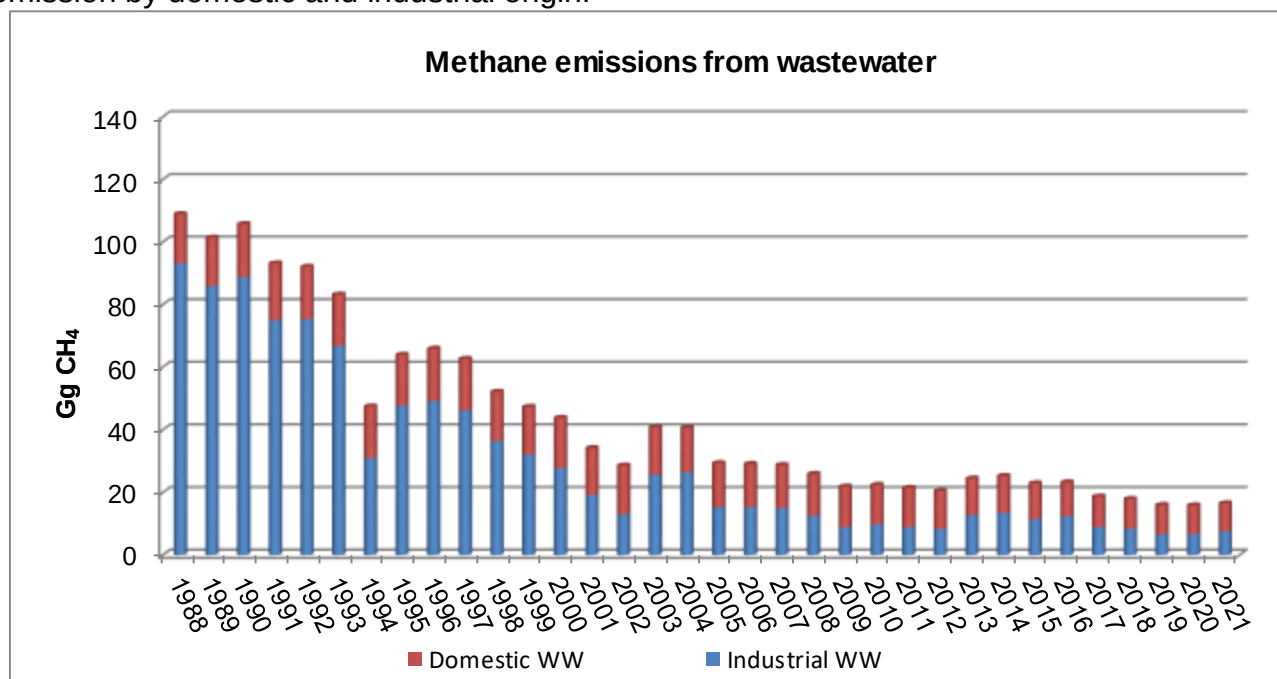


Figure 161 CH₄ emissions from wastewater handling

7.5.3 DOMESTIC WASTEWATER HANDLING (CRF CATEGORY 5D1)

7.5.3.1 Category description

This category is a key category.

The National Statistical Institute is the source of information about treatment and discharge pathways or systems in the country, as well as quantities of wastewater, generated and handled in each treatment system of domestic/industrial wastewater.

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 Bulgaria, 73.12% of the population is classified as urban income group and 26.88 % - as rural income group (NSI data). Degree of utilization (T) of treatment and discharge pathways for each income group are shown in Table 264.

Total methane emissions from domestic wastewater treatment for 2021 are 9.02Gg. Significant contribution to these emissions have septic systems – 4.10 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 262 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	1999	224225231	2010	205445762
1989	240005057	2000	223091687	2011	200582757
1990	237321239	2001	216018726	2012	199414611
1991	235300854	2002	214779897	2013	198350408
1992	232273125	2003	213559848	2014	197160170
1993	231586012	2004	212458716	2015	195834837
1994	230700568	2005	211300781	2016	194413390
1995	229531573	2006	210220564	2017	192994681
1996	228333123	2007	209151515	2018	191626068
1997	226752600	2008	208229334	2019	190296820
1998	225306406	2009	207056561	2020	189340502
2021	187215900				

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 CH₄ producing potential (Bo) and methane correction factor (MCF) for wastewater treatment and discharge system.

The Equation for calculation of EF is:

$$EF_j = B_0 \bullet MCF_j$$

Where:

EF_j – emission factor. kg CH₄/kg BOD

j – each treatment/discharge pathway or system

B_0 – maximum CH₄ producing capacity. kg CH₄/kg BOD

MCF_j – methane correction factor (fraction)

2006 IPCC Guidelines provides the default value for domestic wastewater:

$B_0 = 0.60$ kg CH₄ /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 through 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 through sewer system into centralized aerobic wastewater treatment plant – MCF = 0.03

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 263 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	0.03	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%

	Discharged into sea. river. lake	Centralized. aerobic not well managed treatment plant	Septic systems	Latrines
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	39.01%	42.76%	14.49%	3.74%
2012	35.57%	47.22%	13.90%	3.31%
2013	37.49%	46.42%	11.19%	2.90%
2014	35.58%	48.07%	13.61%	2.74%
2015	34.65%	49.46%	13.43%	2.47%
2016	30.24%	54.97%	12.68%	2.11%
2017	32.11%	56.13%	10.22%	1.53%
2018	32.33%	56.59%	9.77%	1.31%
2019	31.79%	57.36%	9.70%	1.14%
2020	32.24%	57.60%	9.22%	0.94%
2021	32.20%	57.86%	9.14%	0.80%

After determination of TOW, wastewater treatment systems and discharge pathways and respective MCF, we can calculate the CH₄ emissions from domestic wastewater as follows:

$$CH_4 \text{ Emissions} = \left[\sum_{i,j} (U_i \cdot T_{i,j} \cdot EF_j) \right] (TOW - S) - R$$

Where:

CH₄ emissions – CH₄ emissions in inventory year, kg CH₄/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 CH₄/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 CH₄/yr

CH₄ emissions from domestic wastewater treatment and discharge for the period 1988-2020 are shown in figure below

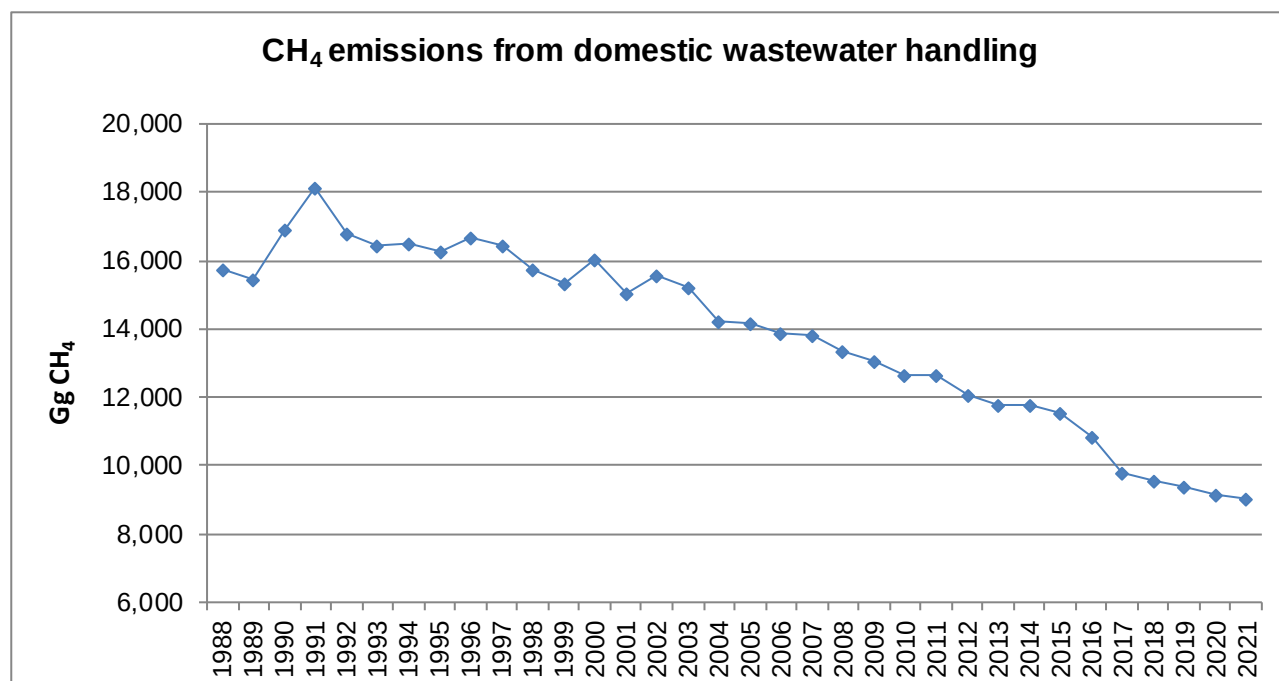


Figure 162 CH₄ emissions from domestic wastewater handling

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 264 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	42
	Septic systems	7
Rural population	Discharge into the sea.river. lake	8
	Centralized aerobic treatment plant	15
	Septic systems	3
	Latrines	1

7.5.3.3 Choice of emission factors and parameters

For CH₄ emission estimation, default 2006 IPCC Guidelines were used.

Wastewater treatment and discharge pathways

The National Statistical Institute is the source of information about treatment and discharge pathways or systems in the country, as well as quantities of wastewater, generated and handled in each treatment system of domestic/industrial wastewater.

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 through sewer system into centralized aerobic wastewater treatment plant – MCF = 0.03

The methodology applies the MCF value (0.03) for centralized wastewater treatment plants (WWTP) from the 2019 IPCC Refinement (Table 6.3 updated) across the time series, replacing Bulgaria's previous methodology that adopted the 2006 IPCC default MCF for WWTP that are poorly managed / overloaded (0.3). This change was made to better account for information on implementation of the Urban Waste Water Directive (UWWTD) showing that the majority of WWTP in Bulgaria are in compliance with the legislation on remaining BOD in effluent and can therefore be considered as well managed / not overloaded.

- c) waters treated in septic systems – MCF = 0.5

- d) waters treated in latrines – MCF = 0.1

The MCF = 0.1 for waters treated in latrines was chosen because of climate conditions in Bulgaria and the average number of persons per family (which is three, according to the National Statistical Institute). Therefore, it used a methane correction factor value of 0.1 for dry climates and small families (3–5 persons) and BOD value of 60 g/person/day in accordance with the 2006 IPCC Guidelines (vol. 5, chap. 6, table 6.3)

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 2021 the quantity of recovered methane is 1.13 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).. 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 2021 the quantity of sludge, used in agriculture is 18.49 kt.

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 265 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	151 742	69 720	45.95%	82 022	54.05%
2012	132 543	69 526	52.46 %	63 017	47.54%
2013	129 229	74 043	57.30 %	55 186	42.70 %
2014	126 183	74 743	59.23%	51 440	40.77%
2015	110 518	65 976	59.70%	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%
2018	110 469	67 380	60.99%	43 090	39.01%
2019	98 812	58 302	59.00%	40 510	41.00%
2020	92 637	54 031	58.33%	38 606	41.67%
2021	99 483	59 879	60.19%	39 604	39.81%

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

P_i – total industrial product for industrial sector i, t/yr

W_i – wastewater generated, m³/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 CH₄ producing potential (Bo) and methane correction factor (MCF).

$$EF_j = B_0 \bullet MCF_j$$

Where:

EF_j – emission factor for each treatment/discharge pathway or system. kg CH₄/kg COD

B₀ – maximum CH₄ producing capacity. kg CH₄/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 CH₄ emissions from industrial wastewater treatment.

In the end. the total emission of methane from industrial wastewater is estimated. The equation for calculation of annual CH₄ emissions is as follows:

$$CH_4 \text{ emission} = \sum_i [(TOW_i - S_i)EF_i - R_i]$$

Where:

CH₄ emissions – CH₄ emissions in inventory year. kg CH₄/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 CH₄/kg COD for treatment/discharge pathway or system

R_i – amount of CH₄ recovered in inventory year.

CH₄ emissions from industrial wastewater treatment for the period 1988-2021 are shown in figure below.

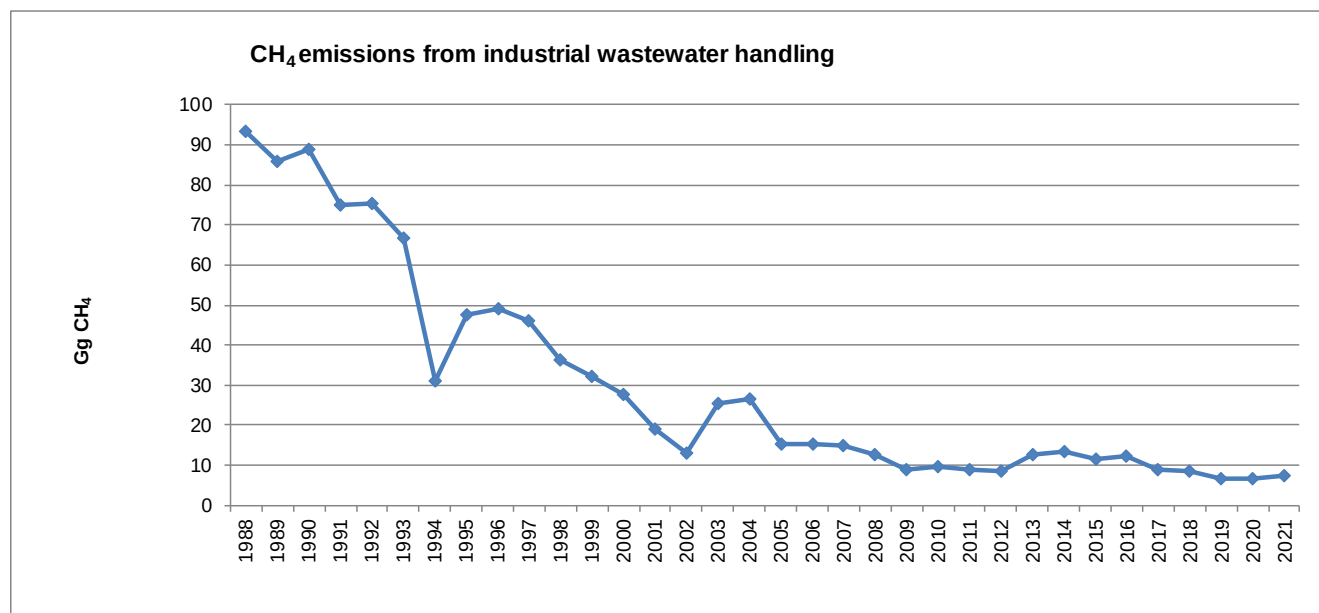


Figure 163 CH₄ emissions from industrial wastewater handling

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 preceeding 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.

Table 266 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
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	223990129	0.04	8.86
2012	226922449	0.04	8.41
2013	266197205	0.05	12.71
2014	278433815	0.05	13.52
2015	236732556	0.05	11.42
2016	286189751	0.04	12.42
2017	241114483	0.04	8.90
2018	211831635	0.04	8.39
2019	175876911	0.04	6.62
2020	159370144	0.04	6.73
2021	182334322	0.04	7.53

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.

Quantity of wastewater

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 267 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%
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	58.32%	39.66%	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%
2018	57.16%	42.17%	1.60%
2019	60.36%	38.92%	0.72%
2020	53.05%	46.23%	0.71%
2021	54.83%	44.07%	1.10%

7.5.3.5 Choice of emission factors and parameters

For CH₄ emission estimation, default IPCC 2006 values were used.

Industrial degradable organic component indicator (COD)

The principal factor in determining the CH₄ 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/m³) 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/m³) is 2.8, which is a default value. For other industries: paper and pulp COD (kg/m³)=9.0; organic chemicals COD (kg/m³)=3.0; textile COD (kg/m³)=0.9

Maximum methane producing capacity (B₀)

It is good practice for the maximum CH₄ producing capacity B₀ to use country specific data from measurements made of various wastewaters. If there is no such specific data, IPCC provides for B₀ to take a default value for industrial wastewater B₀ = 0.25 kg CH₄ / 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 CH₄ 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 through 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 268 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 ₂ O	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 is no specific recalculations.

7.5.7 SOURCE-SPECIFIC IMPROVEMENT PLAN

There is no planned improvement.

7.5.8 NITROUS OXIDE EMISSIONS FROM WASTEWATER

7.5.8.1 Methodological Issues

For estimation of N₂O from domestic wastewater effluent, 2006 IPCC Guidelines suggest a single methodology for calculations with no higher TIER 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 N₂O emissions from wastewater treatment effluent that is discharged into aquatic environments. 2006 IPCC Guidelines suggests a methodology for calculation of N₂O emissions.

The calculations of the emissions follow the general equation 6.7 (p.6.25):

Equation 6.7:

$$N_2O \text{ Emissions} = N_{\text{Effluent}} \bullet EF_{\text{Effluent}} \bullet 44/28.$$

Where:

N₂O emissions - N₂O emissions in inventory year. kg N₂O/yr

N_{Effluent} - nitrogen in the effluent discharged to aquatic environments. kg N/yr

EF_{Effluent} - emission factor for N₂O emissions from discharged to wastewater, kg N₂O-N/kg N

The factor 44/28 is the conversion of kg N₂O-N into kg N₂O.

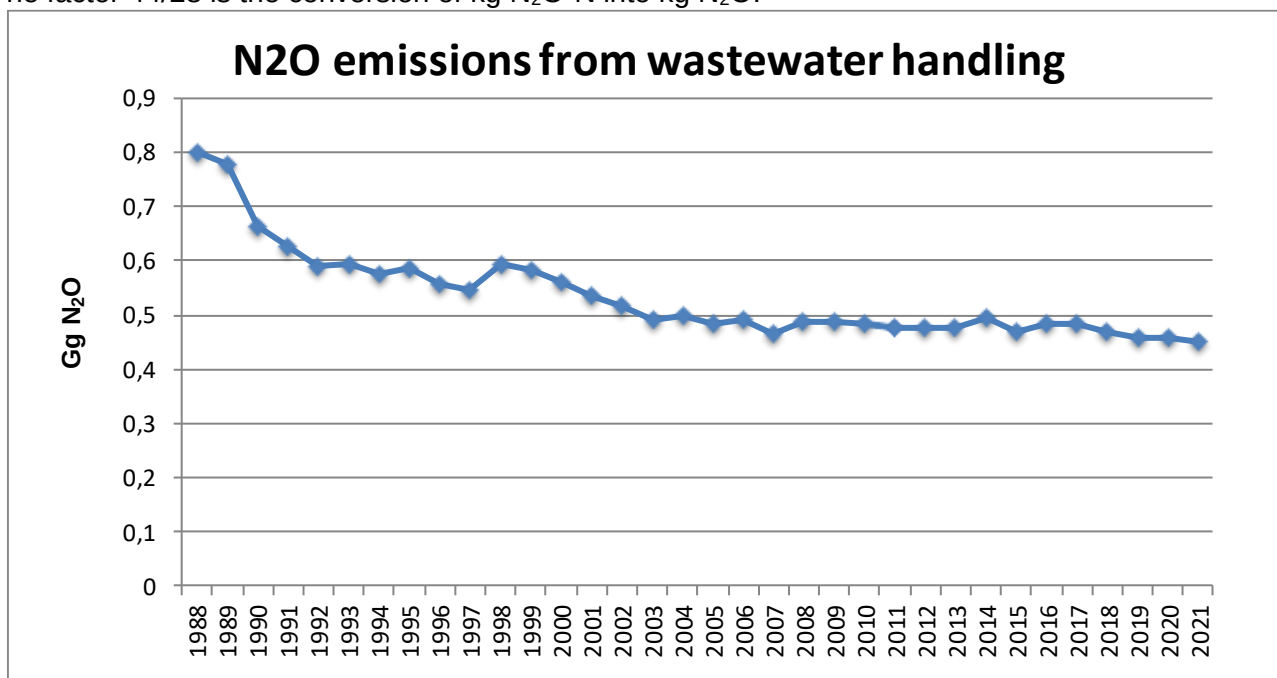


Figure 164 N₂O emissions from wastewater handling

7.5.8.3 Choice of emission factors

The default IPCC emission factor for N₂O emissions from domestic wastewater nitrogen effluent is 0.005 (0.0005-0.25) kg N₂O-N/kg N.

7.5.8.4 Choice of Activity data

The activity data that are needed for estimating N₂O 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:

$$N_{\text{Effluent}} = (P \bullet \text{Protein} \bullet F_{\text{NPR}} \bullet F_{\text{NON-CON}} \bullet F_{\text{IND-COM}}) - N_{\text{sludge}}.$$

Where:

N_{Effluent} - 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-CON} – factor for none-consumed protein added to the wastewater (1.4)

F_{IND-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 N₂O methodology default data

7.5.9 UNCERTAINTIES AND TIME SERIES CONSISTENCY

Large uncertainties are associated with IPCC default emission factors for N₂O from effluent. Calculations of the N₂O emissions with new emission factors are made for whole time series.

7.5.10 SOURCE-SPECIFIC RECALCULATIONS

There is no specific 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 CO₂ AND NITROUS OXIDE EMISSIONS

Indirect CO₂ 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 1988-2021 (emission data 1988-2021) 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 269 Summary of GHG emission recalculations in submission 2023

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
1. Energy			
A. Fuel combustion (sectoral approach)	Revised calculation	A calculation error for the 2020 emission estimates was identified and corrected – the country-specific EFs for 2019 have been previously applied for all subcategories.	See Chapter 3.3.8.9
	Revised AD	Revisions in the national energy balances reflecting net calorific values, statistical differences and non-energy use of natural gas as well as for some liquid fuels (kerosene, gas-diesel oil and bitumen).	
2. Manufacturing industries and construction			
3. Transport	Revised AD and method	New COPERT v. 5.6.1 lead to recalculation of the entire time series for Road transport. Corrected NCVs for 1988, 1989 and 2020. Revised method of allocation between fossil and biofuels.	See Chapter 3.3.12.3.8
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			
B. Chemical industry			
C. Metal industry			
D. Non-energy products from fuels and solvent use			
E. Electronic Industry			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
F. Product uses as ODS substitutes	Recalculation in 2F1 from the previous year, received additional recommendations.	Recalculation in 2F1 from the previous year, received additional recommendations.	2F1
G. Other product manufacture and use	Revised EF	The sector 2G4I has been revised in accordance with ESIG survey in order to estimate the increased consumption during Covid 19 pandemic.	2G4I
H. Other			
3. Agriculture			
A. Enteric fermentation	-	-	-
B. Manure management	-	-	-
C. Rice cultivation	-	-	-
D. Agricultural soils	-	-	-
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	Area of perennial CL converted to FL; biomass growth in LUC to FL, non-CO2 emissions from wildfires; N2O emissions from soils	An improved estimates of the emissions and removals in sub-category LUC to FL due to differentiating the gains in biomass between coniferous and deciduous forests. fixing a technical error in reporting of perennial cropland converted to FL. Another change in the calculations is related to the updated GWP of CH4 and N2O emissions.	6.1.7; 6.3.7
B. Cropland	N2O emissions from soils	Update of the GWP of N2O emissions	6.1.7
C. Grassland	N2O emissions from soils	Update of the GWP of N2O emissions	6.1.7
D. Wetlands	Area of WL and LUC to WL; N2O emissions from soils	Refinement in the estimate of the WL area and LUC to WL across the time series; Update of the GWP of N2O emissions	6.1.7, 6.6.6
E. Settlements	N2O emissions from soils	Update of the GWP of N2O emissions	6.1.7
F. Other land			
G. Harvested wood products		Recalculations of emissions and removals due to availability of updated information for the recent years in FAO stat	
H. Other			
5. Waste			
A. Solid waste disposal	Revised AD	For the years 2019 and 2020 were made recalculations due to revised AD provided by 1) NSI, which present the amounts of the direct landfilled municipal waste and 2) Executive Environment Agency's annual reports, which provide the data for Waste from the installations for in advance treatment, submitted for disposal. The quantities are summarized based on the data received from the submitted annual reports by the obligated persons on the procedure and templates for providing information on waste activities, as well as the procedure for conducting public registers.	5A

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
B. Biological treatment of solid waste	Revised AD	A recalculation was made in sector 5B1 due to revised activity data for total annual amount treated by composting for 2020.	5B
C. Incineration and open burning of waste	Revised AD	The activity data for this sector are revised for 2020.	5C
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 2021 which are submitted this year differ slightly from data reported previously.

Table 270 Recalculation Difference of National Total GHG Emissions.

Year	National Total GHG emissions without LULUCF		
	Submission 2022 [Gg CO ₂ e]	Submission 2023 [Gg CO ₂ e]	Recalculation Difference [%] **
1988*	95367,2	97510,3	2,20
1990	95367,2	97510,3	2,20
1991	80468,1	82566,1	2,54
1992	62312,1	64426,6	3,28
1993	57260,6	59373,5	3,56
1994	56437,0	58373,8	3,32
1995	52526,6	54189,3	3,07
1996	54038,1	55640,3	2,88
1997	55146,3	56673,1	2,69
1998	51813,4	53209,7	2,62
1999	48075,6	49385,5	2,65
2000	41273,6	42436,0	2,74
2001	39208,7	40304,1	2,72
2002	44900,2	45838,5	2,05
2003	42015,0	42949,7	2,18
2004	47315,7	48293,6	2,02
2005	45810,8	46624,4	1,75
2006	45153,0	45904,2	1,64
2007	49205,0	49951,4	1,49
2008	52244,8	52927,0	1,29
2009	52673,0	53230,0	1,05
2010	43727,4	44269,2	1,22
2011	47022,5	47506,3	1,02
2012	55695,6	56209,3	0,91
2013	51234,7	51654,6	0,81
2014	48278,5	47567,2	-1,50
2015	50308,8	49365,0	-1,91
2016	54188,4	52732,3	-2,76

2017	50267,4	48285,8	-4,10
2018	53521,7	50289,8	-6,43
2019	50262,7	45798,2	-9,75
2020	49484,3	44576,6	-11,01

*Base year is 1988 for all gases

**The differences can not be taken into consideration because 2023 submission is prepared under the Fifth Assessment Report (AR5).

10.3 IMPLICATIONS FOR EMISSION TRENDS, INCLUDING TIME SERIES' CONSISTENCY

10.3.1 GHG I INVENTORY AS CAN BE SEEN IN TABLE 270 AND FIGURE 165 BULGARIA'S GREENHOUSE GAS EMISSIONS AS REPORTED IN THE UNFCCC SUBMISSION 2022 ARE DIFFERENT COMPARED TO THE VALUES REPORTED LAST YEAR DUE TO RECALCULATIONS.

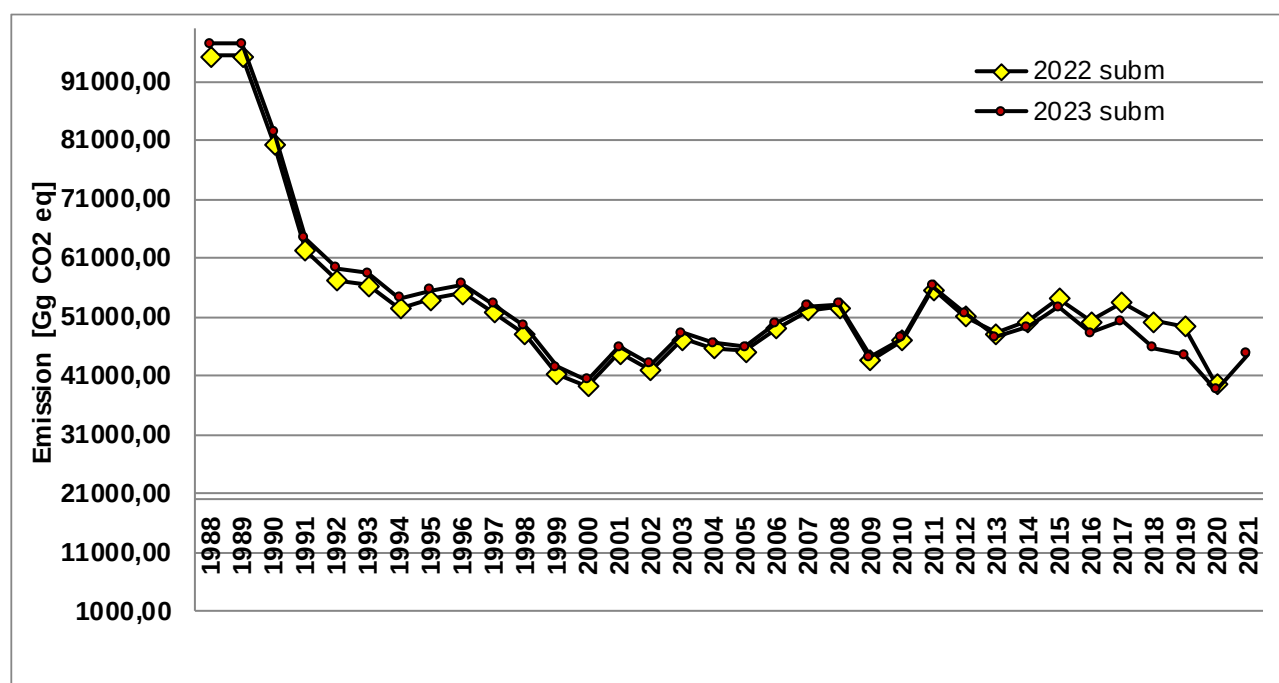


Figure 165 Emission estimates of the submission 2023 and recalculated value

**The differences can not be taken into consideration because 2023 submission is prepared under the Fifth Assessment Report (AR5).

10.4 PLANNED IMPROVEMENTS, INCLUDING RESPONSE TO THE REVIEW PROCESS

Many recalculations have been carried out in response to recommendations proposed in review reports. The following general improvements are planned for the next submissions

- Revision of activity data, update of emission factors and related parameters;
- Conduct further studies for verification of emission factors and assumptions;
- Improvement of uncertainty assessment;
- Improvement of the relation with Branch Business Associations;
- Executive Environmental 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.

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 (CO₂, CH₄, N₂O, HFCs, PFCs, and SF₆).

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 271 Key category Analysis T1: Trend assessment excluding LULUCF

Source	Gas	Fuel/Cat.	1988 (BY) Gg CO ₂ -eq.	2021 Gg CO ₂ - eq.	% excl. (2020)	Trend	Contributi on to Trend	cumul. %
1A1	CO2	Solid fuels	25416,6	18811,9	34,96%	0,264545	16,36%	16,36%
1A3b	CO2	Diesel Oil	2635,8	6779,4	12,60%	0,216580	13,40%	29,76%
1A2	CO2	Solid fuels	10047,7	650,2	1,21%	0,161267	9,98%	39,74%
1A1	CO2	Liquid fuels	10099,2	686,1	1,28%	0,160818	9,95%	49,69%
1A2	CO2	Gaseous fuels	0,0	2063,4	3,83%	0,080830	5,00%	54,69%
1A2	CO2	Liquid fuels	7319,8	1554,7	2,89%	0,075138	4,65%	59,34%
2C1	CO2	Iron and Steel Production	3481,4	10,8	0,02%	0,064282	3,98%	63,31%
5A	CH4	Solid waste disposal	2001,0	2238,7	4,16%	0,050508	3,12%	66,44%
1A4	CO2	Solid fuel	3548,1	564,7	1,05%	0,043822	2,71%	69,15%
1A3b	CO2	LPG	0,0	1107,0	2,06%	0,043366	2,68%	71,83%
4G	CO2	Harvested wood products	-583,3	-1185,3	2,20%	0,035592	2,20%	74,03%
1A4	CO2	Liquid fuel	2825,1	554,6	1,03%	0,030779	1,90%	75,94%
3Da	N2O	Direct N2O emissions from managed soils	4286,2	2785,1	5,18%	0,029439	1,82%	77,76%
2B2	N2O	Nitric Acid Production	1718,1	64,9	0,12%	0,029388	1,82%	79,57%
2F	CO2eq	Product uses as substitutes for ODS - HFCs and PFCs	0,0	739,4	1,37%	0,028966	1,79%	81,37%
2A4d	CO2	DeSOx - instalations	0,0	717,1	1,33%	0,028089	1,74%	83,10%
1A1	CO2	Gaseous fuels	6508,6	2465,2	4,58%	0,024395	1,51%	84,61%
2B1	CO2	Ammonia Production	2557,5	595,1	1,11%	0,024218	1,50%	86,11%
3A2	CH4	Sheep	1795,8	265,3	0,49%	0,022982	1,42%	87,53%
1A4	CO2	Gaseous fuel	0,0	537,4	1,00%	0,021053	1,30%	88,83%
1B2	CO2	Oil and Natural Gas	94,3	539,6	1,00%	0,019386	1,20%	90,03%
1A3b	CO2	Gasoline	4216,6	1507,6	2,80%	0,019309	1,19%	91,23%
2B7	CO2	Soda ash production	397,6	569,4	1,06%	0,014916	0,92%	92,15%
3A1	CH4	Cattle	3443,8	1321,3	2,46%	0,012246	0,76%	92,91%

1A2	CO2	Other fossil fuels	0,0	258,6	0,48%	0,010130	0,63%	93,54%
1B2	CH4	Oil and Natural Gas	165,4	303,9	0,56%	0,008828	0,55%	94,08%
1B1	CH4	Solid fuel	2329,2	883,2	1,64%	0,008690	0,54%	94,62%
1A3b	CO2	Gaseous fuel	0,0	215,2	0,40%	0,008430	0,52%	95,14%

Table 272 Key category Analysis T1: Trend assessment including LULUCF

Source	Gas	Fuel/Cat.	1988 (BY) Gg CO ₂ -eq.	2021 Gg CO ₂ -eq.	% incl. (2020)	Trend	Contribution to Trend	cumul. %
1A1	CO2	Solid fuels	25416,6093	18811,94	28,10%	0,172194	12,70%	12,70%
1A3b	CO2	Diesel Oil	2635,8111	6779,35	10,13%	0,159491	11,76%	24,46%
1A2	CO2	Solid fuels	10047,66253	650,22	0,97%	0,130997	9,66%	34,12%
1A1	CO2	Liquid fuels	10099,152	686,11	1,02%	0,130713	9,64%	43,77%
1A2	CO2	Liquid fuels	7319,75814	1554,67	2,32%	0,063723	4,70%	48,46%
1A2	CO2	Gaseous fuels	0	2063,42	3,08%	0,060526	4,46%	52,93%
2C1	CO2	Iron and Steel Production	3481,4	10,8	0,02%	0,051683	3,81%	56,74%
4A1	CO2	Forest Land remaining Forest Land	-13236,9	-8203,5	12,25%	0,042930	3,17%	59,91%
1A4	CO2	Solid fuel	3548,1	564,7	0,84%	0,036430	2,69%	62,59%
5A	CH4	Solid waste disposal	2001,0	2238,7	3,34%	0,035782	2,64%	65,23%
1A3b	CO2	LPG	0	1107,029	1,65%	0,032473	2,39%	67,63%
4G	CO2	Harvested wood products	-583,3	-1185,3	1,77%	0,026057	1,92%	69,55%
1A4	CO2	Liquid fuel	2825,0573	554,592	0,83%	0,025927	1,91%	71,46%
1A1	CO2	Gaseous fuels	6508,598609	2465,1838	3,68%	0,024900	1,84%	73,30%
2B2	N2O	Nitric Acid Production	1718,1	64,9	0,10%	0,023757	1,75%	75,05%
4B2	CO2	Land converted to Cropland	93,4	800,7	1,20%	0,022091	1,63%	76,68%
2F	CO2eq	Product uses as substitutes for ODS - HFCs and PFCs	0,0	739,4	1,10%	0,021690	1,60%	78,28%
2A4d	CO2	DeSOx - instalations	0,0	717,1	1,07%	0,021033	1,55%	79,83%

2B1	CO2	Ammonia Production	2557,5	595,1	0,89%	0,020741	1,53%	81,36%
3A2	CH4	Sheep	1795,8	265,3	0,40%	0,019039	1,40%	82,76%
1A3b	CO2	Gasoline	4216,6	1507,6	2,25%	0,018756	1,38%	84,15%
3Da	N2O	Direct N2O emissions from managed soils	4286,2	2785,1	4,16%	0,017676	1,30%	85,45%
1A4	CO2	Gaseous fuel	0,0	537,4	0,80%	0,015764	1,16%	86,61%
1B2	CO2	Oil and Natural Gas	94,3	539,6	0,81%	0,014420	1,06%	87,68%
4C2	CO2	Land converted to Grassland	-1158,1	-1075,6	1,61%	0,014254	1,05%	88,73%
4A2	CO2	Land converted to Forest Land	-1240,9	-152,8	0,23%	0,014051	1,04%	89,77%
3A1	CH4	Cattle	3443,8	1321,3	1,97%	0,012679	0,94%	90,70%
4E2	CO2	Land converted to Settlements	475,7	617,4	0,92%	0,011006	0,81%	91,51%
2B7	CO2	Soda ash production	397,6	569,4	0,85%	0,010764	0,79%	92,31%
1B1	CH4	Solid fuel	2329,2	883,2	1,32%	0,008881	0,65%	92,96%
1A2	CO2	Other fossil fuels	0,0	258,6	0,39%	0,007585	0,56%	93,52%
3B3	CH4	Swine	582,3	76,5	0,11%	0,006453	0,48%	94,00%
1B2	CH4	Oil and Natural Gas	165,4	303,9	0,45%	0,006442	0,48%	94,47%
1A3b	CO2	Gaseous fuel	0,0	215,2	0,32%	0,006313	0,47%	94,94%
4A1 (V)	CO2eq	Forest fires	1,6	212,6	0,32%	0,006212	0,46%	95,40%

Table 273 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	22,4%	22,4%
1A1	CO2	Liquid fuels	10 099,2	8,9%	31,3%
1A2	CO2	Solid fuels	10 047,7	8,9%	40,2%
1A2	CO2	Liquid fuels	7 319,8	6,5%	46,6%
1A1	CO2	Gaseous fuels	6 508,6	5,7%	52,4%
1A5	CO2	Stationary - Fossil fuels	5 093,8	4,5%	56,9%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% excl.	cumul. %
3Da	N ₂ O	Direct N ₂ O emissions from managed soils	4 286,2	3,8%	60,6%
1A3b	CO ₂	Gasoline	4 216,6	3,7%	64,4%
1A4	CO ₂	Solid fuel	3 548,1	3,1%	67,5%
2C1	CO ₂	Iron and Steel Production	3 481,4	3,1%	70,6%
3A1	CH ₄	Cattle	3 443,8	3,0%	73,6%
5D	CH ₄	Wastewater treatment and discharge	3 051,0	2,7%	76,3%
1A4	CO ₂	Liquid fuel	2 825,1	2,5%	78,8%
1A3b	CO ₂	Diesel Oil	2 635,8	2,3%	81,1%
2B1	CO ₂	Ammonia Production	2 557,5	2,3%	83,4%
2A1	CO ₂	Cement Production	2 454,5	2,2%	85,5%
1B1	CH ₄	Solid fuel	2 329,2	2,1%	87,6%
5A	CH ₄	Solid waste disposal	2 001,0	1,8%	89,3%
3A2	CH ₄	Sheep	1 795,8	1,6%	90,9%
2B2	N ₂ O	Nitric Acid Production	1 718,1	1,5%	92,4%
3Db	N ₂ O	Indirect N ₂ O Emissions from managed soils	1 303,0	1,1%	93,6%
3B	N ₂ O	N ₂ O em. from Manure Management	842,3	0,7%	94,3%
3B3	CH ₄	Swine	582,3	0,5%	94,8%
3B1	CH ₄	Cattle	530,0	0,5%	95,3%

Table 274 Key category Analysis T1: Level Assessment including LULUCF 1988

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% incl.	cumul. %
1A1	CO ₂	Solid fuels	25 416,6	19,3%	19,3%
4A1	CO ₂	Forest Land remaining Forest Land	13 236,9	10,1%	29,4%
1A1	CO ₂	Liquid fuels	10 099,2	7,7%	37,1%
1A2	CO ₂	Solid fuels	10 047,7	7,6%	44,7%
1A2	CO ₂	Liquid fuels	7 319,8	5,6%	50,3%
1A1	CO ₂	Gaseous fuels	6 508,6	4,9%	55,2%
1A5	CO ₂	Stationary - Fossil fuels	5 093,8	3,9%	59,1%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% incl.	cumul. %
3Da	N ₂ O	Direct N ₂ O emissions from managed soils	4 286,2	3,3%	62,4%
1A3b	CO ₂	Gasoline	4 216,6	3,2%	65,6%
1A4	CO ₂	Solid fuel	3 548,1	2,7%	68,3%
2C1	CO ₂	Iron and Steel Production	3 481,4	2,6%	70,9%
3A1	CH ₄	Cattle	3 443,8	2,6%	73,5%
5D	CH ₄	Wastewater treatment and discharge	3 051,0	2,3%	75,9%
1A4	CO ₂	Liquid fuel	2 825,1	2,1%	78,0%
1A3b	CO ₂	Diesel Oil	2 635,8	2,0%	80,0%
2B1	CO ₂	Ammonia Production	2 557,5	1,9%	82,0%
2A1	CO ₂	Cement Production	2 454,5	1,9%	83,8%
1B1	CH ₄	Solid fuel	2 329,2	1,8%	85,6%
5A	CH ₄	Solid waste disposal	2 001,0	1,5%	87,1%
3A2	CH ₄	Sheep	1 795,8	1,4%	88,5%
2B2	N ₂ O	Nitric Acid Production	1 718,1	1,3%	89,8%
3Db	N ₂ O	Indirect N ₂ O Emissions from managed soils	1 303,0	1,0%	90,8%
4A2	CO ₂	Land converted to Forest Land	1 240,9	0,9%	91,7%
4C2	CO ₂	Land converted to Grassland	1 158,1	0,9%	92,6%
4B1	CO ₂	Cropland remainig Cropland	878,1	0,7%	93,3%
3B	N ₂ O	N ₂ O em. from Manure Management	842,3	0,6%	93,9%
4G	CO ₂	Harvested wood products	583,3	0,4%	94,4%
3B3	CH ₄	Swine	582,3	0,4%	94,8%
3B1	CH ₄	Cattle	530,0	0,4%	95,2%

Table 275 Key category Analysis T1: Level Assessment excluding LULUCF 2021

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% excl.	cumul. %
1A1	CO ₂	Solid fuels	25 416,6	35,0%	35,0%
1A1	CO ₂	Liquid fuels	10 099,2	1,3%	36,2%
1A2	CO ₂	Solid fuels	10 047,7	1,2%	37,4%
1A2	CO ₂	Liquid fuels	7 319,8	2,9%	40,3%
1A1	CO ₂	Gaseous fuels	6 508,6	4,6%	44,9%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% excl.	cumul. %
1A5	CO2	Stationary - Fossil fuels	5 093,8	0,0%	44,9%
3Da	N2O	Direct N2O emissions from managed soils	4 286,2	5,2%	50,1%
1A3b	CO2	Gasoline	4 216,6	2,8%	52,9%
1A4	CO2	Solid fuel	3 548,1	1,0%	53,9%
2C1	CO2	Iron and Steel Production	3 481,4	0,0%	54,0%
3A1	CH4	Cattle	3 443,8	2,5%	56,4%
5D	CH4	Wastewater treatment and discharge	3 051,0	0,9%	57,3%
1A4	CO2	Liquid fuel	2 825,1	1,0%	58,3%
1A3b	CO2	Diesel Oil	2 635,8	12,6%	70,9%
2B1	CO2	Ammonia Production	2 557,5	1,1%	72,0%
2A1	CO2	Cement Production	2 454,5	2,0%	74,0%
1B1	CH4	Solid fuel	2 329,2	1,6%	75,6%
5A	CH4	Solid waste disposal	2 001,0	4,2%	79,8%
3A2	CH4	Sheep	1 795,8	0,5%	80,3%
2B2	N2O	Nitric Acid Production	1 718,1	0,1%	80,4%
3Db	N2O	Indirect N2O Emissions from managed soils	1 303,0	1,4%	81,8%
3B	N2O	N2O em. from Manure Management	842,3	0,5%	82,3%
3B3	CH4	Swine	582,3	0,1%	82,4%
3B1	CH4	Cattle	530,0	0,5%	82,9%
2A4a	CO2	Ceramics - Bricks and Tiles	522,5	0,1%	83,1%
2A2	CO2	Lime Production	450,1	0,5%	83,5%
2B8b	CO2	Ethylene	442,1	0,0%	83,5%
2B7	CO2	Soda ash production	397,6	1,1%	84,6%
1A4	CH4	All fuel	374,8	0,7%	85,3%
3A4	CH4	Other livestock	270,4	0,2%	85,5%
2C2	CO2	Ferroalloys Production	254,9	0,0%	85,5%
1A3a	CO2	Liquid fuel	208,9	0,0%	85,5%
1A4	N2O	All fuel	186,5	0,2%	85,6%
2A3	CO2	Glass production	186,2	0,2%	85,8%
3A3	CH4	Swine	169,8	0,1%	85,9%
1B2	CH4	Oil and Natural Gas	165,4	0,6%	86,4%
2C2	CO2	Lead production	162,8	0,0%	86,5%
3C	CH4	Rice Cultivation	142,2	0,2%	86,7%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% excl.	cumul. %
2D	CO ₂	Non-energy products from fuels and solvent use	138,6	0,0%	86,7%
2A4b	CO ₂	Soda ash uses	126,6	0,3%	87,0%
1A1	N ₂ O	All fuel	121,1	0,2%	87,2%
1B2	CO ₂	Oil and Natural Gas	94,3	1,0%	88,2%
1A2	N ₂ O	All fuel	92,4	0,1%	88,2%
2C2	CO ₂	Zinc production	90,5	0,2%	88,4%
1A3b	CH ₄	All fuel	78,2	0,0%	88,5%
2B5b	CO ₂	Calcium Carbide	73,9	0,0%	88,5%
1B1	CO ₂	Solid fuel	68,8	0,0%	88,6%
4	N ₂ O	Indirect N ₂ O Emissions from managed soils	62,6	0,1%	88,6%
1A3b	N ₂ O	All fuel	54,6	0,2%	88,8%
3B2	CH ₄	Sheep	52,4	0,0%	88,8%
3B4	CH ₄	Other livestock	49,3	0,0%	88,8%
2C1	CH ₄	Iron and Steel Production	36,3	0,0%	88,8%
1A2	CH ₄	All fuel	35,5	0,0%	88,9%
3F	CH ₄	Field burning of agricultural residues	32,6	0,1%	88,9%
3G	CO ₂	Liming	29,1	0,0%	89,0%
2G	N ₂ O	Other product manufacture and use	29,0	0,0%	89,0%
2G	CO ₂	Other product manufacture and use	26,7	0,0%	89,0%
1A1	CH ₄	All fuel	21,1	0,1%	89,1%
2B8	CH ₄	Petrochemical and carbon black production	19,5	0,0%	89,1%
5C	CO ₂	Incineration and open burning of waste	18,5	0,0%	89,1%
1A5	N ₂ O	Stationary - Fossil fuels	8,7	0,0%	89,1%
3F	N ₂ O	Field burning of agricultural residues	7,4	0,0%	89,1%
1A5	CH ₄	Stationary - Fossil fuels	5,4	0,0%	89,1%
1A3b	CO ₂	Other liquid fuels	4,4	0,0%	89,1%
2G1	CO ₂ eq	Electrical equipment - SF ₆	3,4	0,0%	89,2%
2C2	CH ₄	Ferroalloys Production	2,6	0,0%	89,2%
2B8c	CO ₂	Ethylene dichloride and vinyl chloride monomer	1,9	0,0%	89,2%
1A3a	N ₂ O	Liquid fuel	1,6	0,0%	89,2%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% excl.	cumul. %
5C	N ₂ O	Incineration and open burning of waste	1,3	0,0%	89,2%
1B2	N ₂ O	Oil and Natural Gas	0,4	0,0%	89,2%
1A3a	CH ₄	Liquid fuel	0,0	0,0%	89,2%
5C	CH ₄	Incineration and open burning of waste	0,0	0,0%	89,2%
5B	N ₂ O	Biological treatment of solid waste	-	0,0%	89,2%
1A3b	CO ₂	Other fossil fuels	-	0,0%	89,2%
1A2	CO ₂	Gaseous fuels	-	3,8%	93,0%
1A2	CO ₂	Other fossil fuels	-	0,5%	93,5%

Table 276 Key category Analysis T1: Level Assessment including LULUCF 2021

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% incl.	cumul. %
1A1	CO ₂	Solid fuels	18 811,9	28,1%	28,1%
4A1	CO ₂	Forest Land remaining Forest Land	8 203,5	12,3%	40,3%
1A3b	CO ₂	Diesel Oil	6 779,4	10,1%	50,5%
3Da	N ₂ O	Direct N ₂ O emissions from managed soils	2 785,1	4,2%	54,6%
1A1	CO ₂	Gaseous fuels	2 465,2	3,7%	58,3%
5A	CH ₄	Solid waste disposal	2 238,7	3,3%	61,7%
1A2	CO ₂	Gaseous fuels	2 063,4	3,1%	64,7%
1A2	CO ₂	Liquid fuels	1 554,7	2,3%	67,1%
1A3b	CO ₂	Gasoline	1 507,6	2,3%	69,3%
3A1	CH ₄	Cattle	1 321,3	2,0%	71,3%
4G	CO ₂	Harvested wood products	1 185,3	1,8%	73,1%
1A3b	CO ₂	LPG	1 107,0	1,7%	74,7%
4C2	CO ₂	Land converted to Grassland	1 075,6	1,6%	76,3%
2A1	CO ₂	Cement Production	1 060,4	1,6%	77,9%
1B1	CH ₄	Solid fuel	883,2	1,3%	79,2%
4B2	CO ₂	Land converted to Cropland	800,7	1,2%	80,4%
3Db	N ₂ O	Indirect N ₂ O Emissions from managed soils	761,9	1,1%	81,6%

Source	Gas	Fuel/Cat.	GHG emission [Gg CO ₂ eq]	% incl.	cumul. %
2F	CO ₂ eq	Product uses as substitutes for ODS - HFCs and PFCs	739,4	1,1%	82,7%
2A4d	CO ₂	DeSOx - instalations	717,1	1,1%	83,7%
1A1	CO ₂	Liquid fuels	686,1	1,0%	84,8%
1A2	CO ₂	Solid fuels	650,2	1,0%	85,7%
4E2	CO ₂	Land converted to Settlements	617,4	0,9%	86,7%
2B1	CO ₂	Ammonia Production	595,1	0,9%	87,5%
2B7	CO ₂	Soda ash production	569,4	0,9%	88,4%
1A4	CO ₂	Solid fuel	564,7	0,8%	89,2%
1A4	CO ₂	Liquid fuel	554,6	0,8%	90,1%
1B2	CO ₂	Oil and Natural Gas	539,6	0,8%	90,9%
1A4	CO ₂	Gaseous fuel	537,4	0,8%	91,7%
4B1	CO ₂	Cropland remainig Cropland	532,6	0,8%	92,5%
5D	CH ₄	Wastewater treatment and discharge	463,4	0,7%	93,2%
1A4	CH ₄	All fuel	360,5	0,5%	93,7%
1B2	CH ₄	Oil and Natural Gas	303,9	0,5%	94,1%
3B1	CH ₄	Cattle	267,3	0,4%	94,5%
3A2	CH ₄	Sheep	265,3	0,4%	94,9%
1A2	CO ₂	Other fossil fuels	258,6	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 277 and

Table 279 for 2021, while in Table 278 and

Table 280 the results, including LULUCF categories, are shown.

Table 277 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
1	2	3	4	5	6	7	8	9	10
13	3Da	Direct N2O emissions from managed soils	N2O	0,018	200,022	3,643	0,174	0,174	1
8	5A	Solid waste disposal	CH4	0,031	85,440	2,670	0,128	0,302	2
11	4G	Harvested wood products	CO2	0,022	98,509	2,169	0,104	0,405	3
32	3Db	Indirect N2O Emissions from managed soils	N2O	0,003	500,009	1,742	0,083	0,489	4
21	1B2	Oil and Natural Gas	CO2	0,012	100,125	1,201	0,057	0,546	5
27	1B1	Solid fuel	CH4	0,005	200,250	1,077	0,051	0,598	6
33	3B	N2O em. from Manure Management	N2O	0,003	300,007	1,036	0,050	0,647	7
15	2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0,018	50,990	0,914	0,044	0,691	8
2	1A3b	Diesel Oil	CO2	0,134	5,831	0,781	0,037	0,728	9
4	1A1	Liquid fuels	CO2	0,099	7,616	0,758	0,036	0,764	10
26	1B2	Oil and Natural Gas	CH4	0,005	100,125	0,547	0,026	0,791	11
1	1A1	Solid fuels	CO2	0,164	2,236	0,366	0,017	0,808	12
6	1A2	Liquid fuels	CO2	0,046	7,616	0,354	0,017	0,825	13
19	3A2	Sheep	CH4	0,014	20,066	0,285	0,014	0,839	14
7	2C1	Iron and Steel Production	CO2	0,040	7,071	0,281	0,013	0,852	15
44	1A1	All fuel	N2O	0,001	200,022	0,235	0,011	0,863	16
3	1A2	Solid fuels	CO2	0,100	2,236	0,223	0,011	0,874	17
30	1A4	All fuel	CH4	0,004	50,249	0,222	0,011	0,885	18
14	2B2	Nitric Acid Production	N2O	0,018	10,198	0,185	0,009	0,894	19
12	1A4	Liquid fuel	CO2	0,019	8,602	0,164	0,008	0,901	20
57	4	Indirect N2O Emissions from managed soils	N2O	0,000	500,009	0,157	0,008	0,909	21
10	1A3b	LPG	CO2	0,027	5,831	0,156	0,007	0,916	22
29	3B3	Swine	CH4	0,005	32,016	0,155	0,007	0,924	23
24	3A1	Cattle	CH4	0,008	20,010	0,152	0,007	0,931	24
9	1A4	Solid fuel	CO2	0,027	5,385	0,146	0,007	0,938	25
5	1A2	Gaseous fuels	CO2	0,050	2,236	0,112	0,005	0,943	26
18	2B1	Ammonia Production	CO2	0,015	7,280	0,109	0,005	0,949	27
41	3C	Rice Cultivation	CH4	0,001	63,246	0,083	0,004	0,952	28
20	1A4	Gaseous fuel	CO2	0,013	5,385	0,070	0,003	0,956	29

22	1A3b	Gasoline	CO2	0,012	5,831	0,070	0,003	0,959	30
56	1A2	All fuel	N2O	0,000	200,022	0,067	0,003	0,962	31
42	3A3	Swine	CH4	0,001	50,003	0,065	0,003	0,965	32
40	1A3b	All fuel	N2O	0,001	40,112	0,055	0,003	0,968	33
60	1B1	Solid fuel	CO2	0,000	200,250	0,047	0,002	0,970	34
43	2D	Non-energy products from fuels and solvent use	CO2	0,001	31,623	0,038	0,002	0,972	35
62	1A4	All fuel	N2O	0,000	200,062	0,037	0,002	0,974	36
16	2A4d	DeSOx - instalations	CO2	0,017	2,121	0,037	0,002	0,976	37
47	3A4	Other livestock	CH4	0,001	50,040	0,034	0,002	0,977	38
25	1A2	Other fossil fuels	CO2	0,006	5,385	0,034	0,002	0,979	39
17	1A1	Gaseous fuels	CO2	0,015	2,236	0,034	0,002	0,981	40
66	5B	Biological treatment of solid waste	CH4	0,000	401,123	0,032	0,002	0,982	41
28	1A3b	Gaseous fuel	CO2	0,005	5,831	0,030	0,001	0,984	42
50	2G1	Electrical equipment - SF6	CO2eq	0,001	50,990	0,027	0,001	0,985	43
38	2C2	Zinc production	CO2	0,002	15,811	0,027	0,001	0,986	44
23	2B7	Soda ash production	CO2	0,009	2,828	0,026	0,001	0,987	45
39	2C2	Lead production	CO2	0,002	15,811	0,026	0,001	0,989	46
51	1A1	All fuel	CH4	0,001	50,090	0,026	0,001	0,990	47
31	2A4a	Ceramics - Bricks and Tiles	CO2	0,004	5,831	0,025	0,001	0,991	48
52	3F	Field burning of agricultural residues	CH4	0,000	50,090	0,023	0,001	0,992	49
53	3B2	Sheep	CH4	0,000	53,852	0,022	0,001	0,993	50
34	1A3e	Gaseous fuel	CO2	0,003	5,099	0,016	0,001	0,994	51
37	1A3a	Liquid fuel	CO2	0,002	7,071	0,014	0,001	0,995	52
55	1A3b	All fuel	CH4	0,000	40,112	0,013	0,001	0,995	53
54	3B1	Cattle	CH4	0,000	32,016	0,012	0,001	0,996	54
61	3B4	Other livestock	CH4	0,000	58,310	0,011	0,001	0,996	55
74	1B2	Oil and Natural Gas	N2O	0,000	1000,012	0,009	0,000	0,997	56
59	2G	Other product manufacture and use	CO2	0,000	31,623	0,008	0,000	0,997	57
68	5C	Incineration and open burning of waste	CO2	0,000	100,499	0,007	0,000	0,998	58
49	2B5b	Calcium Carbide	CO2	0,001	11,180	0,007	0,000	0,998	59
46	1A3c	Liquid fuel	CO2	0,001	7,071	0,005	0,000	0,998	60
63	1A3d	Gas/diesel oil	CO2	0,000	50,249	0,005	0,000	0,998	61
35	2A1	Cement Production	CO2	0,003	2,121	0,005	0,000	0,999	62
67	1A3c	Liquid fuel	N2O	0,000	60,208	0,005	0,000	0,999	63
36	2A4b	Soda ash uses	CO2	0,002	2,236	0,005	0,000	0,999	64

58	2A3	Glass production	CO2	0,000	14,142	0,004	0,000	0,999	65
48	1A3b	Other fossil fuels	CO2	0,001	5,831	0,004	0,000	1,000	66
45	2A2	Lime Production	CO2	0,001	2,828	0,003	0,000	1,000	67
69	5B	Biological treatment of solid waste	N2O	0,000	42,426	0,002	0,000	1,000	68
64	3F	Field burning of agricultural residues	N2O	0,000	20,224	0,002	0,000	1,000	69
73	5C	Incineration and open burning of waste	N2O	0,000	100,499	0,001	0,000	1,000	70
65	2G	Other product manufacture and use	N2O	0,000	10,050	0,001	0,000	1,000	71
72	1A2	All fuel	CH4	0,000	50,090	0,001	0,000	1,000	72
71	1A3a	Liquid fuel	N2O	0,000	40,311	0,001	0,000	1,000	73
70	1A3b	Other liquid fuels	CO2	0,000	5,831	0,000	0,000	1,000	74
76	1A3e	Gaseous fuel	N2O	0,000	150,003	0,000	0,000	1,000	75
78	1A3d	Gas/diesel oil	N2O	0,000	148,661	0,000	0,000	1,000	76
75	1A3e	Gaseous fuel	CH4	0,000	50,010	0,000	0,000	1,000	77
77	1A3c	Liquid fuel	CH4	0,000	60,208	0,000	0,000	1,000	78
79	1A3d	Gas/diesel oil	CH4	0,000	70,711	0,000	0,000	1,000	79
80	1A3a	Liquid fuel	CH4	0,000	40,311	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	2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	0,000	20,616	0,000	0,000	1,000	82
83	2H	Other	CO2	0,000	31,623	0,000	0,000	1,000	83
84	2C2	Ferroalloys Production	CH4	0,000	25,495	0,000	0,000	1,000	84
85	1A5	Stationary - Fossil fuels	N2O	0,000	200,062	0,000	0,000	1,000	85
86	1A5	Stationary - Fossil fuels	CO2	0,000	8,602	0,000	0,000	1,000	86
87	1A5	Stationary - Fossil fuels	CH4	0,000	50,249	0,000	0,000	1,000	87
88	2B8	Petrochemical and carbon black production	CH4	0,000	11,180	0,000	0,000	1,000	88
89	2B8b	Ethylene	CO2	0,000	30,414	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
91	2C2	Ferroalloys Production	CO2	0,000	25,495	0,000	0,000	1,000	91

Table 278 Key category Analysis T2: Trend assessment including LULUCF

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment excluding LULUCF	Cumulative Percentage	T2
1	2	3	4	5	6	7	8	9	10
8	4A1	Forest Land remaining Forest Land	CO2	0,032	240,019	7,600	0,273	0,273	1
22	3Da	Direct N2O emissions from managed soils	N2O	0,013	200,022	2,608	0,094	0,367	2
10	5A	Solid waste disposal	CH4	0,026	85,440	2,255	0,081	0,448	3
12	4G	Harvested wood products	CO2	0,019	98,509	1,893	0,068	0,516	4
30	1B1	Solid fuel	CH4	0,007	200,250	1,312	0,047	0,563	5
38	3B	N2O em. from Manure Management	N2O	0,004	300,007	1,115	0,040	0,603	6
42	3Db	Indirect N2O Emissions from managed soils	N2O	0,002	500,009	1,065	0,038	0,642	7
24	1B2	Oil and Natural Gas	CO2	0,011	100,125	1,065	0,038	0,680	8
17	2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0,016	50,990	0,816	0,029	0,709	9
4	1A1	Liquid fuels	CO2	0,096	7,616	0,734	0,026	0,736	10
2	1A3b	Diesel Oil	CO2	0,118	5,831	0,686	0,025	0,760	11
33	1B2	Oil and Natural Gas	CH4	0,005	100,125	0,476	0,017	0,777	12
35	4A1 (V)	Forest fires	CO2eq	0,005	103,375	0,474	0,017	0,794	13
26	4A2	Land converted to Forest Land	CO2	0,010	43,105	0,447	0,016	0,810	14
44	4B1	Cropland remainig Cropland	CO2	0,002	207,022	0,383	0,014	0,824	15
5	1A2	Liquid fuels	CO2	0,047	7,616	0,358	0,013	0,837	16
25	4C2	Land converted to Grassland	CO2	0,011	29,732	0,313	0,011	0,848	17
1	1A1	Solid fuels	CO2	0,127	2,236	0,284	0,010	0,859	18
20	3A2	Sheep	CH4	0,014	20,066	0,282	0,010	0,869	19
7	2C1	Iron and Steel Production	CO2	0,038	7,071	0,270	0,010	0,878	20
16	4B2	Land converted to Cropland	CO2	0,016	15,852	0,258	0,009	0,888	21
3	1A2	Solid fuels	CO2	0,097	2,236	0,216	0,008	0,895	22
52	1A1	All fuel	N2O	0,001	200,022	0,192	0,007	0,902	23
27	3A1	Cattle	CH4	0,009	20,010	0,187	0,007	0,909	24
39	1A4	All fuel	CH4	0,004	50,249	0,184	0,007	0,916	25
15	2B2	Nitric Acid Production	N2O	0,018	10,198	0,179	0,006	0,922	26

13	1A4	Liquid fuel	CO2	0,019	8,602	0,164	0,006	0,928	27
32	3B3	Swine	CH4	0,005	32,016	0,152	0,005	0,933	28
9	1A4	Solid fuel	CO2	0,027	5,385	0,145	0,005	0,939	29
11	1A3b	LPG	CO2	0,024	5,831	0,140	0,005	0,944	30
66	4	Indirect N2O Emissions from managed soils	N2O	0,000	500,009	0,117	0,004	0,948	31
19	2B1	Ammonia Production	CO2	0,015	7,280	0,111	0,004	0,952	32
28	4E2	Land converted to Settlements	CO2	0,008	13,454	0,109	0,004	0,956	33
6	1A2	Gaseous fuels	CO2	0,045	2,236	0,100	0,004	0,959	34
21	1A3b	Gasoline	CO2	0,014	5,831	0,081	0,003	0,962	35
62	1A2	All fuel	N2O	0,000	200,022	0,073	0,003	0,965	36
51	3C	Rice Cultivation	CH4	0,001	63,246	0,067	0,002	0,967	37
48	3A3	Swine	CH4	0,001	50,003	0,064	0,002	0,970	38
23	1A4	Gaseous fuel	CO2	0,012	5,385	0,063	0,002	0,972	39
64	1A4	All fuel	N2O	0,000	200,062	0,061	0,002	0,974	40
65	1B1	Solid fuel	CO2	0,000	200,250	0,053	0,002	0,976	41
49	1A3b	All fuel	N2O	0,001	40,112	0,048	0,002	0,978	42
40	4D2	Land converted to Wetlands	CO2	0,003	14,866	0,047	0,002	0,979	43
14	1A1	Gaseous fuels	CO2	0,018	2,236	0,041	0,001	0,981	44
53	3A4	Other livestock	CH4	0,001	50,040	0,041	0,001	0,982	45
50	2D	Non-energy products from fuels and solvent use	CO2	0,001	31,623	0,037	0,001	0,984	46
18	2A4d	DeSOx - instalations	CO2	0,016	2,121	0,033	0,001	0,985	47
31	1A2	Other fossil fuels	CO2	0,006	5,385	0,030	0,001	0,986	48
77	5B	Biological treatment of solid waste	CH4	0,000	401,123	0,029	0,001	0,987	49
34	1A3b	Gaseous fuel	CO2	0,005	5,831	0,027	0,001	0,988	50
46	2C2	Lead production	CO2	0,002	15,811	0,025	0,001	0,989	51
36	2A4a	Ceramics - Bricks and Tiles	CO2	0,004	5,831	0,025	0,001	0,990	52
58	2G1	Electrical equipment - SF6	CO2eq	0,000	50,990	0,024	0,001	0,991	53
47	2C2	Zinc production	CO2	0,001	15,811	0,023	0,001	0,991	54
29	2B7	Soda ash production	CO2	0,008	2,828	0,022	0,001	0,992	55
59	1A1	All fuel	CH4	0,000	50,090	0,022	0,001	0,993	56
60	3B2	Sheep	CH4	0,000	53,852	0,022	0,001	0,994	57
61	3F	Field burning of agricultural residues	CH4	0,000	50,090	0,019	0,001	0,995	58
63	1A3b	All fuel	CH4	0,000	40,112	0,014	0,001	0,995	59
43	1A3a	Liquid fuel	CO2	0,002	7,071	0,014	0,001	0,996	60
41	1A3e	Gaseous fuel	CO2	0,003	5,099	0,014	0,000	0,996	61
73	4C1	Grassland remaining grassland	CO2	0,000	143,087	0,012	0,000	0,997	62
68	3B4	Other livestock	CH4	0,000	58,310	0,012	0,000	0,997	63

37	2A1	Cement Production	CO2	0,004	2,121	0,009	0,000	0,997	64
75	5C	Incineration and open burning of waste	CO2	0,000	100,499	0,008	0,000	0,998	65
86	1B2	Oil and Natural Gas	N2O	0,000	1000,012	0,007	0,000	0,998	66
74	4A2 (V)	Forest fires	CO2eq	0,000	83,958	0,007	0,000	0,998	67
55	2B5b	Calcium Carbide	CO2	0,001	11,180	0,007	0,000	0,998	68
69	2G	Other product manufacture and use	CO2	0,000	31,623	0,006	0,000	0,999	69
54	1A3c	Liquid fuel	CO2	0,001	7,071	0,005	0,000	0,999	70
71	1A3d	Gas/diesel oil	CO2	0,000	50,249	0,005	0,000	0,999	71
67	3G	Liming	CO2	0,000	20,224	0,004	0,000	0,999	72
78	1A3c	Liquid fuel	N2O	0,000	60,208	0,004	0,000	0,999	73
45	2A4b	Soda ash uses	CO2	0,002	2,236	0,004	0,000	0,999	74
57	1A3b	Other fossil fuels	CO2	0,001	5,831	0,003	0,000	0,999	75
80	3H	Urea application	CO2	0,000	50,040	0,002	0,000	1,000	76
83	1A2	All fuel	CH4	0,000	50,090	0,002	0,000	1,000	77
79	3B1	Cattle	CH4	0,000	32,016	0,002	0,000	1,000	78
82	5B	Biological treatment of solid waste	N2O	0,000	42,426	0,002	0,000	1,000	79
56	2A2	Lime Production	CO2	0,001	2,828	0,002	0,000	1,000	80
70	2A3	Glass production	CO2	0,000	14,142	0,002	0,000	1,000	81
76	3F	Field burning of agricultural residues	N2O	0,000	20,224	0,001	0,000	1,000	82
72	2G	Other product manufacture and use	N2O	0,000	10,050	0,001	0,000	1,000	83
85	5C	Incineration and open burning of waste	N2O	0,000	100,499	0,001	0,000	1,000	84
84	1A3a	Liquid fuel	N2O	0,000	40,311	0,001	0,000	1,000	85
81	1A3b	Other liquid fuels	CO2	0,000	5,831	0,000	0,000	1,000	86
88	1A3e	Gaseous fuel	N2O	0,000	150,003	0,000	0,000	1,000	87
90	1A3d	Gas/diesel oil	N2O	0,000	148,661	0,000	0,000	1,000	88
87	1A3e	Gaseous fuel	CH4	0,000	50,010	0,000	0,000	1,000	89
89	1A3c	Liquid fuel	CH4	0,000	60,208	0,000	0,000	1,000	90
92	1A3d	Gas/diesel oil	CH4	0,000	70,711	0,000	0,000	1,000	91
91	1A3a	Liquid fuel	CH4	0,000	40,311	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	4F	Land converted to other land	CO2	0,000	10,000	0,000	0,000	1,000	94
95	2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	0,000	20,616	0,000	0,000	1,000	95
96	2H	Other	CO2	0,000	31,623	0,000	0,000	1,000	96
97	2C2	Ferroalloys Production	CH4	0,000	25,495	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	1A5	Stationary - Fossil fuels	CO2	0,000	8,602	0,000	0,000	1,000	99
100	1A5	Stationary - Fossil fuels	CH4	0,000	50,249	0,000	0,000	1,000	100

101	2B8	Petrochemical and carbon black production	CH4	0,000	11,180	0,000	0,000	1,000	101
102	2B8b	Ethylene	CO2	0,000	30,414	0,000	0,000	1,000	102
103	2C1	Iron and Steel Production	CH4	0,000	26,926	0,000	0,000	1,000	103
104	2C2	Ferroalloys Production	CO2	0,000	25,495	0,000	0,000	1,000	104

Table 279 Key category Analysis T2: Level Assessment excluding LULUCF 2021

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment excluding LULUCF	Cumulative Percentage	T2
1	2	3	4	5	6	7	8	9	10
7	3Da	Direct N2O emissions from managed soils	N2O	0,1	200,0	10,353	0,300	0,300	1
21	3Db	Indirect N2O Emissions from managed soils	N2O	0,0	500,0	7,080	0,205	0,505	2
18	5A	Solid waste disposal	CH4	0,0	85,4	3,555	0,103	0,608	3
17	1B1	Solid fuel	CH4	0,0	200,2	3,287	0,095	0,703	4
22	3B	N2O em. from Manure Management	N2O	0,0	300,0	1,433	0,041	0,744	5
42	1B2	Oil and Natural Gas	CO2	0,0	100,1	1,004	0,029	0,773	6
1	1A1	Solid fuels	CO2	0,3	2,2	0,782	0,023	0,796	7
14	1A3b	Diesel Oil	CO2	0,1	5,8	0,735	0,021	0,817	8
12	5D	Wastewater treatment and discharge	CH4	0,0	84,8	0,730	0,021	0,838	9
90	2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0,0	51,0	0,701	0,020	0,859	10
36	1B2	Oil and Natural Gas	CH4	0,0	100,1	0,565	0,016	0,875	11
11	3A1	Cattle	CH4	0,0	20,0	0,491	0,014	0,889	12
48	4	Indirect N2O Emissions from managed soils	N2O	0,0	500,0	0,396	0,011	0,901	13
41	1A1	All fuel	N2O	0,0	200,0	0,394	0,011	0,912	14
29	1A4	All fuel	CH4	0,0	50,2	0,337	0,010	0,922	15
33	1A4	All fuel	N2O	0,0	200,1	0,300	0,009	0,930	16
4	1A2	Liquid fuels	CO2	0,0	7,6	0,220	0,006	0,937	17
8	1A3b	Gasoline	CO2	0,0	5,8	0,163	0,005	0,942	18
24	3B1	Cattle	CH4	0,0	32,0	0,159	0,005	0,946	19
38	3C	Rice Cultivation	CH4	0,0	63,2	0,143	0,004	0,950	20
77	1A3b	LPG	CO2	0,0	5,8	0,120	0,003	0,954	21

43	1A2	All fuel	N2O	0,0	200,0	0,112	0,003	0,957	22
5	1A1	Gaseous fuels	CO2	0,0	2,2	0,102	0,003	0,960	23
19	3A2	Sheep	CH4	0,0	20,1	0,099	0,003	0,963	24
2	1A1	Liquid fuels	CO2	0,0	7,6	0,097	0,003	0,966	25
30	3A4	Other livestock	CH4	0,0	50,0	0,093	0,003	0,968	26
13	1A4	Liquid fuel	CO2	0,0	8,6	0,089	0,003	0,971	27
75	1A2	Gaseous fuels	CO2	0,0	2,2	0,086	0,002	0,973	28
47	1B1	Solid fuel	CO2	0,0	200,2	0,085	0,002	0,976	29
15	2B1	Ammonia Production	CO2	0,0	7,3	0,081	0,002	0,978	30
49	1A3b	All fuel	N2O	0,0	40,1	0,062	0,002	0,980	31
9	1A4	Solid fuel	CO2	0,0	5,4	0,057	0,002	0,982	32
88	1A4	Gaseous fuel	CO2	0,0	5,4	0,054	0,002	0,983	33
23	3B3	Swine	CH4	0,0	32,0	0,046	0,001	0,985	34
16	2A1	Cement Production	CO2	0,0	2,1	0,042	0,001	0,986	35
44	2C2	Zinc production	CO2	0,0	15,8	0,033	0,001	0,987	36
54	3F	Field burning of agricultural residues	CH4	0,0	50,1	0,032	0,001	0,988	37
28	2B7	Soda ash production	CO2	0,0	2,8	0,030	0,001	0,988	38
58	1A1	All fuel	CH4	0,0	50,1	0,029	0,001	0,989	39
89	2A4d	DeSOx - instalations	CO2	0,0	2,1	0,028	0,001	0,990	40
3	1A2	Solid fuels	CO2	0,0	2,2	0,027	0,001	0,991	41
34	2A3	Glass production	CO2	0,0	14,1	0,026	0,001	0,992	42
76	1A2	Other fossil fuels	CO2	0,0	5,4	0,026	0,001	0,992	43
35	3A3	Swine	CH4	0,0	50,0	0,025	0,001	0,993	44
78	1A3b	Gaseous fuel	CO2	0,0	5,8	0,023	0,001	0,994	45
65	2G1	Electrical equipment - SF6	CO2eq	0,0	51,0	0,022	0,001	0,994	46
45	1A3b	All fuel	CH4	0,0	40,1	0,017	0,001	0,995	47
51	3B4	Other livestock	CH4	0,0	58,3	0,017	0,000	0,995	48
53	1A2	All fuel	CH4	0,0	50,1	0,015	0,000	0,996	49
26	2A2	Lime Production	CO2	0,0	2,8	0,013	0,000	0,996	50
57	2G	Other product manufacture and use	CO2	0,0	31,6	0,013	0,000	0,997	51
20	2B2	Nitric Acid Production	N2O	0,0	10,2	0,012	0,000	0,997	52
85	1A3e	Gaseous fuel	CO2	0,0	5,1	0,012	0,000	0,997	53
60	5C	Incineration and open burning of waste	CO2	0,0	100,5	0,011	0,000	0,998	54
70	1B2	Oil and Natural Gas	N2O	0,0	1000,0	0,010	0,000	0,998	55
39	2D	Non-energy products from fuels and solvent use	CO2	0,0	31,6	0,010	0,000	0,998	56

55	3G	Liming	CO2	0,0	20,2	0,009	0,000	0,999	57
25	2A4a	Ceramics - Bricks and Tiles	CO2	0,0	5,8	0,008	0,000	0,999	58
50	3B2	Sheep	CH4	0,0	53,9	0,008	0,000	0,999	59
40	2A4b	Soda ash uses	CO2	0,0	2,2	0,006	0,000	0,999	60
79	1A3c	Liquid fuel	CO2	0,0	7,1	0,004	0,000	0,999	61
82	1A3d	Gas/diesel oil	CO2	0,0	50,2	0,004	0,000	0,999	62
81	1A3c	Liquid fuel	N2O	0,0	60,2	0,004	0,000	0,999	63
74	1A3b	Other fossil fuels	CO2	0,0	5,8	0,003	0,000	1,000	64
37	2C2	Lead production	CO2	0,0	15,8	0,003	0,000	1,000	65
62	3F	Field burning of agricultural residues	N2O	0,0	20,2	0,003	0,000	1,000	66
46	2B5b	Calcium Carbide	CO2	0,0	11,2	0,002	0,000	1,000	67
32	1A3a	Liquid fuel	CO2	0,0	7,1	0,002	0,000	1,000	68
56	2G	Other product manufacture and use	N2O	0,0	10,0	0,002	0,000	1,000	69
73	5B	Biological treatment of solid waste	N2O	0,0	42,4	0,001	0,000	1,000	70
10	2C1	Iron and Steel Production	CO2	0,0	7,1	0,001	0,000	1,000	71
69	5C	Incineration and open burning of waste	N2O	0,0	100,5	0,000	0,000	1,000	72
87	1A3e	Gaseous fuel	N2O	0,0	150,0	0,000	0,000	1,000	73
68	1A3a	Liquid fuel	N2O	0,0	40,3	0,000	0,000	1,000	74
84	1A3d	Gas/diesel oil	N2O	0,0	148,7	0,000	0,000	1,000	75
86	1A3e	Gaseous fuel	CH4	0,0	50,0	0,000	0,000	1,000	76
80	1A3c	Liquid fuel	CH4	0,0	60,2	0,000	0,000	1,000	77
64	1A3b	Other liquid fuels	CO2	0,0	5,8	0,000	0,000	1,000	78
83	1A3d	Gas/diesel oil	CH4	0,0	70,7	0,000	0,000	1,000	79
71	1A3a	Liquid fuel	CH4	0,0	40,3	0,000	0,000	1,000	80
72	5C	Incineration and open burning of waste	CH4	0,0	100,5	0,000	0,000	1,000	81
31	2C2	Ferroalloys Production	CO2	0,0	25,5	0,000	0,000	1,000	82
59	2B8	Petrochemical and carbon black production	CH4	0,0	11,2	0,000	0,000	1,000	83
52	2C1	Iron and Steel Production	CH4	0,0	26,9	0,000	0,000	1,000	84
91	2H	Other	CO2	0,0	31,6	0,000	0,000	1,000	85
27	2B8b	Ethylene	CO2	0,0	30,4	0,000	0,000	1,000	86
6	1A5	Stationary - Fossil fuels	CO2	0,0	8,6	0,000	0,000	1,000	87
61	1A5	Stationary - Fossil fuels	N2O	0,0	200,1	0,000	0,000	1,000	88
67	2B8c	Ethylene dichloride and vinyl chloride monomer	CO2	0,0	20,6	0,000	0,000	1,000	89
66	2C2	Ferroalloys Production	CH4	0,0	25,5	0,000	0,000	1,000	90
63	1A5	Stationary - Fossil fuels	CH4	0,0	50,2	0,000	0,000	1,000	91

Table 280 Key category Analysis T2: Level Assessment including LULUCF 2021

T1	Source	Fuel/Cat.	GHG	Share	Uncertainty	T*U	Relevant trend assessment excluding LULUCF	Cumulative Percentage	T2
1	2	3	4	5	6	7	8	9	10
2	4A1	Forest Land remaining Forest Land	CO2	0,123	240,019	29,408	0,473	0,473	1
4	3Da	Direct N2O emissions from managed soils	N2O	0,042	200,022	8,320	0,134	0,607	2
17	3Db	Indirect N2O Emissions from managed soils	N2O	0,011	500,009	5,690	0,092	0,699	3
6	5A	Solid waste disposal	CH4	0,033	85,440	2,857	0,046	0,745	4
15	1B1	Solid fuel	CH4	0,013	200,250	2,642	0,043	0,787	5
11	4G	Harvested wood products	CO2	0,018	98,509	1,744	0,028	0,815	6
29	4B1	Cropland remainig Cropland	CO2	0,008	207,022	1,647	0,027	0,842	7
36	3B	N2O em. from Manure Management	N2O	0,004	300,007	1,152	0,019	0,860	8
27	1B2	Oil and Natural Gas	CO2	0,008	100,125	0,807	0,013	0,873	9
1	1A1	Solid fuels	CO2	0,281	2,236	0,628	0,010	0,884	10
3	1A3b	Diesel Oil	CO2	0,101	5,831	0,590	0,010	0,893	11
30	5D	Wastewater treatment and discharge	CH4	0,007	84,812	0,587	0,009	0,903	12
18	2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2 eq	0,011	50,990	0,563	0,009	0,912	13
13	4C2	Land converted to Grassland	CO2	0,016	29,732	0,478	0,008	0,919	14
32	1B2	Oil and Natural Gas	CH4	0,005	100,125	0,454	0,007	0,927	15
10	3A1	Cattle	CH4	0,020	20,010	0,395	0,006	0,933	16
39	4A1 (V)	Forest fires	CO2 eq	0,003	103,375	0,328	0,005	0,938	17
55	4	Indirect N2O Emissions from managed soils	N2O	0,001	500,009	0,319	0,005	0,943	18
47	1A1	All fuel	N2O	0,002	200,022	0,317	0,005	0,948	19
31	1A4	All fuel	CH4	0,005	50,249	0,271	0,004	0,953	20
45	4C1	Grassland remaining grassland	CO2	0,002	143,087	0,252	0,004	0,957	21
51	1A4	All fuel	N2O	0,001	200,062	0,241	0,004	0,961	22

16	4B2	Land converted to Cropland	CO2	0,012	15,852	0,190	0,003	0,964	23
8	1A2	Liquid fuels	CO2	0,023	7,616	0,177	0,003	0,967	24
9	1A3b	Gasoline	CO2	0,023	5,831	0,131	0,002	0,969	25
33	3B1	Cattle	CH4	0,004	32,016	0,128	0,002	0,971	26
22	4E2	Land converted to Settlements	CO2	0,009	13,454	0,124	0,002	0,973	27
44	3C	Rice Cultivation	CH4	0,002	63,246	0,115	0,002	0,975	28
41	4A2	Land converted to Forest Land	CO2	0,002	43,105	0,098	0,002	0,976	29
12	1A3b	LPG	CO2	0,017	5,831	0,096	0,002	0,978	30
60	1A2	All fuel	N2O	0,000	200,022	0,090	0,001	0,979	31
5	1A1	Gaseous fuels	CO2	0,037	2,236	0,082	0,001	0,981	32
34	3A2	Sheep	CH4	0,004	20,066	0,080	0,001	0,982	33
20	1A1	Liquid fuels	CO2	0,010	7,616	0,078	0,001	0,983	34
49	3A4	Other livestock	CH4	0,001	50,040	0,075	0,001	0,984	35
26	1A4	Liquid fuel	CO2	0,008	8,602	0,071	0,001	0,985	36
7	1A2	Gaseous fuels	CO2	0,031	2,236	0,069	0,001	0,987	37
66	1B1	Solid fuel	CO2	0,000	200,250	0,069	0,001	0,988	38
23	2B1	Ammonia Production	CO2	0,009	7,280	0,065	0,001	0,989	39
50	1A3b	All fuel	N2O	0,001	40,112	0,050	0,001	0,989	40
40	4D2	Land converted to Wetlands	CO2	0,003	14,866	0,047	0,001	0,990	41
25	1A4	Solid fuel	CO2	0,008	5,385	0,045	0,001	0,991	42
28	1A4	Gaseous fuel	CO2	0,008	5,385	0,043	0,001	0,992	43
52	3B3	Swine	CH4	0,001	32,016	0,037	0,001	0,992	44
14	2A1	Cement Production	CO2	0,016	2,121	0,034	0,001	0,993	45
46	2C2	Zinc production	CO2	0,002	15,811	0,027	0,000	0,993	46
56	3F	Field burning of agricultural residues	CH4	0,001	50,090	0,026	0,000	0,994	47
57	3H	Urea application	CO2	0,001	50,040	0,025	0,000	0,994	48
24	2B7	Soda ash production	CO2	0,009	2,828	0,024	0,000	0,994	49
59	1A1	All fuel	CH4	0,000	50,090	0,023	0,000	0,995	50
19	2A4d	DeSOx - instalations	CO2	0,011	2,121	0,023	0,000	0,995	51
21	1A2	Solid fuels	CO2	0,010	2,236	0,022	0,000	0,996	52
48	2A3	Glass production	CO2	0,001	14,142	0,021	0,000	0,996	53
35	1A2	Other fossil fuels	CO2	0,004	5,385	0,021	0,000	0,996	54
61	3A3	Swine	CH4	0,000	50,003	0,020	0,000	0,997	55
81	5B	Biological treatment of solid waste	CH4	0,000	401,123	0,020	0,000	0,997	56
38	1A3b	Gaseous fuel	CO2	0,003	5,831	0,019	0,000	0,997	57
64	2G1	Electrical equipment - SF6	CO2 eq	0,000	50,990	0,018	0,000	0,997	58

65	1A3b	All fuel	CH4	0,000	40,112	0,014	0,000	0,998	59
70	3B4	Other livestock	CH4	0,000	58,310	0,013	0,000	0,998	60
68	1A2	All fuel	CH4	0,000	50,090	0,012	0,000	0,998	61
37	2A2	Lime Production	CO2	0,004	2,828	0,011	0,000	0,998	62
67	2G	Other product manufacture and use	CO2	0,000	31,623	0,011	0,000	0,998	63
54	2B2	Nitric Acid Production	N2O	0,001	10,198	0,010	0,000	0,999	64
43	1A3e	Gaseous fuel	CO2	0,002	5,099	0,010	0,000	0,999	65
78	5C	Incineration and open burning of waste	CO2	0,000	100,499	0,009	0,000	0,999	66
84	1B2	Oil and Natural Gas	N2O	0,000	1000,012	0,008	0,000	0,999	67
69	2D	Non-energy products from fuels and solvent use	CO2	0,000	31,623	0,008	0,000	0,999	68
63	3G	Liming	CO2	0,000	20,224	0,007	0,000	0,999	69
53	2A4a	Ceramics - Bricks and Tiles	CO2	0,001	5,831	0,006	0,000	0,999	70
76	3B2	Sheep	CH4	0,000	53,852	0,006	0,000	0,999	71
80	4A2 (V)	Forest fires	CO2 eq	0,000	83,958	0,005	0,000	1,000	72
42	2A4b	Soda ash uses	CO2	0,002	2,236	0,005	0,000	1,000	73
58	1A3c	Liquid fuel	CO2	0,000	7,071	0,003	0,000	1,000	74
79	1A3d	Gas/diesel oil	CO2	0,000	50,249	0,003	0,000	1,000	75
82	1A3c	Liquid fuel	N2O	0,000	60,208	0,003	0,000	1,000	76
62	1A3b	Other fossil fuels	CO2	0,000	5,831	0,002	0,000	1,000	77
75	2C2	Lead production	CO2	0,000	15,811	0,002	0,000	1,000	78
77	3F	Field burning of agricultural residues	N2O	0,000	20,224	0,002	0,000	1,000	79
73	2B5b	Calcium Carbide	CO2	0,000	11,180	0,002	0,000	1,000	80
71	1A3a	Liquid fuel	CO2	0,000	7,071	0,002	0,000	1,000	81
74	2G	Other product manufacture and use	N2O	0,000	10,050	0,002	0,000	1,000	82
83	5B	Biological treatment of solid waste	N2O	0,000	42,426	0,001	0,000	1,000	83
72	2C1	Iron and Steel Production	CO2	0,000	7,071	0,001	0,000	1,000	84
86	5C	Incineration and open burning of waste	N2O	0,000	100,499	0,000	0,000	1,000	85
89	1A3e	Gaseous fuel	N2O	0,000	150,003	0,000	0,000	1,000	86
87	1A3a	Liquid fuel	N2O	0,000	40,311	0,000	0,000	1,000	87
91	1A3d	Gas/diesel oil	N2O	0,000	148,661	0,000	0,000	1,000	88
88	1A3e	Gaseous fuel	CH4	0,000	50,010	0,000	0,000	1,000	89
90	1A3c	Liquid fuel	CH4	0,000	60,208	0,000	0,000	1,000	90
85	1A3b	Other liquid fuels	CO2	0,000	5,831	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
95	4F	Land converted to other land	CO2	0,000	10,000	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
103	2C2	Ferroalloys Production	CO2	0,000	25,495	0,000	0,000	1,000	103
104	2C2	Ferroalloys Production	CH4	0,000	25,495	0,000	0,000	1,000	104

ANNEX 2 ASSESSMENT OF THE UNCERTAINTY

Introduction

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 have been described in detail by IPCC (IPCC 2006). Two different approaches may be used in order to achieve the 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 a reliable assessment of inventory uncertainty. More flexibility is available with “Approach 2” method. The Monte-Carlo approach allows any probability distribution of input parameters, and it also allows 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 an error in one of the values would be fully reflected in the other value. While “full dependency” theoretically can be covered with error propagation, this is normally not done and only in a very limited occasions possible in the IPCC spreadsheets.

The general properties of an 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 would result in 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 often uncertainty data may not be available, or a “balance” approach (energy balance, solvent balance) will allow more reliable at 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 assessment of emission uncertainty at any level where the most reasonable uncertainty data are available. Very detailed information can be entered directly, for aggregating 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 (e.g. in the IPCC reports) from variation presented in literature, and by contacting national experts. Structured interviews were held. The difference between Approach 1 and Approach 2 uncertainty can be explained by covariance of uncertainties between (key) source categories, which occurs when data are statistically dependent. The Approach 1 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 value.

Detailed Results of Approach 1 Uncertainty Analysis

The tables 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 281 Approach 1 Uncertainty Calculation and Reporting, Gg CO₂-eq. (excluding LULUCF) for 2021.

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions	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	686,11	3	7	7,6	0,097	-0,036	0,006	-0,253	0,026	0,254
1A1	Solid fuels	CO2	25416,61	18811,94	1	2	2,2	0,780	0,059	0,166	0,119	0,234	0,262
1A1	Gaseous fuels	CO2	6508,60	2465,18	1	2	2,2	0,102	-0,005	0,022	-0,011	0,031	0,033
1A1	All fuel	CH4	21,11	31,31	3	50	50,1	0,029	0,000	0,000	0,009	0,001	0,009
1A1	All fuel	N2O	121,11	106,04	3	200	200,0	0,393	0,000	0,001	0,085	0,004	0,086
1A2	Liquid fuels	CO2	7319,76	1554,68	3	7	7,6	0,220	-0,017	0,014	-0,118	0,058	0,132
1A2	Solid fuels	CO2	10047,66	650,21	1	2	2,2	0,027	-0,036	0,006	-0,072	0,008	0,073
1A2	Gaseous fuels	CO2	0,00	2063,42	1	2	2,2	0,086	0,018	0,018	0,036	0,026	0,044
1A2	Other fossil fuels	CO2	0,00	258,60	5	2	5,4	0,026	0,002	0,002	0,005	0,016	0,017
1A2	All fuel	CH4	35,55	16,31	3	50	50,1	0,015	0,000	0,000	0,000	0,001	0,001
1A2	All fuel	N2O	92,44	30,11	3	200	200,0	0,112	0,000	0,000	-0,024	0,001	0,024
1A3a	Liquid fuel	CO2	208,93	15,26	5	5	7,1	0,002	-0,001	0,000	-0,004	0,001	0,004
1A3a	Liquid fuel	CH4	0,04	0,01	5	40	40,3	0,000	0,000	0,000	0,000	0,000	0,000
1A3a	Liquid fuel	N2O	1,56	0,13	5	40	40,3	0,000	0,000	0,000	0,000	0,000	0,000
1A3b	Gasoline	CO2	4216,56	1507,58	3	5	5,8	0,163	-0,004	0,013	-0,022	0,056	0,060
1A3b	Diesel Oil	CO2	2635,81	6779,35	3	5	5,8	0,733	0,049	0,060	0,243	0,253	0,351
1A3b	All fuel	CH4	78,16	23,27	3	40	40,1	0,017	0,000	0,000	-0,005	0,001	0,005
1A3b	All fuel	N2O	54,58	82,92	3	40	40,1	0,062	0,001	0,001	0,020	0,003	0,020
1A3b	LPG	CO2	0,00	1107,03	3	5	5,8	0,120	0,010	0,010	0,049	0,041	0,064

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions introduced by EF 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.		%	%							
1A3b	Gaseous fuel	CO2	0,00	215,21	3	5	5,8	0,023	0,002	0,002	0,009	0,008	0,012
1A3b	Other liquid fuels	CO2	4,39	0,39	3	5	5,8	0,000	0,000	0,000	0,000	0,000	0,000
1A3b	Other fossil fuels	CO2	0,00	25,75	3	5	5,8	0,003	0,000	0,000	0,001	0,001	0,001
1A3c	Liquid fuel	CO2	0,00	31,79	5	5	7,1	0,004	0,000	0,000	0,001	0,002	0,002
1A3c	Liquid fuel	CH4	0,00	0,05	5	60	60,2	0,000	0,000	0,000	0,000	0,000	0,000
1A3c	Liquid fuel	N2O	0,00	3,25	5	60	60,2	0,004	0,000	0,000	0,002	0,000	0,002
1A3d	Gas/diesel oil	CO2	0,00	4,44	50	5	50,2	0,004	0,000	0,000	0,000	0,003	0,003
1A3d	Gas/diesel oil	CH4	0,00	0,01	50	50	70,7	0,000	0,000	0,000	0,000	0,000	0,000
1A3d	Gas/diesel oil	N2O	0,00	0,03	50	140	148,7	0,000	0,000	0,000	0,000	0,000	0,000
1A3e	Gaseous fuel	CO2	0,00	125,58	1	5	5,1	0,012	0,001	0,001	0,006	0,002	0,006
1A3e	Gaseous fuel	CH4	0,00	0,06	1	50	50,0	0,000	0,000	0,000	0,000	0,000	0,000
1A3e	Gaseous fuel	N2O	0,00	0,06	1	150	150,0	0,000	0,000	0,000	0,000	0,000	0,000
1A4	Liquid fuel	CO2	2825,06	554,59	5	7	8,6	0,088	-0,007	0,005	-0,048	0,035	0,059
1A4	Solid fuel	CO2	3548,08	564,67	2	5	5,4	0,056	-0,010	0,005	-0,049	0,014	0,051
1A4	Gaseous fuel	CO2	0,00	537,43	5	2	5,4	0,054	0,005	0,005	0,009	0,033	0,035
1A4	All fuel	CH4	374,82	360,49	5	50	50,2	0,336	0,002	0,003	0,080	0,022	0,083
1A4	All fuel	N2O	186,48	80,75	5	200	200,1	0,300	0,000	0,001	-0,014	0,005	0,015
1A5	Stationary - Fossil fuels	CO2	5093,82	0,00	5	7	8,6	0,000	-0,021	0,000	-0,149	0,000	0,149
1A5	Stationary - Fossil fuels	CH4	5,39	0,00	5	50	50,2	0,000	0,000	0,000	-0,001	0,000	0,001
1A5	Stationary - Fossil fuels	N2O	8,71	0,00	5	200	200,1	0,000	0,000	0,000	-0,007	0,000	0,007
1B1	Solid fuel	CO2	68,81	22,90	10	200	200,2	0,085	0,000	0,000	-0,017	0,003	0,017
1B1	Solid fuel	CH4	2329,19	883,22	10	200	200,2	3,280	-0,002	0,008	-0,391	0,110	0,406
1B2	Oil and Natural Gas	CO2	94,31	539,62	5	100	100,1	1,002	0,004	0,005	0,436	0,034	0,437
1B2	Oil and Natural Gas	CH4	165,42	303,85	5	100	100,1	0,564	0,002	0,003	0,198	0,019	0,199
1B2	Oil and Natural Gas	N2O	0,36	0,53	5	1000	1000,0	0,010	0,000	0,000	0,003	0,000	0,003

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions	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.		%	%							
2A1	Cement Production	CO2	2454,46	1060,39	1,5	1,5	2,1	0,042	-0,001	0,009	-0,001	0,020	0,020
2A2	Lime Production	CO2	450,07	255,85	2	2	2,8	0,013	0,000	0,002	0,001	0,006	0,006
2A3	Glass production	CO2	186,24	100,03	10	10	14,1	0,026	0,000	0,001	0,001	0,012	0,012
2A4a	Ceramics - Bricks and Tiles	CO2	522,51	71,41	3	5	5,8	0,008	-0,002	0,001	-0,008	0,003	0,008
2A4b	Soda ash uses	CO2	126,58	144,17	2	1	2,2	0,006	0,001	0,001	0,001	0,004	0,004
2A4d	DeSOx - installations	CO2	0,00	717,05	1,5	1,5	2,1	0,028	0,006	0,006	0,009	0,013	0,016
2B1	Ammonia Production	CO2	2557,47	595,13	2	7	7,3	0,080	-0,005	0,005	-0,038	0,015	0,041
2B2	Nitric Acid Production	N2O	1718,08	64,91	2	10	10,2	0,012	-0,007	0,001	-0,066	0,002	0,066
2B5b	Calcium Carbide	CO2	73,94	10,70	5	10	11,2	0,002	0,000	0,000	-0,002	0,001	0,002
2B7	Soda ash production	CO2	397,64	569,43	2	2	2,8	0,030	0,003	0,005	0,007	0,014	0,016
2B8	Petrochemical and carbon black production	CH4	19,52	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	-0,055	0,000	0,055
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	10,76	5	5	7,1	0,001	-0,014	0,000	-0,072	0,001	0,072
2C1	Iron and Steel Production	CH4	36,31	0,00	10	25	26,9	0,000	0,000	0,000	-0,004	0,000	0,004
2C2	Ferroalloys Production	CO2	254,94	0,00	5	25	25,5	0,000	-0,001	0,000	-0,027	0,000	0,027
2C2	Ferroalloys Production	CH4	2,55	0,00	5	25	25,5	0,000	0,000	0,000	0,000	0,000	0,000
2C2	Lead production	CO2	162,82	9,21	5	15	15,8	0,003	-0,001	0,000	-0,009	0,001	0,009
2C2	Zinc production	CO2	90,47	112,68	5	15	15,8	0,033	0,001	0,001	0,009	0,007	0,012
2D	Non-energy products from fuels and solvent use	CO2	138,57	16,28	10	30	31,6	0,010	0,000	0,000	-0,013	0,002	0,013
2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0,00	739,43	10	50	51,0	0,699	0,007	0,007	0,325	0,092	0,338
2G	Other product manufacture and use	N2O	28,99	10,36	10	1	10,0	0,002	0,000	0,000	0,000	0,001	0,001
2G	Other product manufacture and use	CO2	26,73	22,79	10	30	31,6	0,013	0,000	0,000	0,003	0,003	0,004

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions	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.		%	%							
2G1	Electrical equipment - SF6	CO2eq	3,40	23,27	10	50	51,0	0,022	0,000	0,000	0,010	0,003	0,010
2H	Other	CO2	0,00	0,00	10	30	31,6	0,000	0,000	0,000	0,000	0,000	0,000
3A1	Cattle	CH4	3443,83	1321,27	0,64	20	20,0	0,490	-0,003	0,012	-0,055	0,011	0,056
3A2	Sheep	CH4	1795,76	265,29	1,63	20	20,1	0,099	-0,005	0,002	-0,103	0,005	0,103
3A3	Swine	CH4	169,77	27,02	0,51	50	50,0	0,025	0,000	0,000	-0,024	0,000	0,024
3A4	Other livestock	CH4	270,38	99,98	2	50	50,0	0,093	0,000	0,001	-0,012	0,002	0,013
3B	N2O em. from Manure Management	N2O	842,27	257,08	2	300	300,0	1,430	-0,001	0,002	-0,376	0,006	0,377
3B1	Cattle	CH4	530,01	267,29	25	20	32,0	0,159	0,000	0,002	0,003	0,083	0,083
3B2	Sheep	CH4	52,43	7,70	50	20	53,9	0,008	0,000	0,000	-0,003	0,005	0,006
3B3	Swine	CH4	582,32	76,51	25	20	32,0	0,045	-0,002	0,001	-0,035	0,024	0,042
3B4	Other livestock	CH4	49,26	15,43	50	30	58,3	0,017	0,000	0,000	-0,002	0,010	0,010
3C	Rice Cultivation	CH4	142,22	121,58	20	60	63,2	0,143	0,000	0,001	0,029	0,030	0,042
3Da	Direct N2O emissions from managed soils	N2O	4286,24	2785,06	3	200	200,0	10,332	0,007	0,025	1,322	0,104	1,326
3Db	Indirect N2O Emissions from managed soils	N2O	1302,96	761,93	3	500	500,0	7,066	0,001	0,007	0,632	0,028	0,633
3F	Field burning of agricultural residues	CH4	32,55	34,48	3	50	50,1	0,032	0,000	0,000	0,008	0,001	0,008
3F	Field burning of agricultural residues	N2O	7,41	7,15	3	20	20,2	0,003	0,000	0,000	0,001	0,000	0,001
3G	Liming	CO2	29,14	24,64	3	20	20,2	0,009	0,000	0,000	0,002	0,001	0,002
3H	Urea application	CO2	62,17	33,92	2	50	50,0	0,031	0,000	0,000	0,002	0,001	0,002
5A	Solid waste disposal	CH4	2000,99	2238,71	30	80	85,4	3,548	0,011	0,020	0,908	0,836	1,234
5B	Biological treatment of solid waste	CH4	0,00	3,33	30	400	401,1	0,025	0,000	0,000	0,012	0,001	0,012
5B	Biological treatment of solid waste	N2O	0,00	1,83	30	30	42,4	0,001	0,000	0,000	0,000	0,001	0,001
5C	Incineration and open burning of waste	CO2	18,51	5,71	10	100	100,5	0,011	0,000	0,000	-0,003	0,001	0,003
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

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF uncertainty	Uncertainty in trend in national emissions	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.		%	%							
5C	Incineration and open burning of waste	N ₂ O	1,29	0,25	10	100	100,5	0,000	0,000	0,000	0,000	0,000	0,000
5D	Wastewater treatment and discharge	CH ₄	3050,95	463,42	67	52	84,8	0,729	-0,009	0,004	-0,450	0,386	0,593
5D	Wastewater treatment and discharge	N ₂ O	212,59	119,68	20	50	53,9	0,120	0,000	0,001	0,008	0,030	0,031
Total					113622,3	53917,3				13,653			2,25
%					100,0	100,0							
National Total					113622,3	53917,3							

Table 282 Approach 1 Uncertainty Calculation and Reporting, Gg CO₂-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 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	CO ₂	10099,15	10099,15	3	7	7,6	0,677	0,000	0,089	0,000	0,377	0,377
1A1	Solid fuels	CO ₂	25416,61	25416,61	1	2	2,2	0,500	0,000	0,224	0,000	0,316	0,316
1A1	Gaseous fuels	CO ₂	6508,60	6508,60	1	2	2,2	0,128	0,000	0,057	0,000	0,081	0,081
1A1	All fuel	CH ₄	21,11	21,11	3	50	50,1	0,009	0,000	0,000	0,000	0,001	0,001
1A1	All fuel	N ₂ O	121,11	121,11	3	200	200,0	0,213	0,000	0,001	0,000	0,005	0,005
1A2	Liquid fuels	CO ₂	7319,76	7319,76	3	7	7,6	0,491	0,000	0,064	0,000	0,273	0,273
1A2	Solid fuels	CO ₂	10047,66	10047,66	1	2	2,2	0,198	0,000	0,088	0,000	0,125	0,125

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 in trend in national emissions introduced by AD	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.		%	%	%	%	%	%	%	%	%
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	35,55	35,55	3	50	50,1	0,016	0,000	0,000	0,000	0,001	0,001
1A2	All fuel	N2O	92,44	92,44	3	200	200,0	0,163	0,000	0,001	0,000	0,003	0,003
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	1,56	1,56	5	40	40,3	0,001	0,000	0,000	0,000	0,000	0,000
1A3b	Gasoline	CO2	4216,56	4216,56	3	5	5,8	0,216	0,000	0,037	0,000	0,157	0,157
1A3b	Diesel Oil	CO2	2635,81	2635,81	3	5	5,8	0,135	0,000	0,023	0,000	0,098	0,098
1A3b	All fuel	CH4	78,16	78,16	3	40	40,1	0,028	0,000	0,001	0,000	0,003	0,003
1A3b	All fuel	N2O	54,58	54,58	3	40	40,1	0,019	0,000	0,000	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	4,39	4,39	3	5	5,8	0,000	0,000	0,000	0,000	0,000	0,000
1A3b	Other fossil 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
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	0,214	0,000	0,025	0,000	0,176	0,176

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 in trend in national emissions introduced by AD	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.		%	%	%	%	%	%	%	%	%
1A4	Solid fuel	CO2	3548,08	3548,08	2	5	5,4	0,168	0,000	0,031	0,000	0,088	0,088
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	374,82	374,82	5	50	50,2	0,166	0,000	0,003	0,000	0,023	0,023
1A4	All fuel	N2O	186,48	186,48	5	200	200,1	0,328	0,000	0,002	0,000	0,012	0,012
1A5	Stationary - Fossil fuels	CO2	5093,82	5093,82	5	7	8,6	0,386	0,000	0,045	0,000	0,317	0,317
1A5	Stationary - Fossil fuels	CH4	5,39	5,39	5	50	50,2	0,002	0,000	0,000	0,000	0,000	0,000
1A5	Stationary - Fossil fuels	N2O	8,71	8,71	5	200	200,1	0,015	0,000	0,000	0,000	0,001	0,001
1B1	Solid fuel	CO2	68,81	68,81	10	200	200,2	0,121	0,000	0,001	0,000	0,009	0,009
1B1	Solid fuel	CH4	2329,19	2329,19	10	200	200,2	4,105	0,000	0,020	0,000	0,290	0,290
1B2	Oil and Natural Gas	CO2	94,31	94,31	5	100	100,1	0,083	0,000	0,001	0,000	0,006	0,006
1B2	Oil and Natural Gas	CH4	165,42	165,42	5	100	100,1	0,146	0,000	0,001	0,000	0,010	0,010
1B2	Oil and Natural Gas	N2O	0,36	0,36	5	1000	1000,0	0,003	0,000	0,000	0,000	0,000	0,000
2A1	Cement Production	CO2	2454,46	2454,46	1,5	1,5	2,1	0,046	0,000	0,022	0,000	0,046	0,046
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 Tiles	CO2	522,51	522,51	3	5	5,8	0,027	0,000	0,005	0,000	0,020	0,020
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 - installations	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	2557,47	2557,47	2	7	7,3	0,164	0,000	0,023	0,000	0,064	0,064
2B2	Nitric Acid Production	N2O	1718,08	1718,08	2	10	10,2	0,154	0,000	0,015	0,000	0,043	0,043
2B5b	Calcium Carbide	CO2	73,94	73,94	5	10	11,2	0,007	0,000	0,001	0,000	0,005	0,005
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	19,52	19,52	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	0,118	0,000	0,004	0,000	0,028	0,028
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

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 in trend in national emissions intro-duced by AD	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.		%	%	%	%	%	%	%	%	%
2C1	Iron and Steel Production	CO2	3481,44	3481,44	5	5	7,1	0,217	0,000	0,031	0,000	0,217	0,217
2C1	Iron and Steel Production	CH4	36,31	36,31	10	25	26,9	0,009	0,000	0,000	0,000	0,005	0,005
2C2	Ferroalloys Production	CO2	254,94	254,94	5	25	25,5	0,057	0,000	0,002	0,000	0,016	0,016
2C2	Ferroalloys Production	CH4	2,55	2,55	5	25	25,5	0,001	0,000	0,000	0,000	0,000	0,000
2C2	Lead production	CO2	162,82	162,82	5	15	15,8	0,023	0,000	0,001	0,000	0,010	0,010
2C2	Zinc production	CO2	90,47	90,47	5	15	15,8	0,013	0,000	0,001	0,000	0,006	0,006
2D	Non-energy products from fuels and solvent use	CO2	138,57	138,57	10	30	31,6	0,039	0,000	0,001	0,000	0,017	0,017
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	28,99	28,99	10	1	10,0	0,003	0,000	0,000	0,000	0,004	0,004
2G	Other product manufacture and use	CO2	26,73	26,73	10	30	31,6	0,007	0,000	0,000	0,000	0,003	0,003
2G1	Electrical equipment - SF6	CO2eq	3,40	3,40	10	50	51,0	0,002	0,000	0,000	0,000	0,000	0,000
2H	Other	CO2	0,00	0,00	10	30	31,6	0,000	0,000	0,000	0,000	0,000	0,000
3A1	Cattle	CH4	3443,83	3443,83	0,64	20	20,0	0,606	0,000	0,030	0,000	0,027	0,027
3A2	Sheep	CH4	1795,76	1795,76	1,63	20	20,1	0,317	0,000	0,016	0,000	0,036	0,036
3A3	Swine	CH4	169,77	169,77	0,51	50	50,0	0,075	0,000	0,001	0,000	0,001	0,001
3A4	Other livestock	CH4	270,38	270,38	2	50	50,0	0,119	0,000	0,002	0,000	0,007	0,007
3B	N2O em. from Manure Management	N2O	842,27	842,27	2	300	300,0	2,224	0,000	0,007	0,000	0,021	0,021
3B1	Cattle	CH4	530,01	530,01	25	20	32,0	0,149	0,000	0,005	0,000	0,165	0,165
3B2	Sheep	CH4	52,43	52,43	50	20	53,9	0,025	0,000	0,000	0,000	0,033	0,033
3B3	Swine	CH4	582,32	582,32	25	20	32,0	0,164	0,000	0,005	0,000	0,181	0,181
3B4	Other livestock	CH4	49,26	49,26	50	30	58,3	0,025	0,000	0,000	0,000	0,031	0,031
3C	Rice Cultivation	CH4	142,22	142,22	20	60	63,2	0,079	0,000	0,001	0,000	0,035	0,035
3Da	Direct N2O emissions from managed soils	N2O	4286,24	4286,24	3	200	200,0	7,546	0,000	0,038	0,000	0,160	0,160
3Db	Indirect N2O Emissions from managed soils	N2O	1302,96	1302,96	3	500	500,0	5,734	0,000	0,011	0,000	0,049	0,049

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 in trend in national emissions introduced by AD	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.		%	%	%	%	%	%	%	%	%
3F	Field burning of agricultural residues	CH ₄	32,55	32,55	3	50	50,1	0,014	0,000	0,000	0,000	0,001	0,001
3F	Field burning of agricultural residues	N ₂ O	7,41	7,41	3	20	20,2	0,001	0,000	0,000	0,000	0,000	0,000
3G	Liming	CO ₂	29,14	29,14	3	20	20,2	0,009	0,000	0,000	0,002	0,001	0,002
3H	Urea application	CO ₂	62,17	62,17	2	50	50,0	0,027	0,000	0,001	0,000	0,002	0,002
5A	Solid waste disposal	CH ₄	2000,99	2000,99	30	80	85,4	1,505	0,000	0,018	0,000	0,747	0,747
5B	Biological treatment of solid waste	CH ₄	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	N ₂ O	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	CO ₂	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	CH ₄	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	N ₂ O	1,29	1,29	10	100	100,5	0,001	0,000	0,000	0,000	0,000	0,000
5D	Wastewater treatment and discharge	CH ₄	3050,95	3050,95	67	52	84,8	2,277	0,000	0,027	0,000	2,544	2,544
5D	Wastewater treatment and discharge	N ₂ O	212,59	212,59	20	50	53,9	0,101	0,000	0,002	0,000	0,053	0,053
Total					113622,3	113622,3				11,01			2,79
%					100,0	100,0							
National Total					113622,3	113622,3							

Table 283 Tier 1 Uncertainty Calculation and Reporting, Gg CO₂-eq.(Including LULUCF) for 2021.

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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	686,1	3	7	7,6	0,117	-0,040	0,007	-0,283	0,030	0,285
1A1	Solid fuels	CO2	25416,6	18811,9	1	2	2,2	0,940	0,073	0,193	0,146	0,273	0,309
1A1	Gaseous fuels	CO2	6508,6	2465,2	1	2	2,2	0,123	-0,005	0,025	-0,011	0,036	0,037
1A1	All fuel	CH4	21,1	31,3	3	50	50,1	0,035	0,000	0,000	0,011	0,001	0,011
1A1	All fuel	N2O	121,1	106,0	3	200	200,0	0,474	0,001	0,001	0,103	0,005	0,104
1A2	Liquid fuels	CO2	7319,8	1554,7	3	7	7,6	0,264	-0,019	0,016	-0,130	0,068	0,146
1A2	Solid fuels	CO2	10047,7	650,2	1	2	2,2	0,032	-0,041	0,007	-0,081	0,009	0,082
1A2	Gaseous fuels	CO2	0,0	2063,4	1	2	2,2	0,103	0,021	0,021	0,042	0,030	0,052
1A2	Other fossil fuels	CO2	0,0	258,6	5	2	5,4	0,031	0,003	0,003	0,005	0,019	0,019
1A2	All fuel	CH4	35,5	16,3	3	50	50,1	0,018	0,000	0,000	0,000	0,001	0,001
1A2	All fuel	N2O	92,4	30,1	3	200	200,0	0,134	0,000	0,000	-0,025	0,001	0,025
1A3a	Liquid fuel	CO2	208,9	15,3	5	5	7,1	0,002	-0,001	0,000	-0,004	0,001	0,004
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	1,6	0,1	5	40	40,3	0,000	0,000	0,000	0,000	0,000	0,000
1A3b	Gasoline	CO2	4216,6	1507,6	3	5	5,8	0,196	-0,004	0,015	-0,022	0,066	0,069
1A3b	Diesel Oil	CO2	2635,8	6779,4	3	5	5,8	0,883	0,057	0,070	0,285	0,295	0,410
1A3b	All fuel	CH4	78,2	23,3	3	40	40,1	0,021	0,000	0,000	-0,005	0,001	0,005
1A3b	All fuel	N2O	54,6	82,9	3	40	40,1	0,074	0,001	0,001	0,024	0,004	0,024
1A3b	LPG	CO2	0,0	1107,0	3	5	5,8	0,144	0,011	0,011	0,057	0,048	0,074
1A3b	Gaseous fuel	CO2	0,0	215,2	3	5	5,8	0,028	0,002	0,002	0,011	0,009	0,014
1A3b	Other liquid fuels	CO2	4,4	0,4	3	5	5,8	0,000	0,000	0,000	0,000	0,000	0,000
1A3b	Other fossil fuels	CO2	0,0	25,8	3	5	5,8	0,003	0,000	0,000	0,001	0,001	0,002
1A3c	Liquid fuel	CO2	0,0	31,8	5	5	7,1	0,005	0,000	0,000	0,002	0,002	0,003
1A3c	Liquid fuel	CH4	0,0	0,0	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 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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.		%	%	%	%	%	%	%	%	%
1A3c	Liquid fuel	N ₂ O	0,0	3,3	5	60	60,2	0,004	0,000	0,000	0,002	0,000	0,002
1A3d	Gas/diesel oil	CO ₂	0,0	4,4	50	5	50,2	0,005	0,000	0,000	0,000	0,003	0,003
1A3d	Gas/diesel oil	CH ₄	0,0	0,0	50	50	70,7	0,000	0,000	0,000	0,000	0,000	0,000
1A3d	Gas/diesel oil	N ₂ O	0,0	0,0	50	140	148,7	0,000	0,000	0,000	0,000	0,000	0,000
1A3e	Gaseous fuel	CO ₂	0,0	125,6	1	5	5,1	0,014	0,001	0,001	0,006	0,002	0,007
1A3e	Gaseous fuel	CH ₄	0,0	0,1	1	50	50,0	0,000	0,000	0,000	0,000	0,000	0,000
1A3e	Gaseous fuel	N ₂ O	0,0	0,1	1	150	150,0	0,000	0,000	0,000	0,000	0,000	0,000
1A4	Liquid fuel	CO ₂	2825,1	554,6	5	7	8,6	0,107	-0,008	0,006	-0,053	0,040	0,067
1A4	Solid fuel	CO ₂	3548,1	564,7	2	5	5,4	0,068	-0,011	0,006	-0,055	0,016	0,057
1A4	Gaseous fuel	CO ₂	0,0	537,4	5	2	5,4	0,065	0,006	0,006	0,011	0,039	0,041
1A4	All fuel	CH ₄	374,8	360,5	5	50	50,2	0,405	0,002	0,004	0,097	0,026	0,100
1A4	All fuel	N ₂ O	186,5	80,7	5	200	200,1	0,361	0,000	0,001	-0,010	0,006	0,012
1A5	Stationary - Fossil fuels	CO ₂	5093,8	0,0	5	7	8,6	0,000	-0,024	0,000	-0,168	0,000	0,168
1A5	Stationary - Fossil fuels	CH ₄	5,4	0,0	5	50	50,2	0,000	0,000	0,000	-0,001	0,000	0,001
1A5	Stationary - Fossil fuels	N ₂ O	8,7	0,0	5	200	200,1	0,000	0,000	0,000	-0,008	0,000	0,008
1B1	Solid fuel	CO ₂	68,8	22,9	10	200	200,2	0,102	0,000	0,000	-0,018	0,003	0,018
1B1	Solid fuel	CH ₄	2329,2	883,2	10	200	200,2	3,950	-0,002	0,009	-0,382	0,128	0,403
1B2	Oil and Natural Gas	CO ₂	94,3	539,6	5	100	100,1	1,207	0,005	0,006	0,509	0,039	0,510
1B2	Oil and Natural Gas	CH ₄	165,4	303,9	5	100	100,1	0,679	0,002	0,003	0,234	0,022	0,235
1B2	Oil and Natural Gas	N ₂ O	0,4	0,5	5	1000	1000,0	0,012	0,000	0,000	0,004	0,000	0,004
2A1	Cement Production	CO ₂	2454,5	1060,4	1,5	1,5	2,1	0,050	-0,001	0,011	-0,001	0,023	0,023
2A2	Lime Production	CO ₂	450,1	255,9	2	2	2,8	0,016	0,001	0,003	0,001	0,007	0,007
2A3	Glass production	CO ₂	186,2	100,0	10	10	14,1	0,032	0,000	0,001	0,001	0,015	0,015
2A4a	Ceramics - Bricks and Tiles	CO ₂	522,5	71,4	3	5	5,8	0,009	-0,002	0,001	-0,009	0,003	0,009
2A4b	Soda ash uses	CO ₂	126,6	144,2	2	1	2,2	0,007	0,001	0,001	0,001	0,004	0,004

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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.		%	%	%	%	%	%	%	%	%
2A4d	DeSOx - instalations	CO2	0,0	717,1	1,5	1,5	2,1	0,034	0,007	0,007	0,011	0,016	0,019
2B1	Ammonia Production	CO2	2557,5	595,1	2	7	7,3	0,097	-0,006	0,006	-0,042	0,017	0,045
2B2	Nitric Acid Production	N2O	1718,1	64,9	2	10	10,2	0,015	-0,007	0,001	-0,074	0,002	0,074
2B5b	Calcium Carbide	CO2	73,9	10,7	5	10	11,2	0,003	0,000	0,000	-0,002	0,001	0,003
2B7	Soda ash production	CO2	397,6	569,4	2	2	2,8	0,036	0,004	0,006	0,008	0,017	0,018
2B8	Petrochemical and carbon black production	CH4	19,5	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	-0,062	0,000	0,062
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	10,8	5	5	7,1	0,002	-0,016	0,000	-0,081	0,001	0,081
2C1	Iron and Steel Production	CH4	36,3	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	-0,030	0,000	0,030
2C2	Ferroalloys Production	CH4	2,6	0,0	5	25	25,5	0,000	0,000	0,000	0,000	0,000	0,000
2C2	Lead production	CO2	162,8	9,2	5	15	15,8	0,003	-0,001	0,000	-0,010	0,001	0,010
2C2	Zinc production	CO2	90,5	112,7	5	15	15,8	0,040	0,001	0,001	0,011	0,008	0,014
2D	Non-energy products from fuels and solvent use	CO2	138,6	16,3	10	30	31,6	0,011	0,000	0,000	-0,015	0,002	0,015
2F	Product uses as substitutes for ODS - HFCs and PFCs	CO2eq	0,0	739,4	10	50	51,0	0,842	0,008	0,008	0,379	0,107	0,394
2G	Other product manufacture and use	N2O	29,0	10,4	10	1	10,0	0,002	0,000	0,000	0,000	0,002	0,002
2G	Other product manufacture and use	CO2	26,7	22,8	10	30	31,6	0,016	0,000	0,000	0,003	0,003	0,005
2G1	Electrical equipment - SF6	CO2eq	3,4	23,3	10	50	51,0	0,027	0,000	0,000	0,011	0,003	0,012
2H	Other	CO2	0,0	0,0	10	30	31,6	0,000	0,000	0,000	0,000	0,000	0,000
3A1	Cattle	CH4	3443,8	1321,3	0,64	20	20,0	0,591	-0,003	0,014	-0,053	0,012	0,055
3A2	Sheep	CH4	1795,8	265,3	1,63	20	20,1	0,119	-0,006	0,003	-0,115	0,006	0,115
3A3	Swine	CH4	169,8	27,0	0,51	50	50,0	0,030	-0,001	0,000	-0,026	0,000	0,026
3A4	Other livestock	CH4	270,4	100,0	2	50	50,0	0,112	0,000	0,001	-0,012	0,003	0,013

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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	N ₂ O em. from Manure Management	N ₂ O	842,3	257,1	2	300	300,0	1,723	-0,001	0,003	-0,399	0,007	0,399
3B1	Cattle	CH ₄	530,0	267,3	25	20	32,0	0,191	0,000	0,003	0,005	0,097	0,097
3B2	Sheep	CH ₄	52,4	7,7	50	20	53,9	0,009	0,000	0,000	-0,003	0,006	0,007
3B3	Swine	CH ₄	582,3	76,5	25	20	32,0	0,055	-0,002	0,001	-0,039	0,028	0,048
3B4	Other livestock	CH ₄	49,3	15,4	50	30	58,3	0,020	0,000	0,000	-0,002	0,011	0,011
3C	Rice Cultivation	CH ₄	142,2	121,6	20	60	63,2	0,172	0,001	0,001	0,035	0,035	0,049
3Da	Direct N ₂ O emissions from managed soils	N ₂ O	4286,2	2785,1	3	200	200,0	12,442	0,008	0,029	1,675	0,121	1,679
3Db	Indirect N ₂ O Emissions from managed soils	N ₂ O	1303,0	761,9	3	500	500,0	8,509	0,002	0,008	0,839	0,033	0,840
3F	Field burning of agricultural residues	CH ₄	32,6	34,5	3	50	50,1	0,039	0,000	0,000	0,010	0,002	0,010
3F	Field burning of agricultural residues	N ₂ O	7,4	7,1	3	20	20,2	0,003	0,000	0,000	0,001	0,000	0,001
3G	Liming	CO ₂	29,1	24,6	3	20	20,2	0,011	0,000	0,000	0,002	0,001	0,003
3H	Urea application	CO ₂	62,2	33,9	2	50	50,0	0,038	0,000	0,000	0,003	0,001	0,003
4A1	Forest Land remaining Forest Land	CO ₂	-13236,9	-8203,5	3	240	240,0	-43,977	-0,022	-0,084	-5,239	-0,357	5,251
4A2	Land converted to Forest Land	CO ₂	-1240,9	-152,8	3	43	43,1	-0,147	0,004	-0,002	0,184	-0,007	0,184
4A1 (V)	Forest fires	CO ₂ eq	1,6	212,6	10	102,89	103,4	0,491	0,002	0,002	0,224	0,031	0,226
4A2 (V)	Forest fires	CO ₂ eq	0,2	3,9	10	83,36	84,0	0,007	0,000	0,000	0,003	0,001	0,003
4B1	Cropland remainig Cropland	CO ₂	-878,1	-532,6	3	207	207,0	-2,463	-0,001	-0,005	-0,275	-0,023	0,276
4B2	Land converted to Cropland	CO ₂	93,4	800,7	10	12,3	15,9	0,283	0,008	0,008	0,096	0,116	0,150
4C1	Grassland remaining grassland	CO ₂	223,5	117,8	5	143	143,1	0,376	0,000	0,001	0,022	0,009	0,024
4C2	Land converted to Grassland	CO ₂	-1158,1	-1075,6	10	28	29,7	-0,714	-0,006	-0,011	-0,156	-0,156	0,221
4D2	Land converted to Wetlands	CO ₂	128,3	210,8	10	11	14,9	0,070	0,002	0,002	0,017	0,031	0,035
4E2	Land converted to Settlements	CO ₂	475,7	617,4	10	9	13,5	0,186	0,004	0,006	0,037	0,090	0,097
4F	Land converted to other land	CO ₂	0,0	0,0	10	0	10,0	0,000	0,000	0,000	0,000	0,000	0,000
4G	Harvested wood products	CO ₂	-583,3	-1185,3	10	98	98,5	-2,608	-0,009	-0,012	-0,922	-0,172	0,938
4	Indirect N ₂ O Emissions from managed soils	N ₂ O	62,6	42,7	3	500	500,0	0,476	0,000	0,000	0,071	0,002	0,071
5A	Solid waste disposal	CH ₄	2001,0	2238,7	30	80	85,4	3,548	0,011	0,020	0,908	0,836	1,234

IPCC Source category		GHG	Base year emissions (1988)	Year 2021 emissions	Activity data (AD) uncertainty	Emission factor (EF) uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year 2019	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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.		%	%	%	%	%	%	%	%	%
5B	Biological treatment of solid waste	CH ₄	0,0	3,3	30	400	401,1	0,025	0,000	0,000	0,012	0,001	0,012
5B	Biological treatment of solid waste	N ₂ O	0,0	1,8	30	30	42,4	0,001	0,000	0,000	0,000	0,001	0,001
5C	Incineration and open burning of waste	CO ₂	18,5	5,7	10	100	100,5	0,011	0,000	0,000	-0,003	0,001	0,003
5C	Incineration and open burning of waste	CH ₄	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	N ₂ O	1,3	0,3	10	100	100,5	0,000	0,000	0,000	0,000	0,000	0,000
5D	Wastewater treatment and discharge	CH ₄	3051,0	463,4	67	52	84,8	0,729	-0,009	0,004	-0,450	0,386	0,593
5D	Wastewater treatment and discharge	N ₂ O	212,6	119,7	20	50	53,9	0,120	0,000	0,001	0,008	0,030	0,031
Total			97510,3	44773,2				47,04					5,95
%			100,0	100,0									
National total			97510,3	44773,2									

* 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 284 Tier 1 Uncertainty Calculation and Reporting, Gg CO₂-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 intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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	0,789	0,000	0,104	0,000	0,439	0,439
1A1	Solid fuels	CO2	25416,6	25416,6	1	2	2,2	0,583	0,000	0,261	0,000	0,369	0,369
1A1	Gaseous fuels	CO2	6508,6	6508,6	1	2	2,2	0,149	0,000	0,067	0,000	0,094	0,094
1A1	All fuel	CH4	21,1	21,1	3	50	50,1	0,011	0,000	0,000	0,000	0,001	0,001
1A1	All fuel	N2O	121,1	121,1	3	200	200,0	0,248	0,000	0,001	0,000	0,005	0,005
1A2	Liquid fuels	CO2	7319,8	7319,8	3	7	7,6	0,572	0,000	0,075	0,000	0,318	0,318
1A2	Solid fuels	CO2	10047,7	10047,7	1	2	2,2	0,230	0,000	0,103	0,000	0,146	0,146
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	35,5	35,5	3	50	50,1	0,018	0,000	0,000	0,000	0,002	0,002
1A2	All fuel	N2O	92,4	92,4	3	200	200,0	0,190	0,000	0,001	0,000	0,004	0,004
1A3a	Liquid fuel	CO2	208,9	208,9	5	5	7,1	0,015	0,000	0,002	0,000	0,015	0,015
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	1,6	1,6	5	40	40,3	0,001	0,000	0,000	0,000	0,000	0,000
1A3b	Gasoline	CO2	4216,6	4216,6	3	5	5,8	0,252	0,000	0,043	0,000	0,183	0,183
1A3b	Diesel Oil	CO2	2635,8	2635,8	3	5	5,8	0,158	0,000	0,027	0,000	0,115	0,115
1A3b	All fuel	CH4	78,2	78,2	3	40	40,1	0,032	0,000	0,001	0,000	0,003	0,003
1A3b	All fuel	N2O	54,6	54,6	3	40	40,1	0,022	0,000	0,001	0,000	0,002	0,002
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	4,4	4,4	3	5	5,8	0,000	0,000	0,000	0,000	0,000	0,000
1A3b	Other fossil 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 intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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	N ₂ O	0,0	0,0	50	140	148,7	0,000	0,000	0,000	0,000	0,000	0,000
1A3e	Gaseous fuel	CO ₂	0,0	0,0	1	5	5,1	0,000	0,000	0,000	0,000	0,000	0,000
1A3e	Gaseous fuel	CH ₄	0,0	0,0	1	50	50,0	0,000	0,000	0,000	0,000	0,000	0,000
1A3e	Gaseous fuel	N ₂ O	0,0	0,0	1	150	150,0	0,000	0,000	0,000	0,000	0,000	0,000
1A4	Liquid fuel	CO ₂	2825,1	2825,1	5	7	8,6	0,249	0,000	0,029	0,000	0,205	0,205
1A4	Solid fuel	CO ₂	3548,1	3548,1	2	5	5,4	0,196	0,000	0,036	0,000	0,103	0,103
1A4	Gaseous fuel	CO ₂	0,0	0,0	5	2	5,4	0,000	0,000	0,000	0,000	0,000	0,000
1A4	All fuel	CH ₄	374,8	374,8	5	50	50,2	0,193	0,000	0,004	0,000	0,027	0,027
1A4	All fuel	N ₂ O	186,5	186,5	5	200	200,1	0,383	0,000	0,002	0,000	0,014	0,014
1A5	Stationary - Fossil fuels	CO ₂	5093,8	5093,8	5	7	8,6	0,449	0,000	0,052	0,000	0,369	0,369
1A5	Stationary - Fossil fuels	CH ₄	5,4	5,4	5	50	50,2	0,003	0,000	0,000	0,000	0,000	0,000
1A5	Stationary - Fossil fuels	N ₂ O	8,7	8,7	5	200	200,2	0,102	0,000	0,000	-0,018	0,003	0,018
1B1	Solid fuel	CO ₂	68,8	68,8	10	200	200,2	0,141	0,000	0,001	0,000	0,010	0,010
1B1	Solid fuel	CH ₄	2329,2	2329,2	10	200	200,2	4,783	0,000	0,024	0,000	0,338	0,338
1B2	Oil and Natural Gas	CO ₂	94,3	94,3	5	100	100,1	0,097	0,000	0,001	0,000	0,007	0,007
1B2	Oil and Natural Gas	CH ₄	165,4	165,4	5	100	100,1	0,170	0,000	0,002	0,000	0,012	0,012
1B2	Oil and Natural Gas	N ₂ O	0,4	0,4	5	1000	1000,0	0,004	0,000	0,000	0,000	0,000	0,000
2A1	Cement Production	CO ₂	2454,5	2454,5	1,5	1,5	2,1	0,053	0,000	0,025	0,000	0,053	0,053
2A2	Lime Production	CO ₂	450,1	450,1	2	2	2,8	0,013	0,000	0,005	0,000	0,013	0,013
2A3	Glass production	CO ₂	186,2	186,2	10	10	14,1	0,027	0,000	0,002	0,000	0,027	0,027
2A4a	Ceramics - Bricks and Tiles	CO ₂	522,5	522,5	3	5	5,8	0,031	0,000	0,005	0,000	0,023	0,023
2A4b	Soda ash uses	CO ₂	126,6	126,6	2	1	2,2	0,003	0,000	0,001	0,000	0,004	0,004
2A4d	DeSO _x - installations	CO ₂	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	CO ₂	2557,5	2557,5	2	7	7,3	0,191	0,000	0,026	0,000	0,074	0,074
2B2	Nitric Acid Production	N ₂ O	1718,1	1718,1	2	10	10,2	0,180	0,000	0,018	0,000	0,050	0,050
2B5b	Calcium Carbide	CO ₂	73,9	73,9	5	10	11,2	0,008	0,000	0,001	0,000	0,005	0,005
2B7	Soda ash production	CO ₂	397,6	397,6	2	2	2,8	0,012	0,000	0,004	0,000	0,012	0,012
2B8	Petrochemical and carbon black production	CH ₄	19,5	19,5	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 intro-duced by EF	Uncertainty in trend in national emissions intro-duced by AD	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	0,138	0,000	0,005	0,000	0,032	0,032
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	0,252	0,000	0,036	0,000	0,252	0,252
2C1	Iron and Steel Production	CH4	36,3	36,3	10	25	26,9	0,010	0,000	0,000	0,000	0,005	0,005
2C2	Ferroalloys Production	CO2	254,9	254,9	5	25	25,5	0,067	0,000	0,003	0,000	0,018	0,018
2C2	Ferroalloys Production	CH4	2,6	2,6	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	0,026	0,000	0,002	0,000	0,012	0,012
2C2	Zinc production	CO2	90,5	90,5	5	15	15,8	0,015	0,000	0,001	0,000	0,007	0,007
2D	Non-energy products from fuels and solvent use	CO2	138,6	138,6	10	30	31,6	0,045	0,000	0,001	0,000	0,020	0,020
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	29,0	29,0	10	1	10,0	0,003	0,000	0,000	0,000	0,004	0,004
2G	Other product manufacture and use	CO2	26,7	26,7	10	30	31,6	0,009	0,000	0,000	0,000	0,004	0,004
2G1	Electrical equipment - SF6	CO2eq	3,4	3,4	10	50	51,0	0,002	0,000	0,000	0,000	0,000	0,000
2H	Other	CO2	0,0	0,0	10	30	31,6	0,000	0,000	0,000	0,000	0,000	0,000
3A1	Cattle	CH4	3443,8	3443,8	0,64	20	20,0	0,707	0,000	0,035	0,000	0,032	0,032
3A2	Sheep	CH4	1795,8	1795,8	1,63	20	20,1	0,370	0,000	0,018	0,000	0,042	0,042
3A3	Swine	CH4	169,8	169,8	0,51	50	50,0	0,087	0,000	0,002	0,000	0,001	0,001
3A4	Other livestock	CH4	270,4	270,4	2	50	50,0	0,139	0,000	0,003	0,000	0,008	0,008
3B	N2O em. from Manure Management	N2O	842,3	842,3	2	300	300,0	2,591	0,000	0,009	0,000	0,024	0,024
3B1	Cattle	CH4	530,0	530,0	25	20	32,0	0,174	0,000	0,005	0,000	0,192	0,192
3B2	Sheep	CH4	52,4	52,4	50	20	53,9	0,029	0,000	0,001	0,000	0,038	0,038
3B3	Swine	CH4	582,3	582,3	25	20	32,0	0,191	0,000	0,006	0,000	0,211	0,211
3B4	Other livestock	CH4	49,3	49,3	50	30	58,3	0,029	0,000	0,001	0,000	0,036	0,036
3C	Rice Cultivation	CH4	142,2	142,2	20	60	63,2	0,092	0,000	0,001	0,000	0,041	0,041
3Da	Direct N2O emissions from managed soils	N2O	4286,2	4286,2	3	200	200,0	8,792	0,000	0,044	0,000	0,186	0,186
3Db	Indirect N2O Emissions from managed soils	N2O	1303,0	1303,0	3	500	500,0	6,681	0,000	0,013	0,000	0,057	0,057

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 in trend in national emissions intro-duced by AD	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.		%	%	%	%	%	%	%	%	%
3F	Field burning of agricultural residues	CH ₄	32,6	32,6	3	50	50,1	0,017	0,000	0,000	0,000	0,001	0,001
3F	Field burning of agricultural residues	N ₂ O	7,4	7,4	3	20	20,2	0,002	0,000	0,000	0,000	0,000	0,000
3G	Liming	CO ₂	29,1	29,1	3	20	20,2	0,009	0,000	0,000	0,002	0,001	0,002
3H	Urea application	CO ₂	62,2	62,2	2	50	50,0	0,032	0,000	0,001	0,000	0,002	0,002
4A1	Forest Land remaining Forest Land	CO ₂	-13236,9	-13236,9	30	80	85,4	-11,598	0,000	-0,136	0,000	-5,759	5,759
4A2	Land converted to Forest Land	CO ₂	-1240,9	-1240,9	30	400	401,1	-5,105	0,000	-0,013	0,000	-0,540	0,540
4A1 (V)	Forest fires	CO ₂ eq	1,6	1,6	30	30	42,4	0,001	0,000	0,000	0,000	0,001	0,001
4A2 (V)	Forest fires	CO ₂ eq	0,2	0,2	10	100	100,5	0,000	0,000	0,000	0,000	0,000	0,000
4B1	Cropland remainig Cropland	CO ₂	-878,1	-878,1	10	100	100,5	-0,905	0,000	-0,009	0,000	-0,127	0,127
4B2	Land converted to Cropland	CO ₂	93,4	93,4	10	100	100,5	0,096	0,000	0,001	0,000	0,014	0,014
4C1	Grassland remaining grassland	CO ₂	223,5	223,5	67	52	84,8	0,194	0,000	0,002	0,000	0,217	0,217
4C2	Land converted to Grassland	CO ₂	-1158,1	-1158,1	20	50	53,9	-0,640	0,000	-0,012	0,000	-0,336	0,336
4D2	Land converted to Wetlands	CO ₂	128,3	128,3	10	24,543 409	26,5	0,035	0,000	0,001	0,000	0,019	0,019
4E2	Land converted to Settlements	CO ₂	475,7	475,7	10	74,330 344	75,0	0,366	0,000	0,005	0,000	0,069	0,069
4F	Land converted to other land	CO ₂	0,0	0,0	10	50	51,0	0,000	0,000	0,000	0,000	0,000	0,000
4G	Harvested wood products	CO ₂	-583,3	-583,3	10	73	73,7	-0,441	0,000	-0,006	0,000	-0,085	0,085
4	Indirect N ₂ O Emissions from managed soils	N ₂ O	62,6	62,6	3	500	500,0	0,321	0,000	0,001	0,000	0,003	0,003
5A	Solid waste disposal	CH ₄	2001,0	2001,0	30	400	401,1	8,231	0,000	0,021	0,000	0,871	0,871
5B	Biological treatment of solid waste	CH ₄	0,0	0,0	30	30	42,4	0,000	0,000	0,000	0,000	0,000	0,000
5B	Biological treatment of solid waste	N ₂ O	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	CO ₂	18,5	18,5	10	100	100,5	0,019	0,000	0,000	0,000	0,003	0,003
5C	Incineration and open burning of waste	CH ₄	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	N ₂ O	1,3	1,3	67	52	84,8	0,001	0,000	0,000	0,000	0,001	0,001
5D	Wastewater treatment and discharge	CH ₄	3051,0	3051,0	20	50	53,9	1,685	0,000	0,031	0,000	0,885	0,885
5D	Wastewater treatment and discharge	N ₂ O	212,6	212,6	0	0	0,0	0,000	0,000	0,002	0,000	0,000	0,000
Total			97510,3	97510,3				19,68					6,02

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 in trend in national emissions introduced by AD	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.		%	%	%	%	%	%	%	%	%
%		100,0	100,0									
National Total		97510,3	97510,3									

* 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		

Eurostat Category	CRF Category	NCV applied
Iron and Steel	1A2a	Used in industry (net)
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:
 - o Coke oven coke used in Blast Furnaces (Transformation) and Iron and Steel industry sector
 - o 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: Anthracite Coking Coal Other Bituminous Coal Sub-bituminous Coal Lignite/Brown Coal Coke Oven Coke Coal Tar BKB/PB	Liquid fuels: 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 285 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	25.880	25.686	-	6.682	18.367	25.061
1991	26.140	25.880	26.705	11.643	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	30.480	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
2005	24.465	28.638	24.365	-	7.079	15.125	27.270

[MJ/t]	Anthracite	Coking Coal	Other Bituminous Coal	Sub-bituminous Coal	Lignite / Brown Coal	BKB	Coke Oven Coke
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
2018	29.901	-	26.657	-	6.981	12.938	28.500
2019	29.871	-	25.421	-	6.972	11.686	28.500
2020	30.109	-	24.404	-	6.995	10.683	28.500
2021	28.680	-	23.713	-	6.951	9.977	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

Table 286 Vehicle fleet data for Road transport (number of vehicles) 1988-2004

Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
PC Gasoline Small	PRE ECE	527486	555663	525315	488467	446732	433523	415328	388541	356030	314911	286702	267748	247929	229590	214437	209367	203484
PC Gasoline Small	ECE 15/00-01	-	-	23493	48846	74918	81284	82671	81874	79171	73638	70217	68368	65658	62676	59912	59356	57930
PC Gasoline Small	ECE 15/02	-	-	11746	24423	37459	54189	72553	91062	108840	123008	140858	147072	136211	124408	112562	103932	92354
PC Gasoline Small	ECE 15/03	-	-	9789	20353	31216	45158	60461	75885	90700	102507	117381	136178	155079	175154	182903	172318	157536
PC Gasoline Small	ECE 15/04	-	-	8443	17554	26924	38949	52148	65451	78228	88412	101242	117453	133756	151071	170900	200904	233898
PC Gasoline Small	Euro 1	-	-	-	-	8470	18380	29531	41183	52739	62584	74320	88685	103289	118821	136485	162530	191325
PC Gasoline Small	Euro 2	-	-	-	-	-	-	-	-	10006	19790	30216	42066	54437	67632	82395	102790	125655
PC Gasoline Small	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	11369	23540	36873	53667	72894
PC Gasoline Small	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	PRE ECE	565259	582380	538517	489805	438193	415987	389876	356824	319887	276824	246579	225305	204123	184944	169008	161448	153521
PC Gasoline Medium	ECE 15/00-01	-	-	24083	48980	73486	77996	77605	75190	71134	64732	60390	57530	54057	50488	47220	45771	43706
PC Gasoline Medium	ECE 15/02	-	-	12042	24490	36743	51997	68107	83628	97791	108130	121146	123758	112144	100216	88715	80145	69678
PC Gasoline Medium	ECE 15/03	-	-	10035	20408	30619	43331	56756	69690	81492	90109	100955	114591	127679	141094	144155	132878	118854
PC Gasoline Medium	ECE 15/04	-	-	8655	17602	26409	37373	48952	60108	70287	77719	87073	98835	110123	121693	134695	154922	176467
PC Gasoline Medium	Euro 1	-	-	-	-	8309	17637	27721	37821	47385	55015	63920	74626	85039	95715	107570	125331	144347
PC Gasoline Medium	Euro 2	-	-	-	-	-	-	-	-	8990	17397	25988	35397	44818	54480	64939	79264	94802
PC Gasoline Medium	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	9360	18963	29061	41384	54995
PC Gasoline Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	PRE ECE	128039	131915	121978	110943	99251	94220	88305	80817	72451	62696	55846	51026	46228	41884	38275	36562	34766
PC Gasoline Large	ECE 15/00-01	-	-	5455	11094	16645	17666	17577	17030	16111	14661	13677	13029	12243	11434	10694	10365	9897
PC Gasoline Large	ECE 15/02	-	-	2727	5547	8322	11777	15426	18941	22148	24490	27437	28028	25398	22696	20091	18150	15779
PC Gasoline Large	ECE 15/03	-	-	2273	4623	6935	9814	12855	15784	18457	20408	22864	25952	28916	31953	32646	30092	26916
PC Gasoline Large	ECE 15/04	-	-	1960	3987	5982	8465	11087	13614	15919	17602	19720	22384	24940	27560	30504	35084	39962
PC Gasoline Large	Euro 1	-	-	-	-	1882	3995	6279	8566	10732	12460	14477	16901	19259	21676	24361	28383	32689
PC Gasoline Large	Euro 2	-	-	-	-	-	-	-	-	2036	3940	5886	8017	10150	12338	14707	17950	21469
PC Gasoline Large	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	2120	4294	6581	9372	12454
PC Gasoline Large	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Small	Conventional	-	-	3103	6239	9279	12260	15180	18042	20582	23021	25376	27576	29206	30675	31839	32466	32761
PC Diesel Small	Euro 1	-	-	-	-	127	345	656	1057	1522	2051	2633	3319	4084	4906	5867	7074	8411

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Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
PC Diesel Small	Euro 2	-	-	-	-	-	-	-	-	289	649	1070	1574	2152	2793	3542	4474	5524
PC Diesel Small	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	450	972	1585	2336	3205
PC Diesel Small	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Small	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Conventional	-	-	4775	9598	14274	18859	23349	27749	31654	35403	39022	42402	44905	47162	48948	49909	50359
PC Diesel Medium	Euro 1	-	-	-	-	196	531	1009	1626	2341	3154	4048	5104	6280	7543	9019	10875	12929
PC Diesel Medium	Euro 2	-	-	-	-	-	-	-	-	444	997	1646	2421	3309	4294	5445	6878	8491
PC Diesel Medium	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	691	1494	2437	3591	4926
PC Diesel Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Conventional	-	-	3049	6017	8785	11393	13843	16142	18065	19818	21422	22824	23695	24390	24805	24778	24487
PC Diesel Large	Euro 1	-	-	-	-	121	321	598	946	1336	1766	2222	2747	3313	3901	4571	5399	6287
PC Diesel Large	Euro 2	-	-	-	-	-	-	-	-	254	558	904	1303	1746	2220	2759	3415	4129
PC Diesel Large	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	365	773	1235	1783	2395
PC Diesel Large	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Conventional	-	-	-	-	-	-	-	-	-	10792	21043	30720	39244	47000	53775	59116	56540
PC LPG Medium	Euro 1	-	-	-	-	-	-	-	-	-	961	2183	3697	5488	7517	9909	12882	14516
PC LPG Medium	Euro 2	-	-	-	-	-	-	-	-	-	304	888	1754	2892	4279	5982	8147	9534
PC LPG Medium	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	604	1489	2677	4253	5531
PC LPG Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC CNG Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2979
PC CNG Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC CNG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC CNG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Gasoline <3,5 t	Conventional	135352	142020	149053	159989	166819	176241	179613	180343	175061	166798	164525	165167	161589	159309	159730	162111	163491
LCV Gasoline <3,5 t	Euro 1	-	-	-	-	4430	9677	15310	21240	26741	31770	38047	39815	40490	41575	43507	46194	48863
LCV Gasoline <3,5 t	Euro 2	-	-	-	-	-	-	-	-	4160	8237	12682	17696	22599	27975	29411	30992	32531
LCV Gasoline <3,5 t	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	4222	8711	13738	19539	25958
LCV Gasoline <3,5 t	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Gasoline <3,5 t	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Gasoline <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Diesel <3,5 t	Conventional	51685	53074	54498	55957	55968	55919	55806	55624	54253	52849	51410	51212	50030	48779	48402	47993	47472
LCV Diesel <3,5 t	Euro 1	-	-	-	-	1486	3070	4757	6551	8287	10066	11889	12345	12536	12730	13184	13676	14188
LCV Diesel <3,5 t	Euro 2	-	-	-	-	-	-	-	-	1289	2610	3963	5487	6997	8566	8912	9175	9446
LCV Diesel <3,5 t	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	1307	2667	4163	5785	7537
LCV Diesel <3,5 t	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Diesel <3,5 t	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Diesel <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HDV Gasoline >3,5 t	Conventional	2762	2898	3042	3265	3495	3794	3978	4114	4203	4220	4393	4544	4671	4848	5028	5282	5527
HDV Diesel Rigid <=7,5 t	Conventional	6093	6083	6069	6053	5878	5698	5515	5328	5033	4746	4466	4300	4058	3818	3653	3489	3322
HDV Diesel Rigid <=7,5 t	Euro I	-	-	-	-	156	313	470	627	769	904	1033	1037	1017	996	995	994	993
HDV Diesel Rigid <=7,5 t	Euro II	-	-	-	-	-	-	-	-	120	234	344	461	567	670	673	667	661
HDV Diesel Rigid <=7,5 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	106	209	314	421	527
HDV Diesel Rigid <=7,5 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid <=7,5 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid <=7,5 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 7,5 - 12 t	Conventional	2585	2611	2636	2662	2618	2571	2523	2472	2370	2269	2169	2123	2038	1952	1902	1853	1800
HDV Diesel Rigid 7,5 - 12 t	Euro I	-	-	-	-	70	141	215	291	362	432	502	512	511	509	518	528	538
HDV Diesel Rigid 7,5 - 12 t	Euro II	-	-	-	-	-	-	-	-	56	112	167	227	285	343	350	354	358
HDV Diesel Rigid 7,5 - 12 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	53	107	164	223	286
HDV Diesel Rigid 7,5 - 12 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 7,5 - 12 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 7,5 - 12 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 12 - 14 t	Conventional	855	859	862	865	846	826	805	784	746	710	674	655	624	593	573	554	533
HDV Diesel Rigid 12 - 14 t	Euro I	-	-	-	-	22	45	69	92	114	135	156	158	156	155	156	158	159
HDV Diesel Rigid 12 - 14 t	Euro II	-	-	-	-	-	-	-	-	18	35	52	70	87	104	106	106	106
HDV Diesel Rigid 12 - 14 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	16	32	49	67	85
HDV Diesel Rigid 12 - 14 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 12 - 14 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 12 - 14 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 14 - 20 t	Conventional	2800	2809	2817	2824	2757	2689	2618	2545	2420	2298	2178	2113	2009	1907	1840	1774	1705
HDV Diesel Rigid 14 - 20 t	Euro I	-	-	-	-	73	148	223	300	370	438	504	509	503	498	501	506	510
HDV Diesel Rigid 14 - 20 t	Euro II	-	-	-	-	-	-	-	-	58	113	168	226	281	335	339	339	339
HDV Diesel Rigid 14 - 20 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	53	104	158	214	271
HDV Diesel Rigid 14 - 20 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 14 - 20 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 20 - 26 t	Conventional	2455	2456	2456	2455	2389	2322	2253	2182	2068	1955	1846	1783	1689	1595	1532	1469	1405
HDV Diesel Rigid 20 - 26 t	Euro I	-	-	-	-	63	127	192	257	316	372	427	430	423	416	417	419	420
HDV Diesel Rigid 20 - 26 t	Euro II	-	-	-	-	-	-	-	-	49	97	142	191	236	280	282	281	280
HDV Diesel Rigid 20 - 26 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	44	87	132	177	223
HDV Diesel Rigid 20 - 26 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 20 - 26 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 20 - 26 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 26 - 28 t	Conventional	369	378	386	394	393	391	388	385	374	363	351	348	339	329	325	321	316
HDV Diesel Rigid 26 - 28 t	Euro I	-	-	-	-	10	21	33	45	57	69	81	84	85	86	89	91	94
HDV Diesel Rigid 26 - 28 t	Euro II	-	-	-	-	-	-	-	-	9	18	27	37	47	58	60	61	63
HDV Diesel Rigid 26 - 28 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	9	18	28	39	50
HDV Diesel Rigid 26 - 28 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 26 - 28 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 26 - 28 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 28 - 32 t	Conventional	280	290	301	313	316	319	321	323	318	313	307	309	304	299	299	299	299
HDV Diesel Rigid 28 - 32 t	Euro I	-	-	-	-	8	18	27	38	49	60	71	74	76	78	82	85	89
HDV Diesel Rigid 28 - 32 t	Euro II	-	-	-	-	-	-	-	-	8	15	24	33	43	53	55	57	59
HDV Diesel Rigid 28 - 32 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	8	16	26	36	47
HDV Diesel Rigid 28 - 32 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HDV Diesel Rigid 28 - 32 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 28 - 32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid >32 t	Conventional	199	203	206	210	209	207	205	202	196	189	183	180	175	169	167	164	161
HDV Diesel Rigid >32 t	Euro I	-	-	-	-	6	11	17	24	30	36	42	43	44	44	45	47	48
HDV Diesel Rigid >32 t	Euro II	-	-	-	-	-	-	-	-	5	9	14	19	24	30	31	31	32
HDV Diesel Rigid >32 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	5	9	14	20	26
HDV Diesel Rigid >32 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid >32 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid >32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 14 - 20 t	Conventional	81	99	117	136	152	168	183	198	207	216	224	236	244	250	260	270	279
HDV Diesel Articulated 14 - 20 t	Euro I	-	-	-	-	4	9	16	23	32	41	52	57	61	65	71	77	83
HDV Diesel Articulated 14 - 20 t	Euro II	-	-	-	-	-	-	-	-	5	11	17	25	34	44	48	52	55
HDV Diesel Articulated 14 - 20 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	6	14	22	33	44
HDV Diesel Articulated 14 - 20 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 14 - 20 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 20 - 28 t	Conventional	274	279	283	288	285	282	278	275	265	256	246	243	235	226	222	218	214
HDV Diesel Articulated 20 - 28 t	Euro I	-	-	-	-	8	15	24	32	40	49	57	58	59	59	61	62	64
HDV Diesel Articulated 20 - 28 t	Euro II	-	-	-	-	-	-	-	-	6	13	19	26	33	40	41	42	43
HDV Diesel Articulated 20 - 28 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	6	12	19	26	34
HDV Diesel Articulated 20 - 28 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 20 - 28 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 20 - 28 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 28 - 34 t	Conventional	431	427	424	420	404	389	374	358	335	313	291	277	259	240	227	214	200
HDV Diesel Articulated 28 - 34 t	Euro I	-	-	-	-	11	21	32	42	51	60	67	67	65	63	62	61	60
HDV Diesel Articulated 28 - 34 t	Euro II	-	-	-	-	-	-	-	-	8	15	22	30	36	42	42	41	40
HDV Diesel Articulated 28 - 34 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	7	13	20	26	32
HDV Diesel Articulated 28 - 34 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 28 - 34 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 28 - 34 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 34 - 40 t	Conventional	2588	2566	2542	2516	2423	2329	2233	2137	1998	1863	1733	1648	1534	1423	1341	1259	1177
HDV Diesel Articulated 34 - 40 t	Euro I	-	-	-	-	64	128	190	252	305	355	401	397	384	371	365	359	352
HDV Diesel Articulated 34 - 40 t	Euro II	-	-	-	-	-	-	-	-	47	92	134	177	215	250	247	241	234
HDV Diesel Articulated 34 - 40 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	40	78	115	152	187
HDV Diesel Articulated 34 - 40 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 34 - 40 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 34 - 40 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 40 - 50 t	Conventional	1953	1996	2041	2086	2078	2067	2054	2039	1980	1921	1861	1846	1796	1744	1724	1702	1677
HDV Diesel Articulated 40 - 50 t	Euro I	-	-	-	-	55	113	175	240	302	366	430	445	450	455	469	485	501
HDV Diesel Articulated 40 - 50 t	Euro II	-	-	-	-	-	-	-	-	47	95	143	198	251	306	317	325	334
HDV Diesel Articulated 40 - 50 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	47	95	148	205	266
HDV Diesel Articulated 40 - 50 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 40 - 50 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 40 - 50 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 50 - 60 t	Conventional	43	46	49	52	54	56	58	59	60	60	60	61	61	61	62	63	63
HDV Diesel Articulated 50 - 60 t	Euro I	-	-	-	-	1	3	5	7	9	11	14	15	15	16	17	18	19
HDV Diesel Articulated 50 - 60 t	Euro II	-	-	-	-	-	-	-	-	1	3	5	7	9	11	11	12	13
HDV Diesel Articulated 50 - 60 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	2	3	5	8	10

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Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HDV Diesel Articulated 50 - 60 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 50 - 60 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 50 - 60 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Midi <=15 t	Conventional	563	667	774	979	1128	1336	1448	1466	1396	1309	1348	1366	1353	1354	1358	1381	815
BUS Diesel Urban Midi <=15 t	Euro I	-	-	-	-	30	73	122	170	210	244	304	319	315	314	314	318	187
BUS Diesel Urban Midi <=15 t	Euro II	-	-	-	-	-	-	-	-	33	63	101	142	182	228	238	242	143
BUS Diesel Urban Midi <=15 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	36	76	118	168	129
BUS Diesel Urban Midi <=15 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Midi <=15 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Midi <=15 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Standard 15 - 18 t	Conventional	1126	1334	1549	1959	2256	2672	2897	2931	2792	2617	2696	2733	2706	2708	2716	2763	1631
BUS Diesel Urban Standard 15 - 18 t	Euro I	-	-	-	-	60	146	245	341	419	488	607	639	631	629	628	637	374
BUS Diesel Urban Standard 15 - 18 t	Euro II	-	-	-	-	-	-	-	-	65	126	202	284	365	456	476	484	286
BUS Diesel Urban Standard 15 - 18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	73	151	237	335	259
BUS Diesel Urban Standard 15 - 18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Standard 15 - 18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Standard 15 - 18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Articulated >18 t	Conventional	188	222	258	326	376	445	483	489	465	436	449	455	451	451	453	460	272
BUS Diesel Urban Articulated >18 t	Euro I	-	-	-	-	10	24	41	57	70	81	101	106	105	105	105	106	62
BUS Diesel Urban Articulated >18 t	Euro II	-	-	-	-	-	-	-	-	11	21	34	47	61	76	79	81	48
BUS Diesel Urban Articulated >18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	12	25	39	56	43
BUS Diesel Urban Articulated >18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Articulated >18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Standard <=18 t	Conventional	3574	4200	4838	6070	6934	8148	8763	8797	8313	7731	7901	7947	7808	7752	7714	7786	4560
BUS Diesel Coach Standard <=18 t	Euro I	-	-	-	-	184	445	740	1022	1248	1441	1780	1857	1819	1800	1785	1794	1046
BUS Diesel Coach Standard <=18 t	Euro II	-	-	-	-	-	-	-	-	194	374	593	825	1053	1305	1353	1365	798
BUS Diesel Coach Standard <=18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	209	433	673	945	724
BUS Diesel Coach Standard <=18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Standard <=18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Standard <=18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Articulated >18 t	Conventional	36	42	49	61	70	82	89	89	84	78	80	80	79	78	78	79	46
BUS Diesel Coach Articulated >18 t	Euro I	-	-	-	-	2	4	7	10	13	15	18	19	18	18	18	18	11
BUS Diesel Coach Articulated >18 t	Euro II	-	-	-	-	-	-	-	-	2	4	6	8	11	13	14	14	8
BUS Diesel Coach Articulated >18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	2	4	7	10	7
BUS Diesel Coach Articulated >18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Articulated >18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS CNG Urban	Euro I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22
BUS CNG Urban	Euro II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
BUS CNG Urban	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
BUS CNG Urban	EEV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOP Gasoline 2-stroke <50 cm³	Conventional	276901	279077	281270	282137	282792	283963	284571	285901	286760	288690	281749	284031	282436	280919	279343	273219	40334
MOP Gasoline 2-stroke <50 cm³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	3611	7371	11288	15125	2870
MOP Gasoline 2-stroke <50 cm³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4883	1483
MOP Gasoline 2-stroke <50 cm³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOP Gasoline 2-stroke <50 cm³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 2-stroke >50 cm³	Conventional	44998	45124	45235	44769	44324	44027	43612	43043	42578	42053	40888	40344	39277	38249	37283	35838	13084

Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
MOT Gasoline 2-stroke >50 cm ³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	502	1004	1507	1984	931
MOT Gasoline 2-stroke >50 cm ³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	641	481
MOT Gasoline 2-stroke >50 cm ³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 2-stroke >50 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke <250 cm ³	Conventional	51709	52888	54089	54625	55203	55982	56632	57097	57712	58262	57919	58451	58220	58028	57912	57018	21330
MOT Gasoline 4-stroke <250 cm ³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	744	1523	2340	3156	1518
MOT Gasoline 4-stroke <250 cm ³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1019	784
MOT Gasoline 4-stroke <250 cm ³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke <250 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke 250 - 750 cm ³	Conventional	86181	88146	90149	91042	92005	93304	94387	95161	96186	97103	96532	97418	97033	96714	96520	95030	35550
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	1241	2538	3900	5261	2530
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1699	1307
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke >750 cm ³	Conventional	34472	35258	36060	36417	36802	37322	37755	38064	38474	38841	38613	38967	38813	38686	38608	38012	14220
MOT Gasoline 4-stroke >750 cm ³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	496	1015	1560	2104	1012
MOT Gasoline 4-stroke >750 cm ³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	679	523
MOT Gasoline 4-stroke >750 cm ³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke >750 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 287 Vehicle fleet data for Road transport (number of vehicles) 2005-2021

Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PC Gasoline Small	PRE ECE	194412	107714	107944	107212	98395	88623	79490	72686	66201	59525	54632	46519	35110	30441	27023	21860	18419
PC Gasoline Small	ECE 15/00-01	54864	29640	26567	22126	15136	7621	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	ECE 15/02	76668	33874	33517	32293	28080	23186	18147	13334	8264	2990	-	-	-	-	-	-	-
PC Gasoline Small	ECE 15/03	136545	64926	68265	70832	67577	62911	57934	53960	49582	41861	32632	18477	7260	2449	-	-	-
PC Gasoline Small	ECE 15/04	266502	165084	181536	197781	199037	196497	193106	193388	192819	188374	182741	150894	101642	85701	72614	53255	41065
PC Gasoline Small	Euro 1	220091	146072	174573	205969	223774	237858	240742	222105	201713	187715	176214	153973	111323	102841	98548	86222	82130
PC Gasoline Small	Euro 2	149136	101620	124207	149419	165110	178141	190550	206981	223162	248528	254158	229125	173679	150773	140041	126796	125932
PC Gasoline Small	Euro 3	93436	67525	86465	108016	123149	136411	149229	165275	181242	180227	202650	226335	221354	224779	225629	196547	191848
PC Gasoline Small	Euro 4	11220	13901	23362	34589	44364	53609	62720	73280	83947	93365	103136	113232	122213	141402	156194	139866	123579
PC Gasoline Small	Euro 5	-	-	-	-	-	5393	10816	16587	22520	25287	37098	43978	45044	42586	42358	54489	52451
PC Gasoline Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	5002	9921	15705	17408	19539	19357	18145
PC Gasoline Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	5803	13026	17999	19124
PC Gasoline Medium	PRE ECE	141447	77914	77931	74068	66642	58022	51425	45993	40970	36027	32334	26922	19867	16840	14614	11555	9515
PC Gasoline Medium	ECE 15/00-01	39917	21440	19180	15286	10251	4989	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	ECE 15/02	55781	24503	24198	22309	19019	15180	11740	8437	5114	1810	-	-	-	-	-	-	-
PC Gasoline Medium	ECE 15/03	99345	46963	49285	48934	45769	41188	37480	34144	30685	25336	19314	10693	4108	1355	-	-	-
PC Gasoline Medium	ECE 15/04	193897	119411	131061	136638	134806	128649	124928	122370	119330	114011	108157	87328	57514	47410	39268	28150	21215
PC Gasoline Medium	Euro 1	160129	105660	126034	142295	151561	155728	155745	140541	124834	113612	104294	89110	62992	56892	53293	45576	42429
PC Gasoline Medium	Euro 2	108506	73505	89672	103227	111828	116631	123274	130971	138108	150419	150427	132602	98276	83408	75732	67023	65058
PC Gasoline Medium	Euro 3	67981	48844	62424	74623	83408	89309	96542	104581	112165	109080	119941	130988	125254	124348	122016	103893	99111
PC Gasoline Medium	Euro 4	8163	10055	16866	23896	30048	35099	40576	46370	51953	56508	61042	65531	69154	78224	84467	73932	63842
PC Gasoline Medium	Euro 5	-	-	-	-	-	3531	6997	10495	13937	15305	21957	25452	25488	23558	22906	28803	27097
PC Gasoline Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	2961	5742	8887	9630	10567	10232	9374

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Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PC Gasoline Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	3210	7044	9514	9880
PC Gasoline Large	PRE ECE	31919	17656	17703	16859	15013	13131	11644	10414	9276	8157	7321	6095	4498	3812	3308	2616	2154
PC Gasoline Large	ECE 15/00-01	9008	4859	4357	3479	2309	1129	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	ECE 15/02	12587	5553	5497	5078	4284	3436	2658	1910	1158	410	-	-	-	-	-	-	-
PC Gasoline Large	ECE 15/03	22418	10642	11196	11138	10311	9321	8486	7731	6948	5736	4373	2421	930	307	-	-	-
PC Gasoline Large	ECE 15/04	43755	27060	29772	31101	30368	29115	28287	27707	27018	25814	24487	19771	13021	10733	8890	6372	4802
PC Gasoline Large	Euro 1	36135	23944	28630	32389	34143	35243	35265	31822	28265	25723	23613	20175	14261	12880	12065	10317	9605
PC Gasoline Large	Euro 2	24485	16657	20370	23496	25192	26395	27913	29655	31270	34057	34058	30021	22249	18883	17145	15173	14727
PC Gasoline Large	Euro 3	15340	11069	14180	16986	18790	20212	21860	23679	25396	24697	27155	29656	28357	28151	27623	23519	22436
PC Gasoline Large	Euro 4	1842	2279	3831	5439	6769	7943	9187	10499	11763	12794	13820	14836	15656	17709	19122	16737	14452
PC Gasoline Large	Euro 5	-	-	-	-	-	799	1584	2376	3156	3465	4971	5762	5770	5333	5186	6520	6134
PC Gasoline Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	670	1300	2012	2180	2392	2316	2122
PC Gasoline Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	727	1595	2154	2237
PC Gasoline Hybrid Medium	Euro 4	-	-	-	-	6	46	102	267	422	704	893	1340	2264	3633	5189	6315	9740
PC Gasoline Hybrid Medium	Euro 5	-	-	-	-	-	5	18	60	113	191	321	520	835	1094	1407	2460	4134
PC Gasoline Hybrid Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	43	117	291	447	649	874	1430
PC Gasoline Hybrid Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	149	433	813	1507
PC Diesel Small	Conventional	32509	49057	65343	77983	82357	83893	85024	89515	92767	94261	94618	86372	65147	58031	52339	45383	38970
PC Diesel Small	Euro 1	9815	17860	27301	37332	45145	52673	58704	59639	59054	60441	61751	61601	50359	50324	51766	52093	53807
PC Diesel Small	Euro 2	6651	12425	19424	27083	33310	39449	46465	55578	65334	80022	89065	91667	78567	73779	73562	76608	82503
PC Diesel Small	Euro 3	4167	8256	13522	19578	24845	30208	36389	44379	53061	58030	71015	90551	100134	109993	118521	118750	125687
PC Diesel Small	Euro 4	500	1700	3653	6269	8950	11872	15294	19677	24577	30062	36142	45302	55286	69194	82047	84504	80962
PC Diesel Small	Euro 5	-	-	-	-	-	1194	2637	4454	6593	8142	13000	17595	20376	20839	22250	32921	34363
PC Diesel Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	1753	3969	7104	8518	10264	11695	11888
PC Diesel Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	2839	6842	10874	12529
PC Diesel Medium	Conventional	49938	75413	100492	119886	126537	128868	130643	137537	142525	144813	145353	132679	100069	89134	80386	69699	59848
PC Diesel Medium	Euro 1	15077	27454	41986	57393	69363	80911	90202	91634	90730	92856	94862	94627	77354	77296	79507	80005	82632
PC Diesel Medium	Euro 2	10216	19099	29873	41635	51179	60598	71396	85394	100377	122938	136822	140813	120683	113322	112983	117655	126703
PC Diesel Medium	Euro 3	6401	12691	20796	30098	38172	46402	55914	68187	81522	89152	109094	139098	153811	168946	182034	182377	193021
PC Diesel Medium	Euro 4	769	2613	5619	9638	13752	18236	23500	30233	37759	46184	55522	69589	84921	106279	126015	129782	124335
PC Diesel Medium	Euro 5	-	-	-	-	-	1835	4053	6843	10129	12509	19971	27028	31299	32008	34174	50561	52772
PC Diesel Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	2693	6097	10913	13084	15764	17961	18256
PC Diesel Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	4361	10509	16701	19241
PC Diesel Large	Conventional	23509	35365	46349	53604	55108	54768	54537	56112	56809	56375	55245	49216	36214	31457	27655	23364	19539
PC Diesel Large	Euro 1	7098	12875	19365	25662	30208	34387	37655	37384	36164	36148	36055	35101	27993	27279	27352	26818	26977
PC Diesel Large	Euro 2	4810	8957	13778	18616	22289	25753	29804	34839	40010	47859	52003	52233	43674	39993	38869	39439	41365
PC Diesel Large	Euro 3	3013	5952	9591	13458	16624	19721	23341	27819	32494	34706	41464	51597	55662	59624	62624	61134	63016
PC Diesel Large	Euro 4	362	1225	2591	4309	5989	7750	9810	12334	15050	17979	21102	25813	30732	37508	43352	43504	40592
PC Diesel Large	Euro 5	-	-	-	-	-	780	1692	2792	4037	4869	7591	10026	11327	11296	11756	16948	17229
PC Diesel Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	1024	2262	3949	4618	5423	6021	5960
PC Diesel Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	1539	3615	5598	6282
PC LPG Medium	Conventional	53258	48960	46168	43242	40289	37112	34706	37765	40134	46839	47305	41222	29985	27012	24357	34091	30521
PC LPG Medium	Euro 1	16079	17824	19289	20701	22085	23301	23963	25161	25549	30033	30873	29400	23178	23425	24091	39132	42141
PC LPG Medium	Euro 2	10895	12400	13724	15018	16295	17451	18967	23448	28266	39763	44529	43749	36161	34343	34235	57547	64616
PC LPG Medium	Euro 3	6826	8240	9554	10856	12154	13363	14854	18723	22956	28835	35505	43217	46088	51200	55157	89204	98437
PC LPG Medium	Euro 4	820	1696	2581	3476	4378	5252	6243	8302	10633	14938	18070	21621	25446	32209	38183	63479	63408
PC LPG Medium	Euro 5	-	-	-	-	-	528	1077	1879	2852	4046	6500	8397	9378	9700	10355	24730	26913
PC LPG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	876	1894	3270	3965	4777	8785	9310

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PC LPG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	1322	3184	8169	9813
PC CNG Medium	Euro 4	5958	8882	11892	14883	17860	20692	19337	19248	19098	19834	20942	20862	20084	21916	23699	26133	27096
PC CNG Medium	Euro 5	-	-	-	-	-	113	211	319	427	500	772	978	1171	1264	1394	2280	2438
PC CNG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	104	221	408	517	643	810	843
PC CNG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	172	429	753	889
LCV Gasoline <3,5 t	Conventional	160845	52019	44691	38302	33936	30418	27048	24145	21579	18841	16452	11544	7051	5670	4604	3777	2985
LCV Gasoline <3,5 t	Euro 1	50567	17258	16569	16994	16568	15136	13290	12973	13053	13299	13460	10495	7208	6615	6248	6115	5970
LCV Gasoline <3,5 t	Euro 2	33402	11309	12145	12992	13719	13151	12824	12342	12152	12616	12787	11825	9275	8918	8879	8993	9154
LCV Gasoline <3,5 t	Euro 3	32388	12957	13166	12753	11694	12732	13525	14287	14456	14067	14414	13593	12130	11966	11728	12259	13548
LCV Gasoline <3,5 t	Euro 4	8062	5529	9051	9904	9051	7604	7085	7948	8726	8206	7946	7416	7551	8253	7928	7357	7256
LCV Gasoline <3,5 t	Euro 5	-	-	-	3301	6034	7863	9166	9773	11331	12826	14055	12877	11134	10971	12403	13460	12492
LCV Gasoline <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	1839	4228	6051	7723	10242	11684	12829	12339
LCV Diesel <3,5 t	Conventional	45458	64419	72921	77175	78023	79164	79087	77566	74622	69920	65562	55093	37916	31489	26249	21667	17526
LCV Diesel <3,5 t	Euro 1	14291	21372	27036	34242	38092	39392	38858	41677	45139	49354	53641	50085	38759	36737	35624	35080	35052
LCV Diesel <3,5 t	Euro 2	9440	14005	19816	26178	31541	34225	37496	39648	42021	46818	50960	56432	49872	49532	50624	51588	53745
LCV Diesel <3,5 t	Euro 3	9153	16046	21482	25696	26885	33135	39544	45899	49991	52204	57442	64869	65225	66458	66866	70324	79542
LCV Diesel <3,5 t	Euro 4	2279	6847	14769	19956	20810	19788	20715	25533	30174	30452	31667	35393	40603	45835	45201	42205	42599
LCV Diesel <3,5 t	Euro 5	-	-	-	6652	13873	20465	26801	31395	39183	47597	56010	61451	59873	60933	70713	77218	73342
LCV Diesel <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	6824	16849	28878	41528	56884	66614	73596	72442
HDV Gasoline >3,5 t	Conventional	5822	2022	1951	1923	1857	1774	1693	1663	1659	1667	1701	1506	1267	1278	1295	1322	1301
HDV Diesel Rigid <=7,5 t	Conventional	3200	4070	4360	4489	4358	4492	4087	3814	3485	3095	2743	2173	1406	1094	851	653	488
HDV Diesel Rigid <=7,5 t	Euro I	1006	1350	1616	1992	2127	2235	2008	2049	2108	2184	2244	1976	1437	1276	1155	1057	977
HDV Diesel Rigid <=7,5 t	Euro II	665	885	1185	1523	1762	1942	1938	1950	1963	2072	2132	2226	1849	1721	1641	1554	1498
HDV Diesel Rigid <=7,5 t	Euro III	644	1014	1284	1495	1502	1880	2043	2257	2335	2311	2403	2559	2419	2309	2168	2119	2216
HDV Diesel Rigid <=7,5 t	Euro IV	160	433	883	1161	1162	1123	1070	1256	1409	1348	1325	1396	1506	1592	1466	1272	1187
HDV Diesel Rigid <=7,5 t	Euro V	-	-	-	387	775	1161	1385	1544	1830	2107	2344	2424	2220	2117	2293	2327	2044
HDV Diesel Rigid <=7,5 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	302	705	1139	1540	1976	2160	2218	2018
HDV Diesel Rigid 7,5 - 12 t	Conventional	1696	2383	2581	2720	2650	2733	2633	2533	2391	2197	2020	1664	1123	914	746	603	478
HDV Diesel Rigid 7,5 - 12 t	Euro I	533	790	957	1207	1294	1360	1294	1361	1446	1551	1653	1513	1147	1066	1013	977	956
HDV Diesel Rigid 7,5 - 12 t	Euro II	352	518	701	922	1071	1181	1248	1295	1346	1471	1570	1704	1476	1437	1439	1437	1466
HDV Diesel Rigid 7,5 - 12 t	Euro III	342	593	760	905	913	1144	1317	1499	1602	1640	1770	1959	1931	1928	1901	1958	2170
HDV Diesel Rigid 7,5 - 12 t	Euro IV	85	253	523	703	707	683	690	834	967	957	976	1069	1202	1330	1285	1175	1162
HDV Diesel Rigid 7,5 - 12 t	Euro V	-	-	-	234	471	706	892	1025	1255	1495	1726	1856	1773	1768	2010	2150	2000
HDV Diesel Rigid 7,5 - 12 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	214	519	872	1229	1650	1894	2050	1976
HDV Diesel Rigid 12 - 14 t	Conventional	498	695	742	773	761	758	728	693	646	587	532	433	288	231	186	148	115
HDV Diesel Rigid 12 - 14 t	Euro I	156	230	275	343	371	377	358	372	391	414	436	393	294	269	252	239	230
HDV Diesel Rigid 12 - 14 t	Euro II	103	151	202	262	308	328	345	354	364	393	414	443	379	363	358	352	353
HDV Diesel Rigid 12 - 14 t	Euro III	100	173	219	257	262	317	364	410	433	438	467	510	495	487	473	480	523
HDV Diesel Rigid 12 - 14 t	Euro IV	25	74	150	200	203	189	191	228	261	255	257	278	308	336	320	288	280
HDV Diesel Rigid 12 - 14 t	Euro V	-	-	-	67	135	196	247	280	339	399	455	483	455	447	501	527	482
HDV Diesel Rigid 12 - 14 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	57	137	227	315	417	472	502	476
HDV Diesel Rigid 14 - 20 t	Conventional	1580	2191	2400	2464	2408	2365	2290	2172	2020	1827	1653	1339	887	709	568	450	349
HDV Diesel Rigid 14 - 20 t	Euro I	497	727	890	1093	1175	1177	1125	1167	1222	1290	1353	1217	907	827	771	728	697
HDV Diesel Rigid 14 - 20 t	Euro II	328	476	652	836	973	1023	1086	1110	1137	1224	1285	1372	1167	1115	1095	1071	1069
HDV Diesel Rigid 14 - 20 t	Euro III	318	546	707	820	830	990	1145	1286	1353	1364	1448	1577	1527	1496	1446	1460	1582
HDV Diesel Rigid 14 - 20 t	Euro IV	79	233	486	637	642	591	600	715	817	796	799	860	950	1032	978	876	847
HDV Diesel Rigid 14 - 20 t	Euro V	-	-	-	212	428	611	776	879	1061	1244	1412	1494	1401	1372	1530	1603	1459
HDV Diesel Rigid 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	178	425	702	972	1281	1441	1528	1441

Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
HDV Diesel Rigid 20 - 26 t	Conventional	1279	1793	1989	1957	1895	1886	1799	1692	1559	1397	1251	1002	656	517	408	319	243
HDV Diesel Rigid 20 - 26 t	Euro I	402	595	737	868	925	938	884	909	943	986	1023	911	671	603	554	516	486
HDV Diesel Rigid 20 - 26 t	Euro II	266	390	540	664	766	815	853	865	878	936	972	1026	863	814	788	758	745
HDV Diesel Rigid 20 - 26 t	Euro III	258	447	586	652	653	789	900	1001	1045	1043	1096	1180	1128	1092	1040	1034	1102
HDV Diesel Rigid 20 - 26 t	Euro IV	64	191	403	506	505	471	471	557	631	608	604	644	702	753	703	621	590
HDV Diesel Rigid 20 - 26 t	Euro V	-	-	-	169	337	487	610	685	819	951	1069	1117	1036	1001	1100	1135	1016
HDV Diesel Rigid 20 - 26 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	136	321	525	718	934	1036	1082	1004
HDV Diesel Rigid 26 - 28 t	Conventional	293	428	493	512	512	502	512	500	479	447	418	350	240	198	165	135	109
HDV Diesel Rigid 26 - 28 t	Euro I	92	142	183	227	250	250	251	269	290	316	342	318	245	231	224	219	218
HDV Diesel Rigid 26 - 28 t	Euro II	61	93	134	174	207	217	243	256	270	299	325	358	315	312	318	323	335
HDV Diesel Rigid 26 - 28 t	Euro III	59	107	145	170	177	210	256	296	321	334	366	412	412	419	420	440	495
HDV Diesel Rigid 26 - 28 t	Euro IV	15	45	100	132	137	125	134	165	194	195	202	225	257	289	284	264	265
HDV Diesel Rigid 26 - 28 t	Euro V	-	-	-	44	91	130	173	202	252	304	357	390	379	384	444	483	457
HDV Diesel Rigid 26 - 28 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	44	107	183	263	358	418	460	451
HDV Diesel Rigid 28 - 32 t	Conventional	284	409	483	504	506	516	524	517	501	473	446	377	261	218	183	152	124
HDV Diesel Rigid 28 - 32 t	Euro I	89	136	179	224	247	257	257	278	303	334	365	343	267	255	249	246	247
HDV Diesel Rigid 28 - 32 t	Euro II	59	89	131	171	205	223	248	264	282	316	347	386	344	343	353	362	379
HDV Diesel Rigid 28 - 32 t	Euro III	57	102	142	168	174	216	262	306	336	353	391	444	449	461	466	494	562
HDV Diesel Rigid 28 - 32 t	Euro IV	14	43	98	130	135	129	137	170	203	206	215	242	280	318	315	296	301
HDV Diesel Rigid 28 - 32 t	Euro V	-	-	-	43	90	133	178	209	263	322	381	421	413	423	493	542	518
HDV Diesel Rigid 28 - 32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	46	115	198	286	394	465	517	511
HDV Diesel Rigid >32 t	Conventional	150	216	243	258	254	252	254	247	236	219	204	170	116	96	79	65	52
HDV Diesel Rigid >32 t	Euro I	47	72	90	115	124	125	125	133	143	155	167	155	119	112	108	105	104
HDV Diesel Rigid >32 t	Euro II	31	47	66	88	103	109	120	126	133	147	159	174	153	151	153	155	160
HDV Diesel Rigid >32 t	Euro III	30	54	72	86	88	105	127	146	158	164	179	201	200	202	202	211	237
HDV Diesel Rigid >32 t	Euro IV	8	23	49	67	68	63	66	81	95	96	99	109	125	140	137	127	127
HDV Diesel Rigid >32 t	Euro V	-	-	-	22	45	65	86	100	124	149	174	190	184	186	214	232	218
HDV Diesel Rigid >32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	21	52	89	127	173	201	221	216
HDV Diesel Articulated 14 - 20 t	Conventional	282	403	460	555	560	563	594	600	594	572	551	475	335	285	243	205	169
HDV Diesel Articulated 14 - 20 t	Euro I	89	134	170	246	274	280	292	323	359	404	451	431	342	332	329	332	338
HDV Diesel Articulated 14 - 20 t	Euro II	58	88	125	188	226	243	282	307	335	383	428	486	440	448	468	488	519
HDV Diesel Articulated 14 - 20 t	Euro III	57	100	135	185	193	236	297	355	398	427	483	559	576	601	618	665	768
HDV Diesel Articulated 14 - 20 t	Euro IV	14	43	93	143	149	141	156	198	240	249	266	305	358	414	418	399	411
HDV Diesel Articulated 14 - 20 t	Euro V	-	-	-	48	100	146	201	243	312	389	470	529	529	551	654	730	708
HDV Diesel Articulated 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	56	142	249	367	514	616	696	700
HDV Diesel Articulated 20 - 28 t	Conventional	204	278	322	339	329	336	332	322	307	285	264	220	150	123	102	83	66
HDV Diesel Articulated 20 - 28 t	Euro I	64	92	120	151	161	167	163	173	186	201	216	200	153	144	138	134	133
HDV Diesel Articulated 20 - 28 t	Euro II	42	60	88	115	133	145	157	165	173	191	205	225	197	194	196	198	204
HDV Diesel Articulated 20 - 28 t	Euro III	41	69	95	113	113	141	166	191	206	212	231	259	258	260	259	269	302
HDV Diesel Articulated 20 - 28 t	Euro IV	10	30	65	88	88	84	87	106	124	124	128	141	160	179	175	162	162
HDV Diesel Articulated 20 - 28 t	Euro V	-	-	-	29	59	87	112	130	161	194	226	245	236	238	274	296	278
HDV Diesel Articulated 20 - 28 t	Euro VI	-	-	-	-	-	-	-	-	-	28	68	115	164	222	258	282	275
HDV Diesel Articulated 28 - 34 t	Conventional	180	238	270	251	230	233	209	188	165	140	118	88	53	37	26	17	10
HDV Diesel Articulated 28 - 34 t	Euro I	57	79	100	111	112	116	103	101	100	99	96	80	54	44	35	28	21
HDV Diesel Articulated 28 - 34 t	Euro II	37	52	73	85	93	101	99	96	93	94	92	90	69	59	50	41	32
HDV Diesel Articulated 28 - 34 t	Euro III	36	59	79	84	79	97	104	111	111	105	103	103	91	79	66	56	47
HDV Diesel Articulated 28 - 34 t	Euro IV	9	25	55	65	61	58	55	62	67	61	57	56	56	54	45	33	25
HDV Diesel Articulated 28 - 34 t	Euro V	-	-	-	22	41	60	71	76	87	95	101	98	83	72	70	61	44

Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
HDV Diesel Articulated 28 - 34 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	14	30	46	58	68	66	58	43
HDV Diesel Articulated 34 - 40 t	Conventional	1021	1414	1617	1493	1336	1289	1197	1072	934	785	652	478	282	195	131	82	45
HDV Diesel Articulated 34 - 40 t	Euro I	321	469	600	663	652	641	588	576	565	554	533	435	288	228	177	132	90
HDV Diesel Articulated 34 - 40 t	Euro II	212	308	439	507	540	557	567	548	526	525	507	490	371	307	252	194	138
HDV Diesel Articulated 34 - 40 t	Euro III	206	352	476	497	460	539	598	634	625	586	571	563	485	412	333	265	204
HDV Diesel Articulated 34 - 40 t	Euro IV	51	150	328	386	356	322	314	353	378	342	315	307	302	284	225	159	109
HDV Diesel Articulated 34 - 40 t	Euro V	-	-	-	129	238	333	406	434	490	534	557	534	445	378	352	291	188
HDV Diesel Articulated 34 - 40 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	77	168	251	309	353	331	277	186
HDV Diesel Articulated 40 - 50 t	Conventional	1596	2239	2526	2722	2817	2632	2720	2658	2547	2378	2222	1860	1276	1056	877	721	581
HDV Diesel Articulated 40 - 50 t	Euro I	502	743	936	1208	1375	1310	1336	1428	1541	1679	1818	1691	1304	1232	1190	1168	1163
HDV Diesel Articulated 40 - 50 t	Euro II	331	487	686	923	1139	1138	1290	1359	1435	1592	1727	1905	1678	1661	1691	1717	1783
HDV Diesel Articulated 40 - 50 t	Euro III	321	558	744	906	971	1102	1360	1573	1707	1776	1947	2190	2194	2228	2234	2341	2639
HDV Diesel Articulated 40 - 50 t	Euro IV	80	238	512	704	751	658	712	875	1030	1036	1073	1195	1366	1537	1510	1405	1413
HDV Diesel Articulated 40 - 50 t	Euro V	-	-	-	235	501	680	922	1076	1338	1619	1898	2075	2014	2043	2362	2571	2433
HDV Diesel Articulated 40 - 50 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	232	571	975	1397	1907	2225	2450	2403
HDV Diesel Articulated 50 - 60 t	Conventional	62	88	105	112	116	117	120	120	118	112	107	91	64	54	45	38	31
HDV Diesel Articulated 50 - 60 t	Euro I	19	29	39	50	56	58	59	65	71	79	87	83	65	62	61	61	62
HDV Diesel Articulated 50 - 60 t	Euro II	13	19	28	38	47	51	57	61	66	75	83	93	84	84	87	90	95
HDV Diesel Articulated 50 - 60 t	Euro III	12	22	31	37	40	49	60	71	79	84	93	107	109	113	115	123	141
HDV Diesel Articulated 50 - 60 t	Euro IV	3	9	21	29	31	29	32	40	48	49	51	58	68	78	78	74	75
HDV Diesel Articulated 50 - 60 t	Euro V	-	-	-	10	21	30	41	49	62	76	91	101	100	104	122	135	130
HDV Diesel Articulated 50 - 60 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	11	27	48	70	97	115	129	128
BUS Diesel Urban Midi <=15 t	Conventional	853	1037	1026	1028	984	921	848	768	699	613	536	426	292	237	191	143	103
BUS Diesel Urban Midi <=15 t	Euro I	195	236	276	327	354	354	329	350	381	418	438	387	298	276	259	231	206
BUS Diesel Urban Midi <=15 t	Euro II	149	181	220	243	272	280	300	307	313	351	382	423	386	371	369	340	316
BUS Diesel Urban Midi <=15 t	Euro III	170	254	285	307	295	338	366	392	403	380	437	490	492	494	448	458	479
BUS Diesel Urban Midi <=15 t	Euro IV	45	115	200	263	260	217	207	257	297	295	257	262	291	339	337	274	238
BUS Diesel Urban Midi <=15 t	Euro V	-	-	-	88	173	225	238	212	226	290	337	361	306	275	347	370	292
BUS Diesel Urban Midi <=15 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	23	53	109	172	232	270	276	261
BUS Diesel Urban Standard 15 - 18 t	Conventional	1707	2074	2051	2055	1968	1842	1697	1536	1397	1225	1072	852	584	473	382	286	206
BUS Diesel Urban Standard 15 - 18 t	Euro I	390	471	551	653	708	708	658	700	761	835	877	775	597	552	519	463	413
BUS Diesel Urban Standard 15 - 18 t	Euro II	298	362	440	485	544	561	599	615	626	702	763	846	773	743	737	681	633
BUS Diesel Urban Standard 15 - 18 t	Euro III	341	508	570	615	590	677	733	784	806	760	873	979	983	987	896	916	957
BUS Diesel Urban Standard 15 - 18 t	Euro IV	90	230	401	525	520	434	414	514	595	590	514	524	582	677	674	547	475
BUS Diesel Urban Standard 15 - 18 t	Euro V	-	-	-	175	347	450	476	423	452	579	675	721	612	551	695	740	583
BUS Diesel Urban Standard 15 - 18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	46	106	218	344	464	540	552	521
BUS Diesel Urban Articulated >18 t	Conventional	284	346	342	343	328	307	283	256	233	204	179	142	97	79	64	48	34
BUS Diesel Urban Articulated >18 t	Euro I	65	79	92	109	118	118	110	117	127	139	146	129	99	92	86	77	69
BUS Diesel Urban Articulated >18 t	Euro II	50	60	73	81	91	93	100	102	104	117	127	141	129	124	123	113	105
BUS Diesel Urban Articulated >18 t	Euro III	57	85	95	102	98	113	122	131	134	127	146	163	164	165	149	153	160
BUS Diesel Urban Articulated >18 t	Euro IV	15	38	67	88	87	72	69	86	99	98	86	87	97	113	112	91	79
BUS Diesel Urban Articulated >18 t	Euro V	-	-	-	29	58	75	79	71	75	97	112	120	102	92	116	123	97
BUS Diesel Urban Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	8	18	36	57	77	90	92	87
BUS Diesel Coach Standard <=18 t	Conventional	4675	5659	5761	5644	5247	4868	4495	4036	3644	3171	2754	2173	1476	1189	952	707	506
BUS Diesel Coach Standard <=18 t	Euro I	1068	1286	1548	1795	1888	1871	1743	1839	1986	2162	2253	1975	1509	1387	1292	1144	1013
BUS Diesel Coach Standard <=18 t	Euro II	818	989	1235	1332	1451	1482	1587	1616	1633	1817	1961	2157	1955	1865	1837	1683	1553
BUS Diesel Coach Standard <=18 t	Euro III	933	1385	1601	1688	1573	1789	1940	2061	2102	1968	2243	2496	2487	2479	2233	2265	2349
BUS Diesel Coach Standard <=18 t	Euro IV	246	627	1125	1443	1387	1148	1097	1350	1551	1527	1322	1336	1473	1700	1679	1353	1167

Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
BUS Diesel Coach Standard <=18 t	Euro V	-	-	-	481	924	1190	1260	1113	1180	1500	1733	1839	1549	1383	1731	1830	1432
BUS Diesel Coach Standard <=18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	120	272	556	870	1165	1345	1366	1280
BUS Diesel Coach Articulated >18 t	Conventional	47	57	58	57	53	49	45	41	37	32	28	22	15	12	10	7	5
BUS Diesel Coach Articulated >18 t	Euro I	11	13	16	18	19	19	18	19	20	22	23	20	15	14	13	12	10
BUS Diesel Coach Articulated >18 t	Euro II	8	10	12	13	15	15	16	16	16	18	20	22	20	19	19	17	16
BUS Diesel Coach Articulated >18 t	Euro III	9	14	16	17	16	18	20	21	21	20	23	25	25	25	23	23	24
BUS Diesel Coach Articulated >18 t	Euro IV	2	6	11	15	14	12	11	14	16	15	13	13	15	17	17	14	12
BUS Diesel Coach Articulated >18 t	Euro V	-	-	-	5	9	12	13	11	12	15	18	19	16	14	17	18	14
BUS Diesel Coach Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	1	3	6	9	12	14	14	13
BUS CNG Urban	Euro I	42	59	73	84	97	108	127	140	153	173	187	149	121	124	123	111	97
BUS CNG Urban	Euro II	6	8	12	15	20	24	32	38	44	59	73	78	79	90	100	101	99
BUS CNG Urban	Euro III	7	12	16	19	21	29	40	49	57	64	84	90	101	119	122	136	150
BUS CNG Urban	EEV	2	5	11	22	31	38	48	59	74	102	124	134	157	204	260	274	247
MOP Gasoline 2-stroke <50 cm³	Conventional	42519	27593	30636	33607	35465	36394	36590	37137	37472	38351	38667	38283	38012	37375	37563	35648	35235
MOP Gasoline 2-stroke <50 cm³	Euro 1	3736	2913	3703	4261	4199	5043	6227	7235	7393	7202	7635	8556	9185	9348	9188	11311	14730
MOP Gasoline 2-stroke <50 cm³	Euro 2	2412	2150	3037	4426	4560	4250	4562	5733	7059	7374	7290	7807	8884	9960	9746	9327	10505
MOP Gasoline 2-stroke <50 cm³	Euro 3	-	716	2024	4507	7042	9296	10639	11735	13555	16056	18292	20043	21186	22453	24574	25785	23574
MOP Gasoline 2-stroke <50 cm³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	847	1677	2642	3431	3129
MOT Gasoline 2-stroke >50 cm³	Conventional	12775	5363	5819	6256	6178	6403	6183	6070	5966	6028	6056	5971	5857	5732	5703	5381	5266
MOT Gasoline 2-stroke >50 cm³	Euro 1	1123	566	703	793	731	887	1052	1182	1177	1132	1196	1334	1415	1434	1395	1707	2202
MOT Gasoline 2-stroke >50 cm³	Euro 2	725	418	577	824	794	748	771	937	1124	1159	1142	1218	1369	1527	1480	1408	1570
MOT Gasoline 2-stroke >50 cm³	Euro 3	-	139	384	839	1227	1635	1798	1918	2158	2524	2865	3126	3264	3443	3731	3892	3524
MOT Gasoline 2-stroke >50 cm³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	131	257	401	518	468
MOT Gasoline 4-stroke <250 cm³	Conventional	21789	9027	10133	11073	11914	12057	12109	12227	12371	12874	13331	13556	13724	13874	14273	13934	14126
MOT Gasoline 4-stroke <250 cm³	Euro 1	1914	953	1225	1404	1411	1671	2061	2382	2441	2418	2632	3030	3316	3470	3491	4421	5905
MOT Gasoline 4-stroke <250 cm³	Euro 2	1236	703	1004	1458	1532	1408	1510	1888	2330	2475	2513	2764	3207	3697	3703	3646	4211
MOT Gasoline 4-stroke <250 cm³	Euro 3	-	234	669	1485	2366	3080	3521	3863	4475	5390	6306	7097	7649	8335	9337	10079	9451
MOT Gasoline 4-stroke <250 cm³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	306	622	1004	1341	1254
MOT Gasoline 4-stroke 250 - 750 cm³	Conventional	36314	15044	16888	18455	19856	20096	20181	20378	20618	21457	22218	22593	22874	23123	23788	23224	23543
MOT Gasoline 4-stroke 250 - 750 cm³	Euro 1	3191	1588	2041	2340	2351	2785	3435	3970	4068	4030	4387	5049	5527	5783	5819	7369	9842
MOT Gasoline 4-stroke 250 - 750 cm³	Euro 2	2060	1172	1674	2430	2553	2347	2516	3146	3884	4126	4189	4607	5346	6162	6172	6076	7019
MOT Gasoline 4-stroke 250 - 750 cm³	Euro 3	-	391	1116	2475	3943	5133	5868	6439	7458	8983	10511	11829	12749	13891	15562	16798	15752
MOT Gasoline 4-stroke 250 - 750 cm³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	510	1037	1673	2235	2090
MOT Gasoline 4-stroke >750 cm³	Conventional	14526	6018	6755	7382	7942	8038	8072	8151	8247	8583	8887	9037	9149	9249	9515	9290	9417
MOT Gasoline 4-stroke >750 cm³	Euro 1	1276	635	817	936	940	1114	1374	1588	1627	1612	1755	2020	2211	2313	2327	2948	3937
MOT Gasoline 4-stroke >750 cm³	Euro 2	824	469	670	972	1021	939	1007	1258	1554	1650	1676	1843	2138	2465	2469	2431	2808
MOT Gasoline 4-stroke >750 cm³	Euro 3	-	156	446	990	1577	2053	2347	2576	2983	3593	4204	4731	5100	5556	6225	6719	6301
MOT Gasoline 4-stroke >750 cm³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	204	415	669	894	836

Table 288 Mileage data for Road transport (average km/year/vehicle) 1988-2004

Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
PC Gasoline Small	PRE ECE	9561	10224	8941	4007	4857	5304	5064	5313	4343	2774	3477	3227	2525	2037	2083	1840	1671
PC Gasoline Small	ECE 15/00-01	-	-	10770	4827	5850	6389	6099	6400	5231	3342	4189	3887	3042	2453	2509	2216	2013
PC Gasoline Small	ECE 15/02	-	-	10906	4888	5925	6470	6177	6481	5297	3384	4241	3936	3080	2484	2541	2244	2038
PC Gasoline Small	ECE 15/03	-	-	12852	5760	6982	7624	7279	7637	6242	3988	4998	4638	3630	2927	2995	2645	2402
PC Gasoline Small	ECE 15/04	-	-	17266	7738	9379	10242	9778	10260	8386	5357	6715	6231	4876	3933	4023	3553	3227
PC Gasoline Small	Euro 1	-	-	-	-	11291	12330	11771	12351	10095	6449	8083	7501	5870	4734	4843	4277	3885
PC Gasoline Small	Euro 2	-	-	-	-	-	-	-	-	11697	7473	9366	8691	6802	5486	5612	4956	4501
PC Gasoline Small	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	7848	6329	6475	5718	5193
PC Gasoline Small	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	PRE ECE	10246	10958	9583	4295	5206	5685	5427	5694	4654	2973	3727	3458	2706	2183	2233	1972	1791
PC Gasoline Medium	ECE 15/00-01	-	-	11473	5142	6232	6806	6498	6818	5572	3560	4462	4140	3240	2613	2673	2361	2144
PC Gasoline Medium	ECE 15/02	-	-	12037	5395	6539	7140	6817	7153	5846	3735	4681	4344	3399	2742	2805	2477	2250
PC Gasoline Medium	ECE 15/03	-	-	13796	6183	7495	8184	7813	8198	6701	4281	5366	4979	3896	3142	3215	2839	2578
PC Gasoline Medium	ECE 15/04	-	-	18554	8316	10079	11006	10508	11026	9012	5757	7216	6696	5240	4226	4323	3818	3468
PC Gasoline Medium	Euro 1	-	-	-	-	12473	13620	13004	13644	11152	7124	8930	8286	6485	5230	5350	4725	4291
PC Gasoline Medium	Euro 2	-	-	-	-	-	-	-	-	12576	8034	10070	9344	7313	5898	6033	5328	4839
PC Gasoline Medium	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	8438	6805	6962	6148	5584
PC Gasoline Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	PRE ECE	10776	11524	10078	4517	5475	5978	5708	5989	4895	3127	3919	3637	2846	2295	2348	2074	1883
PC Gasoline Large	ECE 15/00-01	-	-	12056	5403	6549	7152	6828	7164	5855	3741	4689	4351	3405	2746	2809	2481	2253
PC Gasoline Large	ECE 15/02	-	-	12266	5497	6663	7276	6947	7289	5958	3806	4770	4427	3464	2794	2858	2524	2292
PC Gasoline Large	ECE 15/03	-	-	14549	6520	7903	8630	8240	8645	7066	4514	5658	5250	4109	3314	3390	2994	2719
PC Gasoline Large	ECE 15/04	-	-	19302	8651	10485	11450	10931	11470	9375	5989	7507	6966	5451	4396	4497	3972	3607
PC Gasoline Large	Euro 1	-	-	-	-	12779	13954	13322	13979	11425	7299	9148	8489	6643	5358	5481	4840	4396
PC Gasoline Large	Euro 2	-	-	-	-	-	-	-	-	13422	8575	10748	9973	7805	6295	6439	5686	5165
PC Gasoline Large	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	8689	7008	7169	6331	5750
PC Gasoline Large	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Hybrid Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Small	Conventional	-	-	24416	16766	11691	10573	6599	6374	10938	19104	21770	22156	18786	20030	19565	24189	31632
PC Diesel Small	Euro 1	-	-	-	-	13170	11912	7434	7181	12323	21522	24526	24960	21163	22565	22042	27251	35635
PC Diesel Small	Euro 2	-	-	-	-	-	-	-	-	14514	25349	28888	29400	24927	26578	25962	32098	41973
PC Diesel Small	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	28285	30158	29458	36421	47626
PC Diesel Small	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Bulgaria's National Inventory Report 2023 – Submission under UNFCCC

Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
PC Diesel Small	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Conventional	-	-	24416	16766	11691	10573	6599	6374	10938	19104	21770	22156	18786	20030	19565	24189	31632
PC Diesel Medium	Euro 1	-	-	-	-	13170	11912	7434	7181	12323	21522	24526	24960	21163	22565	22042	27251	35635
PC Diesel Medium	Euro 2	-	-	-	-	-	-	-	-	14514	25349	28888	29400	24927	26578	25962	32098	41973
PC Diesel Medium	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	28285	30158	29458	36421	47626
PC Diesel Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Conventional	-	-	26964	18515	12910	11676	7287	7039	12079	21097	24042	24467	20745	22119	21606	26713	34931
PC Diesel Large	Euro 1	-	-	-	-	14626	13229	8256	7975	13685	23901	27238	27720	23503	25060	24479	30264	39575
PC Diesel Large	Euro 2	-	-	-	-	-	-	-	-	15385	26870	30621	31163	26422	28173	27519	34023	44491
PC Diesel Large	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	30888	32934	32170	39773	52010
PC Diesel Large	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC Diesel Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Conventional	-	-	-	-	-	-	-	-	-	91349	40905	38412	67954	71682	68755	62497	56570
PC LPG Medium	Euro 1	-	-	-	-	-	-	-	-	-	103687	46430	43601	77132	81363	78041	70938	64210
PC LPG Medium	Euro 2	-	-	-	-	-	-	-	-	-	110087	49295	46292	81893	86385	82857	75317	68173
PC LPG Medium	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	85843	90552	86854	78950	71462
PC LPG Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC LPG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC CNG Medium	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25140
PC CNG Medium	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC CNG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PC CNG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Gasoline <3,5 t	Conventional	26231	28052	24532	10995	13327	14553	13894	14578	11915	7612	9541	8853	6928	5588	5716	5048	4585
LCV Gasoline <3,5 t	Euro 1	-	-	-	-	15338	16749	15991	16779	13714	8761	10981	10190	7974	6431	6579	5810	5277
LCV Gasoline <3,5 t	Euro 2	-	-	-	-	-	-	-	-	15341	9800	12284	11399	8920	7194	7359	6499	5903
LCV Gasoline <3,5 t	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	10119	8161	8349	7373	6696
LCV Gasoline <3,5 t	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Gasoline <3,5 t	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Gasoline <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Diesel <3,5 t	Conventional	49434	45949	25145	17266	12040	10889	6796	6565	11265	19674	22420	22818	19346	20628	20149	24912	32576
LCV Diesel <3,5 t	Euro 1	-	-	-	-	13967	12632	7884	7616	13068	22824	26010	26471	23931	23375	28900	37791	
LCV Diesel <3,5 t	Euro 2	-	-	-	-	-	-	-	-	14376	25108	28613	29119	24690	26325	25714	31792	41573
LCV Diesel <3,5 t	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	26938	28722	28056	34687	45359
LCV Diesel <3,5 t	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Diesel <3,5 t	Euro 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LCV Diesel <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Gasoline >3,5 t	Conventional	34510	36906	32275	14465	17533	19146	18279	19179	15676	10015	12552	11648	9115	7351	7520	6641	6032
HDV Diesel Rigid <=7,5 t	Conventional	71565	66520	36403	24996	17430	15764	9838	9503	16308	28482	32458	33033	28008	29863	29170	36064	47160
HDV Diesel Rigid <=7,5 t	Euro I	-	-	-	-	20436	18483	11535	11143	19121	33395	38057	38731	32839	35014	34202	42285	55294

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Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HDV Diesel Rigid <=7,5 t	Euro II	-	-	-	-	-	-	-	-	22527	39345	44837	45631	38689	41252	40295	49819	65146
HDV Diesel Rigid <=7,5 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	45274	48272	47153	58297	76233
HDV Diesel Rigid <=7,5 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid <=7,5 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid <=7,5 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 7,5 - 12 t	Conventional	73620	68430	37448	25714	17930	16217	10120	9776	16776	29300	33390	33981	28812	30720	30008	37100	48514
HDV Diesel Rigid 7,5 - 12 t	Euro I	-	-	-	-	22516	20364	12709	12277	21067	36794	41930	42673	36181	38578	37683	46589	60923
HDV Diesel Rigid 7,5 - 12 t	Euro II	-	-	-	-	-	-	-	-	24743	43214	49246	50118	42494	45309	44257	54718	71552
HDV Diesel Rigid 7,5 - 12 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	50254	53583	52340	64710	84619
HDV Diesel Rigid 7,5 - 12 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 7,5 - 12 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 7,5 - 12 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 12 - 14 t	Conventional	64201	59676	32657	22424	15636	14142	8826	8526	14630	25551	29118	29634	25126	26790	26168	32353	42307
HDV Diesel Rigid 12 - 14 t	Euro I	-	-	-	-	20423	18471	11528	11136	19108	33374	38032	38706	32818	34991	34180	42258	55259
HDV Diesel Rigid 12 - 14 t	Euro II	-	-	-	-	-	-	-	-	22843	39897	45466	46271	39232	41831	40861	50518	66060
HDV Diesel Rigid 12 - 14 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	48948	52190	50979	63028	82419
HDV Diesel Rigid 12 - 14 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 12 - 14 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 12 - 14 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 14 - 20 t	Conventional	80801	75105	41101	28222	19679	17798	11108	10730	18412	32158	36647	37296	31622	33717	32935	40719	53246
HDV Diesel Rigid 14 - 20 t	Euro I	-	-	-	-	24676	22318	13928	13455	23088	40324	45953	46767	39653	42279	41298	51059	66768
HDV Diesel Rigid 14 - 20 t	Euro II	-	-	-	-	-	-	-	-	26607	46470	52956	53894	45696	48722	47592	58840	76943
HDV Diesel Rigid 14 - 20 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	52980	56489	55179	68220	89209
HDV Diesel Rigid 14 - 20 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 14 - 20 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 20 - 26 t	Conventional	80921	75217	41162	28264	19708	17825	11124	10746	18440	32206	36701	37351	31669	33767	32983	40779	53325
HDV Diesel Rigid 20 - 26 t	Euro I	-	-	-	-	25005	22615	14114	13634	23396	40861	46565	47390	40181	42842	41848	51739	67657
HDV Diesel Rigid 20 - 26 t	Euro II	-	-	-	-	-	-	-	-	26828	46856	53397	54342	46076	49127	47988	59330	77583
HDV Diesel Rigid 20 - 26 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	54722	58347	56993	70464	92143
HDV Diesel Rigid 20 - 26 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 20 - 26 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 20 - 26 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 26 - 28 t	Conventional	80599	74917	40998	28151	19630	17754	11080	10703	18366	32077	36555	37202	31543	33632	32852	40616	53113
HDV Diesel Rigid 26 - 28 t	Euro I	-	-	-	-	24161	21852	13637	13174	22606	39482	44993	45790	38825	41396	40436	49993	65374
HDV Diesel Rigid 26 - 28 t	Euro II	-	-	-	-	-	-	-	-	25988	45389	51724	52641	44633	47589	46485	57471	75153
HDV Diesel Rigid 26 - 28 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	52446	55920	54623	67533	88310
HDV Diesel Rigid 26 - 28 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 26 - 28 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 26 - 28 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 28 - 32 t	Conventional	80782	75088	41091	28215	19674	17794	11105	10727	18408	32150	36638	37287	31615	33709	32927	40709	53233
HDV Diesel Rigid 28 - 32 t	Euro I	-	-	-	-	24477	22138	13816	13346	22901	39998	45582	46389	39332	41937	40964	50646	66228
HDV Diesel Rigid 28 - 32 t	Euro II	-	-	-	-	-	-	-	-	26351	46022	52446	53375	45256	48253	47134	58274	76202
HDV Diesel Rigid 28 - 32 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	53737	57296	55967	69195	90483
HDV Diesel Rigid 28 - 32 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 28 - 32 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid 28 - 32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid >32 t	Conventional	99529	92513	50627	34763	24240	21924	13682	13217	22680	39611	45141	45940	38952	41532	40568	50156	65587

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Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HDV Diesel Rigid >32 t	Euro I	-	-	-	-	26747	24191	15097	14584	25025	43708	49809	50691	42980	45826	44763	55343	72370
HDV Diesel Rigid >32 t	Euro II	-	-	-	-	-	-	-	-	30708	53632	61118	62201	52739	56232	54927	67909	88802
HDV Diesel Rigid >32 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	60743	64766	63264	78216	102280
HDV Diesel Rigid >32 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid >32 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Rigid >32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 14 - 20 t	Conventional	105245	97825	53534	36760	25632	23183	14468	13976	23982	41886	47733	48578	41188	43916	42898	53036	69354
HDV Diesel Articulated 14 - 20 t	Euro I	-	-	-	-	30974	28014	17483	16889	28981	50616	57681	58703	49772	53069	51838	64090	83808
HDV Diesel Articulated 14 - 20 t	Euro II	-	-	-	-	-	-	-	-	34674	60559	69013	70235	59551	63495	62022	76681	100273
HDV Diesel Articulated 14 - 20 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	74249	79167	77330	95607	125022
HDV Diesel Articulated 14 - 20 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 14 - 20 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 20 - 28 t	Conventional	116695	108469	59359	40759	28421	25705	16042	15497	26592	46443	52926	53864	45669	48694	47565	58807	76899
HDV Diesel Articulated 20 - 28 t	Euro I	-	-	-	-	33763	30536	19057	18409	31590	55173	62874	63988	54254	57847	56505	69860	91354
HDV Diesel Articulated 20 - 28 t	Euro II	-	-	-	-	-	-	-	-	37826	66065	75287	76621	64965	69268	67661	83652	109389
HDV Diesel Articulated 20 - 28 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	78730	83945	81997	101377	132567
HDV Diesel Articulated 20 - 28 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 20 - 28 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 20 - 28 t	Euro VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 28 - 34 t	Conventional	125283	116451	63727	43759	30512	27596	17222	16637	28548	49861	56821	57827	49030	52278	51065	63134	82558
HDV Diesel Articulated 28 - 34 t	Euro I	-	-	-	-	35804	32382	20209	19522	33499	58508	66675	67856	57533	61344	59921	74083	96875
HDV Diesel Articulated 28 - 34 t	Euro II	-	-	-	-	-	-	-	-	40066	69977	79745	81157	68811	73369	71667	88605	115866
HDV Diesel Articulated 28 - 34 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	82988	88485	86432	106860	139737
HDV Diesel Articulated 28 - 34 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 28 - 34 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 28 - 34 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 34 - 40 t	Conventional	119472	111050	60771	41729	29097	26316	16424	15865	27224	47548	54185	55145	46756	49853	48697	60206	78729
HDV Diesel Articulated 34 - 40 t	Euro I	-	-	-	-	37407	33832	21114	20396	34999	61127	69660	70894	60109	64091	62604	77400	101213
HDV Diesel Articulated 34 - 40 t	Euro II	-	-	-	-	-	-	-	-	41512	72502	82623	84086	71295	76017	74254	91803	120047
HDV Diesel Articulated 34 - 40 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	86077	91779	89650	110838	144939
HDV Diesel Articulated 34 - 40 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 34 - 40 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 34 - 40 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 40 - 50 t	Conventional	137928	128205	70159	48175	33592	30382	18961	18316	31430	54893	62556	63664	53979	57555	56219	69507	90891
HDV Diesel Articulated 40 - 50 t	Euro I	-	-	-	-	41205	37268	23258	22467	38553	67335	76734	78093	66213	70599	68961	85260	111491
HDV Diesel Articulated 40 - 50 t	Euro II	-	-	-	-	-	-	-	-	47439	82853	94419	96091	81473	86870	84854	104909	137186
HDV Diesel Articulated 40 - 50 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	97295	103740	101333	125283	163828
HDV Diesel Articulated 40 - 50 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 40 - 50 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 40 - 50 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 50 - 60 t	Conventional	126844	117902	64521	44304	30892	27940	17437	16844	28904	50482	57529	58548	49641	52929	51701	63921	83587
HDV Diesel Articulated 50 - 60 t	Euro I	-	-	-	-	36690	33184	20710	20006	34329	59957	68326	69536	58958	62863	61405	75918	99275
HDV Diesel Articulated 50 - 60 t	Euro II	-	-	-	-	-	-	-	-	41565	72595	82729	84195	71386	76115	74349	91921	120202
HDV Diesel Articulated 50 - 60 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	86981	92742	90591	112001	146460
HDV Diesel Articulated 50 - 60 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 50 - 60 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HDV Diesel Articulated 50 - 60 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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BUS Diesel Urban Midi <=15 t	Conventional	127946	118927	65081	44689	31161	28183	17588	16991	29155	50921	58029	59057	50073	53389	52151	64476	84313
BUS Diesel Urban Midi <=15 t	Euro I	-	-	-	-	38366	34699	21655	20919	35896	62694	71446	72712	61650	65734	64209	79384	103808
BUS Diesel Urban Midi <=15 t	Euro II	-	-	-	-	-	-	-	-	38314	66917	76258	77609	65802	70161	68533	84731	110800
BUS Diesel Urban Midi <=15 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	70192	74842	73105	90383	118191
BUS Diesel Urban Midi <=15 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Midi <=15 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Midi <=15 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Standard 15 - 18 t	Conventional	135478	125927	68913	47319	32995	29842	18624	17991	30872	53918	61445	62533	53020	56532	55221	68272	89276
BUS Diesel Urban Standard 15 - 18 t	Euro I	-	-	-	-	40101	36269	22635	21865	37520	65530	74678	76000	64439	68707	67113	82975	108503
BUS Diesel Urban Standard 15 - 18 t	Euro II	-	-	-	-	-	-	-	-	41821	73042	83238	84712	71825	76583	74806	92487	120941
BUS Diesel Urban Standard 15 - 18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	76594	81667	79773	98627	128970
BUS Diesel Urban Standard 15 - 18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Standard 15 - 18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Standard 15 - 18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Articulated >18 t	Conventional	129786	120637	66017	45331	31609	28588	17841	17235	29575	51653	58863	59906	50793	54157	52901	65403	85526
BUS Diesel Urban Articulated >18 t	Euro I	-	-	-	-	40326	36472	22762	21988	37730	65897	75096	76426	64800	69092	67489	83440	109111
BUS Diesel Urban Articulated >18 t	Euro II	-	-	-	-	-	-	-	-	42499	74225	84586	86085	72989	77824	76018	93985	122900
BUS Diesel Urban Articulated >18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	77466	82597	80681	99749	130438
BUS Diesel Urban Articulated >18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Articulated >18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Urban Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Standard <=18 t	Conventional	130546	121343	66404	45597	31794	28756	17946	17336	29748	51955	59208	60257	51090	54474	53210	65787	86027
BUS Diesel Coach Standard <=18 t	Euro I	-	-	-	-	37175	33622	20983	20270	34782	60748	69228	70455	59737	63693	62216	76920	100586
BUS Diesel Coach Standard <=18 t	Euro II	-	-	-	-	-	-	-	-	38346	66973	76321	77673	65857	70219	68590	84802	110892
BUS Diesel Coach Standard <=18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	71288	76010	74247	91794	120036
BUS Diesel Coach Standard <=18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Standard <=18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Standard <=18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Articulated >18 t	Conventional	129199	120091	65719	45126	31466	28459	17761	17157	29441	51419	58597	59635	50563	53912	52661	65108	85139
BUS Diesel Coach Articulated >18 t	Euro I	-	-	-	-	37935	34309	21412	20684	35493	61990	70643	71894	60957	64995	63487	78492	102641
BUS Diesel Coach Articulated >18 t	Euro II	-	-	-	-	-	-	-	-	40543	70809	80693	82123	69630	74242	72520	89659	117244
BUS Diesel Coach Articulated >18 t	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	73803	78692	76866	95033	124271
BUS Diesel Coach Articulated >18 t	Euro IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Articulated >18 t	Euro V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS Diesel Coach Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BUS CNG Urban	Euro I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43140
BUS CNG Urban	Euro II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48086
BUS CNG Urban	Euro III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51278
BUS CNG Urban	EEV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOP Gasoline 2-stroke <50 cm³	Conventional	3638	3891	3403	1525	1848	2018	1927	2022	1653	1056	1323	1228	961	775	793	700	636
MOP Gasoline 2-stroke <50 cm³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	1149	927	948	837	760
MOP Gasoline 2-stroke <50 cm³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1070	972
MOP Gasoline 2-stroke <50 cm³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOP Gasoline 2-stroke <50 cm³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 2-stroke >50 cm³	Conventional	8271	8845	7735	3467	4202	4589	4381	4597	3757	2400	3008	2792	2185	1762	1802	1592	1446
MOT Gasoline 2-stroke >50 cm³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	2278	1838	1880	1660	1508
MOT Gasoline 2-stroke >50 cm³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1880	1708
MOT Gasoline 2-stroke >50 cm³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Subsector	Technology	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
MOT Gasoline 2-stroke >50 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke <250 cm ³	Conventional	10714	11458	10020	4491	5443	5944	5675	5954	4867	3109	3897	3616	2830	2282	2335	2062	1873
MOT Gasoline 4-stroke <250 cm ³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	3147	2538	2597	2293	2083
MOT Gasoline 4-stroke <250 cm ³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2031	1845
MOT Gasoline 4-stroke <250 cm ³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke <250 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke 250 - 750 cm ³	Conventional	11024	11790	10310	4621	5601	6116	5839	6127	5008	3199	4010	3721	2912	2348	2402	2122	1927
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	3276	2642	2703	2387	2168
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2139	1943
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke >750 cm ³	Conventional	11191	11968	10467	4691	5686	6209	5928	6220	5084	3248	4071	3777	2956	2384	2439	2154	1956
MOT Gasoline 4-stroke >750 cm ³	Euro 1	-	-	-	-	-	-	-	-	-	-	-	-	3369	2717	2779	2455	2229
MOT Gasoline 4-stroke >750 cm ³	Euro 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2195	1993
MOT Gasoline 4-stroke >750 cm ³	Euro 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOT Gasoline 4-stroke >750 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 289 Mileage data for Road transport (average km/year/vehicle) 2005-2021

Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PC Gasoline Small	PRE ECE	1502	2958	2572	2312	2280	2090	1880	1763	1445	1662	1707	1686	1961	1901	1896	1975	2236
PC Gasoline Small	ECE 15/00-01	1809	3563	3098	2785	2747	2518	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Small	ECE 15/02	1832	3608	3137	2820	2781	2550	2293	2150	1762	2027	-	-	-	-	-	-	-
PC Gasoline Small	ECE 15/03	2159	4252	3697	3324	3278	3005	2702	2534	2077	2389	2454	2423	2819	2732	-	-	-
PC Gasoline Small	ECE 15/04	2900	5713	4967	4465	4403	4037	3630	3404	2790	3210	3296	3256	3787	3671	3661	3813	4318
PC Gasoline Small	Euro 1	3491	6877	5979	5375	5301	4859	4369	4098	3359	3864	3968	3919	4559	4419	4407	4591	5198
PC Gasoline Small	Euro 2	4046	7968	6928	6228	6142	5631	5063	4749	3892	4477	4598	4541	5282	5120	5107	5319	6023
PC Gasoline Small	Euro 3	4668	9194	7994	7186	7087	6497	5842	5479	4491	5166	5305	5240	6095	5908	5892	6137	6950
PC Gasoline Small	Euro 4	4945	9740	8468	7613	7507	6882	6189	5805	4757	5472	5620	5551	6457	6258	6242	6502	7362
PC Gasoline Small	Euro 5	-	-	-	-	-	7490	6735	6317	5177	5955	6116	6041	7027	6811	6793	7076	8012
PC Gasoline Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	6649	6566	7639	7404	7384	7692	8710
PC Gasoline Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	7997	7976	8307	9407
PC Gasoline Medium	PRE ECE	1610	3171	2757	2478	2444	2240	2014	1890	1549	1781	1829	1807	2102	2037	2032	2116	2397
PC Gasoline Medium	ECE 15/00-01	1927	3796	3300	2967	2926	2682	-	-	-	-	-	-	-	-	-	-	-
PC Gasoline Medium	ECE 15/02	2022	3983	3463	3113	3070	2814	2530	2373	1945	2238	-	-	-	-	-	-	-
PC Gasoline Medium	ECE 15/03	2318	4565	3969	3568	3518	3225	2900	2720	2230	2565	2634	2601	3026	2933	-	-	-
PC Gasoline Medium	ECE 15/04	3117	6139	5337	4798	4732	4338	3900	3659	2998	3449	3542	3498	4070	3944	3934	4098	4640
PC Gasoline Medium	Euro 1	3857	7597	6605	5938	5856	5368	4827	4527	3711	4268	4384	4329	5036	4881	4869	5071	5742
PC Gasoline Medium	Euro 2	4349	8567	7448	6696	6603	6053	5443	5105	4184	4813	4943	4882	5679	5505	5490	5719	6475
PC Gasoline Medium	Euro 3	5019	9885	8595	7727	7619	6985	6281	5891	4828	5554	5704	5634	6553	6352	6335	6599	7472
PC Gasoline Medium	Euro 4	5292	10424	9063	8148	8035	7366	6623	6212	5091	5857	6015	5940	6910	6698	6680	6958	7879
PC Gasoline Medium	Euro 5	-	-	-	-	-	8066	7253	6803	5575	6414	6587	6505	7567	7335	7316	7620	8628
PC Gasoline Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	7159	7070	8225	7972	7951	8282	9378
PC Gasoline Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8609	8586	8943
PC Gasoline Large	PRE ECE	1693	3334	2899	2606	2570	2356	2119	1987	1629	1873	1924	1900	2210	2143	2137	2226	2520
PC Gasoline Large	ECE 15/00-01	2025	3989	3468	3118	3075	2819	-	-	-	-	-	-	-	-	-	-	-

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Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PC Gasoline Large	ECE 15/02	2060	4058	3529	3172	3128	2868	2579	2419	1982	2280	-	-	-	-	-	-	-
PC Gasoline Large	ECE 15/03	2444	4814	4185	3762	3710	3401	3058	2869	2351	2705	2778	2743	3191	3093	-	-	-
PC Gasoline Large	ECE 15/04	3242	6386	5552	4992	4922	4513	4058	3806	3119	3588	3685	3639	4234	4103	4093	4263	4827
PC Gasoline Large	Euro 1	3951	7783	6767	6083	5999	5500	4945	4638	3801	4373	4491	4435	5160	5001	4988	5195	5883
PC Gasoline Large	Euro 2	4642	9144	7950	7147	7048	6461	5810	5449	4466	5137	5276	5211	6062	5875	5860	6104	6911
PC Gasoline Large	Euro 3	5168	10180	8851	7957	7846	7193	6468	6067	4972	5719	5874	5801	6748	6541	6524	6795	7695
PC Gasoline Large	Euro 4	5810	11444	9950	8945	8821	8086	7271	6820	5589	6430	6603	6522	7586	7353	7334	7639	8650
PC Gasoline Large	Euro 5	-	-	-	-	-	8577	7712	7234	5929	6820	7004	6917	8047	7799	7779	8103	9175
PC Gasoline Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	7621	7527	8756	8486	8464	8816	9983
PC Gasoline Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	9173	9149	9530	10791
PC Gasoline Hybrid Medium	Euro 4	-	-	-	-	9210	8444	7592	7121	5836	6714	6895	6810	7922	7678	7658	7977	9032
PC Gasoline Hybrid Medium	Euro 5	-	-	-	-	-	8596	7730	7250	5942	6835	7020	6933	8065	7817	7796	8121	9196
PC Gasoline Hybrid Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	8182	8081	9400	9111	9087	9465	10718
PC Gasoline Hybrid Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	9635	9609	10009	11334
PC Diesel Small	Conventional	33592	22991	16862	15295	13259	12077	11724	12047	9711	10171	10573	10073	10633	10863	11014	10091	10918
PC Diesel Small	Euro 1	37843	25901	18996	17231	14937	13605	13208	13572	10940	11458	11911	11348	11979	12238	12408	11368	12300
PC Diesel Small	Euro 2	44574	30508	22374	20296	17594	16025	15557	15986	12886	13496	14029	13367	14110	14415	14615	13390	14487
PC Diesel Small	Euro 3	50578	34617	25388	23029	19964	18183	17652	18139	14622	15314	15919	15167	16010	16356	16583	15193	16439
PC Diesel Small	Euro 4	51024	34922	25612	23232	20140	18344	17808	18299	14751	15449	16059	15301	16151	16500	16730	15327	16584
PC Diesel Small	Euro 5	-	-	-	-	-	20780	20173	20729	16710	17501	18193	17333	18297	18692	18952	17363	18787
PC Diesel Small	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	19691	18761	19803	20231	20512	18793	20334
PC Diesel Small	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	21771	22073	20223	21881
PC Diesel Medium	Conventional	33592	22991	16862	15295	13259	12077	11724	12047	9711	10171	10573	10073	10633	10863	11014	10091	10918
PC Diesel Medium	Euro 1	37843	25901	18996	17231	14937	13605	13208	13572	10940	11458	11911	11348	11979	12238	12408	11368	12300
PC Diesel Medium	Euro 2	44574	30508	22374	20296	17594	16025	15557	15986	12886	13496	14029	13367	14110	14415	14615	13390	14487
PC Diesel Medium	Euro 3	50578	34617	25388	23029	19964	18183	17652	18139	14622	15314	15919	15167	16010	16356	16583	15193	16439
PC Diesel Medium	Euro 4	51024	34922	25612	23232	20140	18344	17808	18299	14751	15449	16059	15301	16151	16500	16730	15327	16584
PC Diesel Medium	Euro 5	-	-	-	-	-	20780	20173	20729	16710	17501	18193	17333	18297	18692	18952	17363	18787
PC Diesel Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	19691	18761	19803	20231	20512	18793	20334
PC Diesel Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	21771	22073	20223	21881
PC Diesel Large	Conventional	37096	25390	18621	16891	14642	13336	12947	13304	10724	11232	11676	11124	11742	11996	12163	11144	12057
PC Diesel Large	Euro 1	42028	28765	21096	19136	16589	15109	14668	15072	12150	12725	13228	12603	13304	13591	13780	12625	13660
PC Diesel Large	Euro 2	47248	32338	23717	21513	18649	16986	16490	16945	13659	14306	14871	14169	14956	15279	15492	14193	15356
PC Diesel Large	Euro 3	55233	37803	27725	25149	21801	19857	19277	19808	15968	16724	17384	16563	17484	17862	18110	16592	17952
PC Diesel Large	Euro 4	57149	39114	28686	26021	22557	20546	19946	20495	16522	17304	17987	17138	18090	18481	18738	17167	18574
PC Diesel Large	Euro 5	-	-	-	-	-	22917	22247	22861	18428	19301	20063	19115	20178	20614	20900	19149	20718
PC Diesel Large	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	21741	20714	21865	22338	22648	20750	22451
PC Diesel Large	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	24062	24396	22351	24183
PC LPG Medium	Conventional	64234	65875	61449	56997	59069	55497	50126	45898	43447	37432	35509	36509	38027	34226	30860	17352	15724
PC LPG Medium	Euro 1	72910	74772	69749	64695	67047	62993	56896	52097	49315	42488	40305	41440	43163	38848	35028	19696	17848
PC LPG Medium	Euro 2	77410	79387	74054	68688	71185	66881	60408	55313	52359	45111	42792	43998	45827	41246	37190	20912	18950
PC LPG Medium	Euro 3	81144	83217	77626	72001	74618	70107	63322	57981	54884	47287	44857	46120	48038	43236	38984	21920	19864
PC LPG Medium	Euro 4	79324	81350	75885	70387	72945	68535	61902	56681	53653	46226	43851	45086	46960	42266	38110	21429	19418
PC LPG Medium	Euro 5	-	-	-	-	-	74759	67524	61829	58526	50424	47833	49180	51226	46105	41571	23375	21182
PC LPG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	49957	51364	53500	48152	43416	24413	22122
PC LPG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	50199	45262	25450	23063
PC CNG Medium	Euro 4	41173	36628	40224	30408	35468	40775	38270	39798	42423	43565	39240	37361	38060	35514	35842	31623	32968
PC CNG Medium	Euro 5	-	-	-	-	-	44478	41745	43413	46276	47522	42804	40754	41517	38739	39097	34496	35962

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Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PC CNG Medium	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	-	44704	42563	43360	40459	40832	36027	37558
PC CNG Medium	Euro 6 d-temp	-	-	-	-	-	-	-	-	-	-	-	-	-	42179	42568	37558	39155
LCV Gasoline <3,5 t	Conventional	4121	8117	7057	6344	6256	5735	5157	4837	3964	4560	4684	4626	5381	5215	5202	5418	6135
LCV Gasoline <3,5 t	Euro 1	4743	9342	8122	7302	7201	6601	5936	5567	4563	5249	5391	5324	6193	6003	5987	6236	7061
LCV Gasoline <3,5 t	Euro 2	5306	10450	9086	8168	8055	7384	6640	6228	5104	5871	6030	5955	6928	6715	6697	6976	7899
LCV Gasoline <3,5 t	Euro 3	6019	11855	10307	9266	9138	8377	7532	7065	5790	6661	6841	6756	7859	7617	7597	7914	8961
LCV Gasoline <3,5 t	Euro 4	6806	13405	11655	10478	10332	9472	8517	7989	6547	7532	7735	7639	8886	8613	8591	8948	10132
LCV Gasoline <3,5 t	Euro 5	-	-	-	11381	11223	10289	9251	8677	7112	8181	8402	8298	9653	9356	9331	9720	11006
LCV Gasoline <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	8916	9157	9044	10520	10197	10170	10593	11995
LCV Diesel <3,5 t	Conventional	34595	23678	17365	15752	13655	12437	12074	12407	10001	10475	10888	10374	10951	11187	11343	10392	11244
LCV Diesel <3,5 t	Euro 1	40134	27469	20146	18274	15841	14428	14007	14393	11603	12152	12632	12035	12704	12979	13159	12056	13044
LCV Diesel <3,5 t	Euro 2	44149	30217	22161	20102	17426	15872	15409	15833	12763	13368	13896	13239	13975	14277	14476	13262	14349
LCV Diesel <3,5 t	Euro 3	48170	32969	24179	21933	19013	17318	16812	17275	13926	14585	15161	14445	15248	15577	15794	14470	15656
LCV Diesel <3,5 t	Euro 4	55541	38014	27880	25289	21923	19968	19385	19919	16057	16817	17481	16655	17581	17961	18211	16684	18052
LCV Diesel <3,5 t	Euro 5	-	-	-	27090	23484	21390	20765	21337	17200	18015	18726	17842	18833	19240	19508	17873	19337
LCV Diesel <3,5 t	Euro 6 a/b/c	-	-	-	-	-	-	-	-	-	19526	20298	19339	20414	20855	21145	19372	20960
HDV Gasoline >3,5 t	Conventional	5422	10679	9284	8347	8231	7546	6785	6364	5216	6000	6162	6086	7079	6861	6844	7128	8072
HDV Diesel Rigid <=7,5 t	Conventional	50082	34278	25139	22804	19768	18005	17479	17961	14479	15164	15763	15018	15853	16196	16421	15045	16278
HDV Diesel Rigid <=7,5 t	Euro I	58721	40191	29476	26737	23178	21111	20494	21059	16976	17780	18482	17609	18588	18990	19253	17640	19085
HDV Diesel Rigid <=7,5 t	Euro II	69184	47351	34727	31501	27307	24872	24146	24811	20001	20948	21775	20746	21899	22373	22684	20783	22486
HDV Diesel Rigid <=7,5 t	Euro III	80957	55410	40637	36862	31955	29105	28255	29034	23405	24512	25481	24277	25626	26180	26544	24319	26313
HDV Diesel Rigid <=7,5 t	Euro IV	87543	59917	43943	39861	34554	31473	30554	31396	25309	26507	27554	26252	27711	28310	28704	26298	28453
HDV Diesel Rigid <=7,5 t	Euro V	-	-	-	44824	38857	35392	34358	35305	28460	29807	30985	29521	31162	31836	32278	29573	31996
HDV Diesel Rigid <=7,5 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	32749	34043	32435	34237	34977	35463	32491	35154
HDV Diesel Rigid 7,5 - 12 t	Conventional	51520	35262	25861	23459	20336	18522	17981	18477	14894	15600	16216	15450	16308	16661	16892	15477	16745
HDV Diesel Rigid 7,5 - 12 t	Euro I	64699	44282	32476	29459	25537	23260	22580	23203	18704	19590	20363	19402	20480	20923	21213	19435	21028
HDV Diesel Rigid 7,5 - 12 t	Euro II	75986	52008	38142	34599	29993	27318	26520	27251	21967	23007	23916	22786	24053	24573	24914	22826	24697
HDV Diesel Rigid 7,5 - 12 t	Euro III	89863	61505	45108	40917	35470	32307	31363	32228	25979	27209	28284	26948	28445	29060	29464	26995	29207
HDV Diesel Rigid 7,5 - 12 t	Euro IV	98100	67143	49243	44668	38721	35268	34238	35182	28361	29703	30876	29418	31053	31724	32165	29469	31884
HDV Diesel Rigid 7,5 - 12 t	Euro V	-	-	-	50783	44022	40097	38926	39998	32243	33770	35103	33445	35304	36067	36569	33504	36250
HDV Diesel Rigid 7,5 - 12 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	37352	38828	36994	39050	39894	40448	37058	40095
HDV Diesel Rigid 12 - 14 t	Conventional	44929	30751	22553	20457	17734	16152	15681	16113	12989	13604	14141	13473	14222	14529	14731	13497	14603
HDV Diesel Rigid 12 - 14 t	Euro I	58684	40165	29457	26720	23163	21097	20481	21046	16965	17768	18470	17598	18576	18977	19241	17628	19073
HDV Diesel Rigid 12 - 14 t	Euro II	70154	48016	35215	31943	27691	25221	24485	25159	20281	21242	22080	21038	22207	22687	23002	21074	22801
HDV Diesel Rigid 12 - 14 t	Euro III	87527	59906	43935	39853	34548	31467	30548	31390	25304	26502	27548	26247	27706	28305	28698	26293	28448
HDV Diesel Rigid 12 - 14 t	Euro IV	90267	61781	45310	41101	35629	32452	31504	32372	26096	27331	28411	27069	28573	29191	29596	27116	29338
HDV Diesel Rigid 12 - 14 t	Euro V	-	-	-	48341	41905	38168	37054	38075	30693	32146	33415	31837	33607	34333	34810	31892	34506
HDV Diesel Rigid 12 - 14 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	35765	37177	35421	37390	38198	38729	35483	38391
HDV Diesel Rigid 14 - 20 t	Conventional	56546	38702	28384	25747	22319	20329	19735	20279	16347	17121	17797	16957	17899	18286	18540	16986	18378
HDV Diesel Rigid 14 - 20 t	Euro I	70906	48530	35592	32285	27987	25491	24747	25429	20499	21469	22317	21263	22445	22930	23248	21300	23046
HDV Diesel Rigid 14 - 20 t	Euro II	81712	55926	41016	37205	32252	29376	28518	29304	23623	24741	25718	24503	25865	26424	26791	24546	26558
HDV Diesel Rigid 14 - 20 t	Euro III	94738	64841	47555	43136	37394	34059	33064	33976	27388	28685	29818	28409	29988	30637	31062	28459	30791
HDV Diesel Rigid 14 - 20 t	Euro IV	96814	66262	48597	44082	38213	34805	33789	34720	27989	29313	30471	29032	30646	31308	31743	29082	31466
HDV Diesel Rigid 14 - 20 t	Euro V	-	-	-	50747	43992	40069	38898	39970	32221	33746	35079	33422	35280	36042	36543	33480	36224
HDV Diesel Rigid 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	36906	38364	36552	38583	39417	39965	36615	39616
HDV Diesel Rigid 20 - 26 t	Conventional	56630	38759	28426	25785	22352	20359	19764	20309	16372	17147	17824	16982	17926	18313	18568	17011	18406
HDV Diesel Rigid 20 - 26 t	Euro I	71850	49176	36066	32715	28360	25831	25076	25768	20772	21755	22614	21546	22744	23235	23558	21583	23353
HDV Diesel Rigid 20 - 26 t	Euro II	82391	56391	41357	37515	32521	29620	28755	29548	23819	24947	25932	24707	26080	26644	27014	24750	26779

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Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
HDV Diesel Rigid 20 - 26 t	Euro III	97853	66974	49119	44555	38624	35179	34152	35093	28289	29628	30798	29344	30975	31644	32084	29395	31804
HDV Diesel Rigid 20 - 26 t	Euro IV	89149	61017	44750	40592	35188	32050	31114	31972	25773	26993	28059	26734	28220	28830	29230	26780	28975
HDV Diesel Rigid 20 - 26 t	Euro V	-	-	-	48669	42189	38427	37305	38333	30901	32364	33642	32053	33834	34566	35046	32109	34740
HDV Diesel Rigid 20 - 26 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	35120	36507	34783	36716	37510	38031	34843	37699
HDV Diesel Rigid 26 - 28 t	Conventional	56404	38605	28313	25682	22263	20278	19686	20228	16306	17078	17753	16914	17854	18240	18494	16944	18332
HDV Diesel Rigid 26 - 28 t	Euro I	69425	47517	34849	31611	27403	24959	24230	24898	20071	21021	21851	20819	21976	22451	22763	20855	22564
HDV Diesel Rigid 26 - 28 t	Euro II	79811	54625	40062	36340	31502	28693	27855	28623	23073	24165	25120	23933	25263	25810	26168	23975	25940
HDV Diesel Rigid 26 - 28 t	Euro III	93783	64188	47075	42702	37017	33716	32731	33633	27112	28396	29517	28123	29686	30328	30749	28172	30481
HDV Diesel Rigid 26 - 28 t	Euro IV	96323	65926	48350	43858	38020	34629	33618	34544	27847	29165	30317	28885	30490	31149	31582	28935	31307
HDV Diesel Rigid 26 - 28 t	Euro V	-	-	-	50271	43579	39693	38533	39596	31919	33430	34750	33109	34949	35704	36200	33166	35884
HDV Diesel Rigid 26 - 28 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	36584	38029	36233	38247	39074	39617	36296	39271
HDV Diesel Rigid 28 - 32 t	Conventional	56533	38693	28377	25741	22314	20324	19730	20274	16343	17117	17793	16953	17895	18282	18536	16982	18374
HDV Diesel Rigid 28 - 32 t	Euro I	70332	48138	35304	32024	27761	25285	24547	25223	20333	21295	22137	21091	22263	22744	23060	21128	22859
HDV Diesel Rigid 28 - 32 t	Euro II	80925	55388	40621	36847	31942	29093	28244	29022	23395	24503	25470	24267	25616	26170	26534	24310	26302
HDV Diesel Rigid 28 - 32 t	Euro III	96091	65768	48234	43753	37928	34546	33537	34461	27780	29095	30244	28815	30417	31074	31506	28865	31231
HDV Diesel Rigid 28 - 32 t	Euro IV	90576	61993	45466	41242	35751	32563	31612	32483	26185	27425	28508	27162	28671	29291	29698	27209	29439
HDV Diesel Rigid 28 - 32 t	Euro V	-	-	-	48740	42252	38484	37360	38390	30947	32411	33692	32100	33884	34617	35098	32156	34792
HDV Diesel Rigid 28 - 32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	35253	36645	34915	36855	37652	38175	34975	37842
HDV Diesel Rigid >32 t	Conventional	69652	47672	34963	31714	27492	25041	24309	24979	20136	21089	21922	20887	22048	22524	22837	20923	22638
HDV Diesel Rigid >32 t	Euro I	76855	52602	38578	34994	30335	27630	26823	27562	22219	23270	24189	23047	24328	24854	25199	23087	24979
HDV Diesel Rigid >32 t	Euro II	94306	64546	47338	42940	37223	33904	32914	33821	27264	28554	29682	28280	29852	30497	30921	28329	30651
HDV Diesel Rigid >32 t	Euro III	108619	74342	54522	49457	42873	39050	37909	38954	31401	32888	34187	32572	34382	35126	35614	32629	35303
HDV Diesel Rigid >32 t	Euro IV	99501	68102	49946	45305	39274	35772	34727	35684	28766	30127	31317	29838	31496	32177	32624	29890	32340
HDV Diesel Rigid >32 t	Euro V	-	-	-	53376	46270	42144	40913	42040	33890	35494	36896	35153	37107	37909	38436	35214	38100
HDV Diesel Rigid >32 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	38263	39774	37896	40002	40867	41434	37962	41073
HDV Diesel Articulated 14 - 20 t	Conventional	73652	50410	36970	33535	29071	26479	25705	26414	21293	22300	23181	22086	23314	23818	24149	22125	23938
HDV Diesel Articulated 14 - 20 t	Euro I	89002	60916	44675	40525	35130	31997	31063	31919	25730	26948	28013	26689	28173	28782	29182	26736	28927
HDV Diesel Articulated 14 - 20 t	Euro II	106487	72883	53452	48486	42031	38283	37165	38189	30785	32242	33516	31933	33708	34436	34915	31988	34610
HDV Diesel Articulated 14 - 20 t	Euro III	132770	90872	66645	60453	52405	47732	46338	47615	38383	40200	41788	39814	42027	42936	43532	39884	43153
HDV Diesel Articulated 14 - 20 t	Euro IV	140934	96460	70744	64171	55628	50667	49187	50543	40744	42672	44358	42263	44612	45576	46209	42336	45806
HDV Diesel Articulated 14 - 20 t	Euro V	-	-	-	73794	63970	58265	56564	58123	46854	49072	51010	48600	51302	52411	53139	48685	52675
HDV Diesel Articulated 14 - 20 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	54471	56623	53948	56947	58178	58986	54042	58471
HDV Diesel Articulated 20 - 28 t	Conventional	81665	55894	40993	37184	32234	29359	28502	29287	23609	24727	25703	24489	25850	26409	26776	24532	26543
HDV Diesel Articulated 20 - 28 t	Euro I	97015	66400	48698	44173	38293	34878	33859	34793	28047	29375	30535	29092	30709	31373	31809	29143	31532
HDV Diesel Articulated 20 - 28 t	Euro II	116168	79509	58312	52894	45853	41764	40544	41661	33584	35174	36563	34836	36772	37567	38089	34896	37757
HDV Diesel Articulated 20 - 28 t	Euro III	140783	96356	70668	64102	55568	50613	49135	50489	40700	42627	44310	42217	44564	45527	46160	42291	45757
HDV Diesel Articulated 20 - 28 t	Euro IV	140934	96460	70744	64171	55628	50667	49187	50543	40744	42672	44358	42263	44612	45576	46209	42336	45806
HDV Diesel Articulated 20 - 28 t	Euro V	-	-	-	74676	64734	58961	57239	58817	47413	49658	51619	49181	51914	53037	53774	49267	53305
HDV Diesel Articulated 20 - 28 t	Euro VI	-	-	-	-	-	-	-	-	-	54572	56728	54048	57052	58285	59095	54142	58580
HDV Diesel Articulated 28 - 34 t	Conventional	87675	60007	44009	39921	34606	31520	30599	31443	25347	26546	27595	26291	27753	28353	28747	26337	28496
HDV Diesel Articulated 28 - 34 t	Euro I	102879	70414	51641	46844	40607	36986	35906	36896	29742	31150	32380	30851	32566	33270	33732	30905	33438
HDV Diesel Articulated 28 - 34 t	Euro II	123046	84217	61764	56026	48568	44236	42944	44128	35572	37256	38728	36899	38949	39791	40344	36963	39992
HDV Diesel Articulated 28 - 34 t	Euro III	148397	101568	74490	67569	58574	53350	51792	53220	42901	44932	46707	44501	46974	47989	48656	44578	48232
HDV Diesel Articulated 28 - 34 t	Euro IV	161567	110582	81100	73566	63772	58085	56389	57943	46709	48920	50852	48450	51143	52248	52974	48534	52512
HDV Diesel Articulated 28 - 34 t	Euro V	-	-	-	83190	72115	65684	63765	65523	52819	55320	57504	54788	57833	59083	59904	54884	59382
HDV Diesel Articulated 28 - 34 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	61172	63588	60585	63952	65335	66242	60690	65665
HDV Diesel Articulated 34 - 40 t	Conventional	83608	57224	41968	38069	33001	30058	29180	29984	24171	25315	26315	25072	26465	27038	27413	25116	27174
HDV Diesel Articulated 34 - 40 t	Euro I	107486	73567	53954	48941	42426	38642	37514	38548	31074	32545	33830	32232	34024	34759	35242	32288	34935

Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
HDV Diesel Articulated 34 - 40 t	Euro II	127487	87256	63994	58048	50320	45833	44494	45721	36856	38601	40126	38230	40355	41227	41800	38297	41436
HDV Diesel Articulated 34 - 40 t	Euro III	153921	105349	77263	70084	60754	55336	53720	55201	44498	46605	48445	46157	48723	49776	50467	46237	50027
HDV Diesel Articulated 34 - 40 t	Euro IV	163167	111677	81904	74294	64404	58660	56947	58517	47171	49404	51355	48930	51649	52766	53499	49015	53032
HDV Diesel Articulated 34 - 40 t	Euro V	-	-	-	85966	74521	67876	65893	67709	54582	57165	59423	56617	59763	61055	61903	56715	61363
HDV Diesel Articulated 34 - 40 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	63389	65893	62781	66270	67702	68643	62890	68044
HDV Diesel Articulated 40 - 50 t	Conventional	96524	66064	48451	43950	38099	34701	33688	34616	27905	29226	30380	28945	30554	31214	31648	28996	31372
HDV Diesel Articulated 40 - 50 t	Euro I	118401	81037	59433	53911	46734	42566	41323	42462	34229	35850	37266	35506	37479	38289	38821	35567	38482
HDV Diesel Articulated 40 - 50 t	Euro II	145688	99714	73130	66335	57504	52376	50847	52248	42118	44112	45854	43688	46116	47113	47768	43764	47351
HDV Diesel Articulated 40 - 50 t	Euro III	173981	119078	87332	79218	68672	62548	60721	62395	50297	52678	54759	52173	55072	56263	57044	52263	56547
HDV Diesel Articulated 40 - 50 t	Euro IV	163167	111677	81904	74294	64404	58660	56947	58517	47171	49404	51355	48930	51649	52766	53499	49015	53032
HDV Diesel Articulated 40 - 50 t	Euro V	-	-	-	89340	77447	70540	68480	70367	56724	59410	61756	58839	62109	63452	64334	58941	63772
HDV Diesel Articulated 40 - 50 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	65128	67700	64503	68088	69559	70526	64615	69911
HDV Diesel Articulated 50 - 60 t	Conventional	88767	60755	44558	40418	35037	31913	30981	31834	25662	26877	27939	26619	28098	28706	29105	26665	28851
HDV Diesel Articulated 50 - 60 t	Euro I	105427	72158	52920	48004	41613	37902	36795	37809	30479	31922	33182	31615	33372	34094	34567	31670	34266
HDV Diesel Articulated 50 - 60 t	Euro II	127651	87369	64076	58123	50385	45892	44552	45780	36904	38651	40177	38279	40407	41280	41854	38346	41489
HDV Diesel Articulated 50 - 60 t	Euro III	155536	106454	78073	70820	61392	55917	54284	55780	44965	47094	48954	46642	49234	50298	50997	46723	50552
HDV Diesel Articulated 50 - 60 t	Euro IV	163167	111677	81904	74294	64404	58660	56947	58517	47171	49404	51355	48930	51649	52766	53499	49015	53032
HDV Diesel Articulated 50 - 60 t	Euro V	-	-	-	85502	74120	67510	65538	67345	54288	56857	59103	56311	59441	60726	61570	56409	61033
HDV Diesel Articulated 50 - 60 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	62880	65364	62276	65737	67158	68092	62384	67498
BUS Diesel Urban Midi <=15 t	Conventional	89538	61283	44945	40769	35342	32190	31250	32111	25885	27111	28181	26850	28343	28955	29358	26897	29102
BUS Diesel Urban Midi <=15 t	Euro I	110241	75453	55337	50196	43513	39633	38475	39536	31870	33379	34697	33059	34896	35650	36146	33116	35830
BUS Diesel Urban Midi <=15 t	Euro II	117666	80535	59064	53576	46444	42302	41067	42199	34017	35627	37034	35285	37246	38051	38580	35347	38244
BUS Diesel Urban Midi <=15 t	Euro III	125516	85907	63004	57151	49542	45124	43806	45014	36286	38004	39505	37639	39731	40590	41154	37705	40795
BUS Diesel Urban Midi <=15 t	Euro IV	118573	81155	59519	53989	46802	42628	41383	42524	34279	35902	37320	35557	37533	38345	38877	35619	38538
BUS Diesel Urban Midi <=15 t	Euro V	-	-	-	61155	53013	48286	46876	48168	38829	40667	42273	40276	42515	43434	44037	40346	43653
BUS Diesel Urban Midi <=15 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	42887	44581	42476	44836	45806	46442	42550	46037
BUS Diesel Urban Standard 15 - 18 t	Conventional	94809	64890	47591	43169	37422	34085	33089	34001	27409	28707	29840	28431	30011	30660	31086	28480	30815
BUS Diesel Urban Standard 15 - 18 t	Euro I	115228	78865	57840	52466	45481	41426	40216	41324	33312	34889	36267	34554	36474	37263	37781	34614	37451
BUS Diesel Urban Standard 15 - 18 t	Euro II	128436	87906	64470	58480	50695	46174	44826	46061	37131	38888	40424	38515	40655	41534	42111	38582	41744
BUS Diesel Urban Standard 15 - 18 t	Euro III	136963	93742	68750	62363	54061	49240	47802	49119	39596	41470	43108	41072	43355	44292	44907	41143	44515
BUS Diesel Urban Standard 15 - 18 t	Euro IV	132610	90762	66565	60381	52342	47675	46282	47558	38337	40152	41738	39766	41976	42884	43480	39835	43100
BUS Diesel Urban Standard 15 - 18 t	Euro V	-	-	-	68668	59526	54218	52634	54085	43599	45663	47466	45224	47738	48770	49447	45303	49016
BUS Diesel Urban Standard 15 - 18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	48610	50530	48143	50819	51917	52639	48227	52180
BUS Diesel Urban Articulated >18 t	Conventional	90826	62164	45591	41355	35850	32653	31699	32573	26258	27501	28587	27237	28750	29372	29780	27284	29520
BUS Diesel Urban Articulated >18 t	Euro I	115873	79307	58164	52760	45736	41658	40441	41556	33499	35084	36470	34748	36679	37472	37992	34808	37661
BUS Diesel Urban Articulated >18 t	Euro II	130517	89330	65514	59428	51516	46922	45552	46807	37732	39518	41079	39139	41314	42207	42794	39207	42420
BUS Diesel Urban Articulated >18 t	Euro III	138522	94809	69533	63073	54676	49800	48346	49678	40046	41942	43599	41539	43848	44796	45418	41612	45022
BUS Diesel Urban Articulated >18 t	Euro IV	131516	90014	66016	59883	51911	47281	45900	47166	38021	39821	41393	39438	41630	42530	43121	39507	42745
BUS Diesel Urban Articulated >18 t	Euro V	-	-	-	69510	60256	54883	53280	54748	44133	46223	48048	45779	48323	49368	50054	45858	49617
BUS Diesel Urban Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	49372	51322	48898	51616	52732	53464	48983	52998
BUS Diesel Coach Standard <=18 t	Conventional	91358	62528	45858	41598	36060	32844	31885	32764	26411	27662	28754	27396	28919	29544	29954	27444	29693
BUS Diesel Coach Standard <=18 t	Euro I	106819	73111	53619	48638	42163	38403	37281	38309	30881	32343	33620	32033	33813	34544	35024	32088	34718
BUS Diesel Coach Standard <=18 t	Euro II	117764	80602	59113	53621	46483	42337	41101	42234	34045	35657	37065	35315	37277	38083	38612	35376	38275
BUS Diesel Coach Standard <=18 t	Euro III	127475	87248	63988	58043	50316	45829	44490	45716	36853	38597	40122	38227	40351	41223	41796	38293	41432
BUS Diesel Coach Standard <=18 t	Euro IV	133352	91270	66937	60718	52635	47941	46541	47824	38552	40377	41971	39989	42211	43124	43723	40058	43342
BUS Diesel Coach Standard <=18 t	Euro V	-	-	-	66817	57922	52757	51216	52628	42424	44432	46187	44006	46451	47456	48115	44082	47695
BUS Diesel Coach Standard <=18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	47601	49481	47144	49764	50840	51546	47226	51096
BUS Diesel Coach Articulated >18 t	Conventional	90415	61883	45385	41168	35688	32505	31556	32426	26139	27376	28457	27113	28620	29239	29645	27160	29387

Subsector	Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
BUS Diesel Coach Articulated >18 t	Euro I	109002	74605	54715	49632	43024	39187	38043	39091	31512	33004	34308	32687	34504	35250	35739	32744	35428
BUS Diesel Coach Articulated >18 t	Euro II	124510	85219	62499	56693	49145	44763	43455	44653	35996	37700	39188	37338	39413	40265	40824	37402	40468
BUS Diesel Coach Articulated >18 t	Euro III	131973	90326	66245	60091	52091	47446	46060	47329	38153	39959	41537	39575	41775	42678	43271	39644	42894
BUS Diesel Coach Articulated >18 t	Euro IV	131841	90236	66179	60030	52039	47398	46014	47282	38115	39919	41496	39536	41733	42635	43228	39604	42851
BUS Diesel Coach Articulated >18 t	Euro V	-	-	-	67978	58928	53673	52105	53542	43161	45204	46989	44770	47258	48280	48950	44848	48523
BUS Diesel Coach Articulated >18 t	Euro VI A/B/C	-	-	-	-	-	-	-	-	-	48408	50320	47943	50608	51702	52420	48026	51963
BUS CNG Urban	Euro I	70654	62854	69026	52181	60864	69972	65672	68295	72799	74759	67337	64113	65312	60943	61505	54267	56574
BUS CNG Urban	Euro II	78753	70059	76939	58162	67841	77993	73200	76124	81144	83329	75056	71462	72799	67929	68556	60488	63059
BUS CNG Urban	Euro III	83981	74711	82047	62024	72345	83171	78060	81178	86532	88861	80039	76207	77632	72439	73107	64503	67245
BUS CNG Urban	EEV	98440	87573	96172	72702	84801	97490	91499	95154	101430	104160	93819	89327	90998	84911	85694	75609	78822
MOP Gasoline 2-stroke <50 cm ³	Conventional	572	1126	979	880	868	796	715	671	550	633	650	642	746	723	721	752	851
MOP Gasoline 2-stroke <50 cm ³	Euro 1	683	1346	1170	1052	1037	951	855	802	657	756	777	767	892	865	863	898	1017
MOP Gasoline 2-stroke <50 cm ³	Euro 2	874	1721	1496	1345	1326	1216	1093	1026	841	967	993	981	1141	1106	1103	1149	1301
MOP Gasoline 2-stroke <50 cm ³	Euro 3	-	1814	1577	1418	1398	1282	1153	1081	886	1019	1047	1034	1203	1166	1163	1211	1371
MOP Gasoline 2-stroke <50 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	1400	1357	1353	1409	1596
MOT Gasoline 2-stroke >50 cm ³	Conventional	1299	2559	2225	2000	1973	1808	1626	1525	1250	1438	1477	1458	1697	1644	1640	1708	1934
MOT Gasoline 2-stroke >50 cm ³	Euro 1	1355	2669	2321	2086	2057	1886	1696	1591	1304	1500	1540	1521	1769	1715	1711	1782	2018
MOT Gasoline 2-stroke >50 cm ³	Euro 2	1535	3024	2629	2363	2331	2137	1921	1802	1477	1699	1745	1723	2004	1943	1938	2018	2285
MOT Gasoline 2-stroke >50 cm ³	Euro 3	-	3099	2694	2422	2389	2190	1969	1847	1514	1741	1788	1766	2054	1991	1986	2069	2343
MOT Gasoline 2-stroke >50 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	2208	2140	2135	2224	2518
MOT Gasoline 4-stroke <250 cm ³	Conventional	1683	3315	2882	2591	2555	2343	2106	1976	1619	1863	1913	1889	2198	2130	2125	2213	2506
MOT Gasoline 4-stroke <250 cm ³	Euro 1	1872	3687	3206	2882	2842	2605	2343	2197	1801	2072	2128	2101	2444	2369	2363	2461	2787
MOT Gasoline 4-stroke <250 cm ³	Euro 2	1658	3266	2839	2552	2517	2308	2075	1946	1595	1835	1884	1861	2165	2098	2093	2180	2468
MOT Gasoline 4-stroke <250 cm ³	Euro 3	-	3488	3032	2726	2688	2465	2216	2079	1704	1960	2013	1988	2312	2241	2235	2328	2636
MOT Gasoline 4-stroke <250 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	2296	2225	2219	2312	2618
MOT Gasoline 4-stroke 250 - 750 cm ³	Conventional	1732	3411	2966	2666	2629	2410	2167	2033	1666	1917	1968	1944	2261	2192	2186	2277	2579
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 1	1948	3838	3337	3000	2958	2712	2438	2287	1874	2156	2215	2187	2544	2466	2459	2562	2901
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 2	1746	3439	2990	2688	2651	2430	2185	2050	1680	1932	1984	1960	2280	2210	2204	2296	2599
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 3	-	3488	3032	2726	2688	2465	2216	2079	1704	1960	2013	1988	2312	2241	2235	2328	2636
MOT Gasoline 4-stroke 250 - 750 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	2321	2250	2244	2337	2647
MOT Gasoline 4-stroke >750 cm ³	Conventional	1758	3463	3011	2707	2669	2447	2200	2064	1691	1946	1998	1974	2296	2225	2219	2312	2618
MOT Gasoline 4-stroke >750 cm ³	Euro 1	2004	3947	3431	3085	3042	2789	2508	2352	1928	2217	2277	2249	2616	2536	2529	2635	2983
MOT Gasoline 4-stroke >750 cm ³	Euro 2	1792	3529	3068	2758	2720	2494	2242	2103	1724	1983	2036	2011	2339	2267	2261	2356	2667
MOT Gasoline 4-stroke >750 cm ³	Euro 3	-	3488	3032	2726	2688	2465	2216	2079	1704	1960	2013	1988	2312	2241	2235	2328	2636
MOT Gasoline 4-stroke >750 cm ³	Euro 4	-	-	-	-	-	-	-	-	-	-	-	-	2334	2262	2256	2350	2661
